DIVERSITY AND DISTRIBUTION OF MOLLUSC ASSEMBLAGES IN THE LAKES OF THE DANUBE DELTA (STUDY CASE: MATIȚA-MERHEI DEPRESSION)

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Abstract. This study examines the diversity and spatial distribution of freshwater mollusc communities in the lakes of the Matița-Merhei depression (Danube Delta, Romania), based on 20 sampling stations. Field studies were conducted in May and September 2023. A total of 22 taxa belonging to Gastropoda and Bivalvia were identified, distributed among 11 families and 20 genera. Lymnaeidae and Planorbidae were the most species-rich families. *Succinea* sp. was the most frequent and dominant species, showing the highest density and weighted dominance, followed by *Bithynia tentaculata* and *Valvata* sp. Diversity indices revealed marked spatial heterogeneity, with the highest Shannon diversity values recorded in Babina, Ciorticuț, and Lungu lakes. Cluster analysis highlighted distinct lake-specific assemblages shaped by habitat characteristics and hydrological connectivity. The invasive zebra mussel (*Dreissena polymorpha*) show high spatial variation in lake abundances, prospering (>3000 ind./m^2) in optimal sites like Trei Ozere. Overall, mollusc diversity indicates a relatively good ecological status, despite ongoing anthropogenic pressures.

Key words: Danube Delta lakes; freshwater molluscs; diversity

1. INTRODUCTION

1.1. Danube Delta Biosphere Reserve: overview and significance

The Danube Delta Biosphere Reserve is the largest wetland in Romania, covering over 5,800 km^2, and represents the most important and best-preserved delta in Europe. Renowned for its extraordinary biodiversity, one of the highest on the planet, it features a labyrinth of rivers, lakes, and marshes teeming with unique flora and fauna (Gâștescu 1993, 2021; Panin *et al.*, 2016; Bănăduc *et al.*, 2023).

In December 1990, the Danube Delta was designated a Biosphere Reserve under UNESCO's Man and the Biosphere Programme. It was also recognized as a World Natural Heritage Site, a wetland of international importance, especially as a waterfowl habitat (Ramsar Convention, September 1991), and is an integrated part of the Natura 2000 Ecological Network (Gâștescu, 2009, 2012; Rotman and Slave, 2014).

The Danube Delta is a unit with a special position within the Danube River-Danube Delta-Black Sea geosystem, acting as a natural interface between the vast drainage area of the Danube River and the Black Sea catchment basin, a basin with the character of an inland sea (Pavel *et al.*, 2020). This position gives the Delta a buffering or filtering role between the Danube inflows, loaded with suspended solids and more or less contaminating substances (present in solution or associated with particular phases), and the north-western Black Sea (Panin *et al.*, 2016).

The aquatic system of the Danube Delta comprises more than 3,500 km of channels and canals (natural and artificial), and more than 450 lakes and ponds, interconnected in a very complex hydrographic network, which constitutes a huge complex of flowing and stagnant aquatic ecosystems, which influence each other and interact closely with terrestrial ecosystems in the non-water areas (Coteț, 1960).

Delta lakes are shallow, with organic-rich sediments fostering submerged meadows of phanerogams like *Ceratophyllum, Hippuris, Potamogeton*, and *Myriophyllum,* alongside *Chara* green algae (Pavel *et al.*, 2020). The Danube Delta Biosphere Reserve contains a very wide range of habitat types, lower and upper plants, vertebrates, and invertebrates, and many of the species living in the delta are unique. The malacological fauna is represented by 84 species of molluscs (Gâștescu, 2021). Freshwater molluscs play a vital role in the Delta's ecosystems, contributing significantly to water filtration, nutrient cycling, and algal regulation, while also serving as an important food source for a wide range of organisms. As such, they represent a key component of regional biodiversity and ecosystem functioning.

1.2. Historical and recent research on molluscs

Pioneering studies began with Antipa (1910) and expanded in the mid-20th century on taxonomy and ecology (Băcescu, 1967; Gomoiu, 1976). Lake assemblages were detailed by Borcea (1926), Antipa (1941), Grossu (1962), Teodorescu-Leonte *et al.* (1956), Teodorescu-Leonte and Leonte (1969), and Teodorescu-Leonte (1966, 1977). Later work addressed invasive species (Sîrbu *et al.*, 2004; Alexandrov *et al.*, 2004; Popa & Murariu, 2010; Grossu, 1993), Pontocaspian distributions (Popa *et al.*, 2009, 2010, 2012; Wesselingh *et al.*, 2019; van de Velde *et al.*, 2019; Begun *et al.*, 2020), ecological assessments (Gomoiu *et al.*, 2007, 2008; Paraschiv *et al.*, 2010a, 2010b, Begun *et al.*, 2020), and spatio-temporal patterns of invasive like *Corbicula fluminea* and *Dreissena polymorpha* (Pavel *et al.*, 2023). Moreover, the identification and distribution of mollusc fauna in the Danube Delta and the lower Danube sector have been investigated using advanced molecular approaches, via DNA barcoding (Menabit *et al.*, 2022).

The present study aims to assess the diversity and distribution of mollusc populations in the lakes of the Matița-Merhei Depression.

2. MATERIALS AND METHODS

2.1. Description of the aread

The Matița-Merhei Depression is situated in the northern sector of the Danube Delta, between the Chilia and Sulina branches. It is bordered to the north by the Cernovca Channel (a secondary branch of the Chilia branch), to the south by the Old Danube ("Big M" Meander), to the west by the Chilia Plain - Stipoc Channel, and to the east by the Letea - Răducu sand ridges (grinds). West of the Chilia Plain lies the Pardina Depression. This depression encompasses 108 lakes larger than 1 ha, including key ones: Merhei (1,057 ha), Matița (652 ha), Trei Ozere (437 ha), Bogdaproste (435 ha), Babina (432 ha), Roșca (222 ha), Rădăcinos, and Lungu. Lake Miazăzi adjoins Matița, separated by a narrow, discontinuous sandbelt (Driga, 2004, Gâștescu, 2012).

Hydrologically, it draws primarily from the Tulcea branch via the Mila 36-Șontea-Old Danube-Eracle-Lopatna canal system (plus Old Danube - Căzănel route). High-water inputs come temporarily from the Chilia branch through Pardina - Rădăcinoasele and Bahrova channels. Outflows route via Bogdaproste and Dovnica southward to Old Danube-Sulina, and Sulimanca northward to Chilia. During low water, Rădăcinoasele and Bahrova channels reverse to discharge, altering local sedimentation (Pavel *et al.*, 2020). All lakes feature low banks fringed by dense *Phragmites* reedbeds (Pavel *et al*, 2020).

The lakes of the Matița-Merhei Depression, located in the central part of the Danube Delta, are shallow freshwater bodies with limited direct connectivity to the Danube's main channels. Their physico-chemical regime is primarily controlled by hydrological exchanges, sedimentation processes, and biological activity (Catianis *et al.*, 2021).

Water temperature exhibits strong seasonal variability, reflecting the lakes' shallow depth and regional climatic conditions. The pH is generally neutral to slightly alkaline, typical of the delta's freshwater systems. Dissolved oxygen concentrations are usually adequate for aquatic biota, though local and seasonal fluctuations may occur due to biological productivity and water circulation (Driga, 2004; Gâștescu, 2012). The lakes show low to moderate mineralization, with electrical conductivity values characteristic of freshwater environments. Nutrient concentrations are generally low to moderate; however, locally elevated phosphorus levels may indicate tendencies toward eutrophic conditions. Water transparency and turbidity vary depending on sediment resuspension and phytoplankton development (Catianis *et al.*, 2021).

The physico-chemical conditions of the Matița-Merhei lakes reflect a productive, shallow freshwater lacustrine system, providing suitable habitats for diverse aquatic communities, including mollusc assemblages.

2.2. Sample collections

This study includes the qualitative and quantitative analysis of the mollusc fauna of the Matița-Merhei Depression in May and September 2023. A total of 20 macrozoobenthos samples were analyzed across the two sampling periods from nine lakes: Bogdaproste, La Amiază, Trei Ozere, Miazăzi, Lungu, Babina, Rădăcinosul, Ciorticuț, and Matița (Fig. 1).

Samples were collected by sweeping about 1 m^2 of vegetation using a limnological net with a mesh size of 12 µm during expeditions on-board GeoeEcoMar's R/V Istros and small boats used on lakes and canals. The samples were partially processed, washed through a 0.250 mm mesh sieve, preserved with 4% formaldehyde, and stored for further laboratory analysis. Organisms were extracted under a Zeiss Stemi 508 stereomicroscope and identified up to the species level using species identification keys (Grossu, 1993). Not all taxa have been identified at the species level; some were determined only to the genus level.

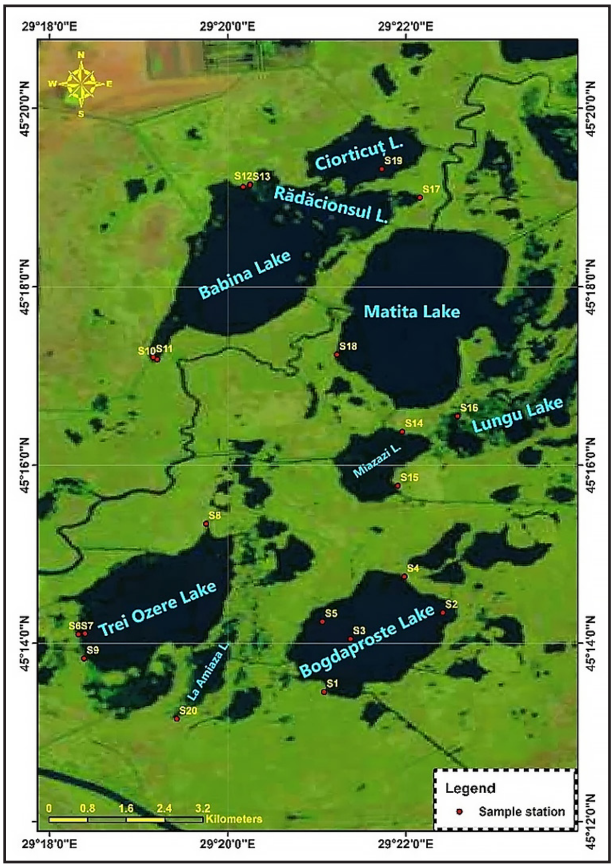

Fig. 1. Map of the Matița-Merhei Depression and sampling stations.

2.3. Data analysis

For each sampling station (Table 1) and sampling period (May and September 2023), mollusc abundance data were standardized to individuals per square meter (ind. m^{-2}). Species richness (S) and total abundance (N) were calculated for each lake.

Community structure was assessed using commonly applied diversity indices, including the Shannon-Wiener diversity index (H'), the Margalef richness index (d), and Pielou's evenness index (J') calculated within PRIMER v7. The relative abundance (%) and frequency of occurrence (%), Density (m^{-2}), and the Density Dominance percentage (DD%) of each taxon were also calculated to identify dominant and rare species.

To analyse spatial variation in mollusc assemblages, a Bray-Curtis similarity matrix was constructed based on square-root-transformed abundance data, reducing the influence of highly abundant taxa. Hierarchical cluster analysis and non-metric multidimensional scaling (nMDS) ordination were applied to visualize similarities among lakes and sampling station.

3. RESULTS AND DISCUSSIONS

3.1. Mollusc species composition and abundance

A total of 22 mollusc taxa were identified in the lakes of the Matița-Merhei depression, comprising 20 gastropods and two bivalves, distributed across 11 families (*Acroloxidae, Lymnaeidae, Viviparidae, Succineidae, Physidae, Planorbidae, Hydrobiidae, Valvatidae, Bithyniidae, Sphaeriidae* and *Dreissenidae*) and 20 genera (Tabel 2).

Table 1. Sampling stations of molluscs in the lakes of Matița-Merhei Depression.

Sampling stations	Lakes	Coordinates	
		Lat.	Long.
S1	Bogdaproste	45.2242306	29.3513778
S2	Bogdaproste	45.2390444	29.3736139
S3	Bogdaproste	45.2341361	29.3563306
S4	Bogdaproste	45.2458167	29.3664222
S5	Bogdaproste	45.2373611	29.3510667
S6	Trei Ozere	45.2350000	29.3053444
S7	Trei Ozere	45.2350194	29.3053639
S8	Trei Ozere	45.2556639	29.3292806
S9	Trei Ozere	45.2304750	29.3064250
S10	Babina	45.2864111	29.3201472
S11	Babina	45.2868194	29.3193944
S12	Babina	45.3191472	29.3375194
S13	Babina	45.3190139	29.3374889
S14	Miazăzi	45.2728972	29.3660389
S15	Miazăzi	45.2627806	29.3651861
S16	Lungu	45.2757972	29.3763611
S17	Rădăcinosul	45.3166722	29.3693361
S18	Matița	45.2873139	29.3537667
S19	Corticuț	45.3219917	29.3622083
S20	La Amiază	45.2192028	29.3237889

Table 2. The taxonomic diversity of mollusca species in the lakes of Matița-Merhei Depression from May and September 2023.

No. crt.	Phylum	Class	Family	Genus	Species
1	Mollusca	Gastropoda	Acroloxidae	Acroloxus	*Acroloxus lacustris* (Linnaeus, 1758)
2			Lymnaeidae	Stagnicola	*Stagnicola palustris* (O.F. Müller, 1774)
3				Ampullaceana	*Ampullaceana balthica* (Linnaeus, 1758)
4				Radix	*Radix* sp. (Montfort, 1810)
5					*Radix auricularia* (Linnaeus, 1758)
6				Lymnaea	*Lymnaea stagnalis* (Linnaeus, 1758)
7			Viviparidae	Viviparus	*Viviparus* sp. (Montfort, 1810)
8			Succineidae	Succinea	*Succinea* sp. (Draparnaud, 1801)
9			Physidae	Physa	*Physa* sp. (Draparnaud, 1801)
10				Physella	*Physella acuta* (Draparnaud, 1805)
11			Planorbidae	Anisus	*Anisus* sp. (S. Studer, 1820)
12				Gyraulus	*Gyraulus* sp. (Charpentier, 1837)
13				Planorbis	*Planorbis carinatus* (O.F. Müller, 1774)
14					*Planorbis planorbis* (Linnaeus, 1758)
15				Planorbarius	*Planorbarius corneus* (Linnaeus, 1758)
16				Segmentina	*Segmentina nitida* (O.F. Müller, 1774)
17			Hydrobiidae	Hydrobia	*Hydrobia* sp. (W. Hartmann, 1821)
18				Pseudamnicola	*Pseudamnicola* sp. (Paulucci, 1878)
19			Valvatidae	Valvata	*Valvata* sp. (O.F. Müller, 1773)
20			Bithyniidae	Bithynia	*Bithynia tentaculata* (Linnaeus, 1758)
21		Bivalvia	Sphaeriidae	Sphaerium	*Sphaerium corneum* (Linnaeus, 1758)
22			Dreissenidae	Dreissena	*Dreissena polymorpha* (Pallas, 1771)

Of these, 13 taxa were identified to species level: *Acroloxus lacustris, Stagnicola palustris, Ampullaceana balthica, Radix auricularia, Lymnaea stagnalis, Physella acuta, Planorbis carinatus, Planorbarius corneus, Segmentina nitida, Bithynia tentaculata, Valvata sp., Sphaerium corneum*, and *Dreissena polymorpha*. The families Lymnaeidae and Planorbidae were the most species-rich, each represented by four genera (Table 2).

Succinea sp. was the most frequent and dominant taxon, followed by *B. tentaculata* and *Valvata* sp. In contrast, taxa such as *Physella acuta*, *Hydrobia* sp., and *Pseudamnicola* sp. were rare. Among bivalves, *Sphaerium corneum* was recorded at a single sampling station, whereas the invasive species *D. polymorpha* was present at eight stations, reaching its highest densities in the Trei Ozere lakes.

Succinea sp. was most frequent (95% occurrence; 19/20 stations), followed by *Bithynia tentaculata* (75%) and *Valvata* sp. (50%) (Table 3). *Succinea sp.* has the highest density (1469.78 individuals/m^2), making it the dominant species with 36.20% of the total, *B. tentaculata* (618.32 individuals/m^2), and *Valvata sp.* (584.32 individuals/m^2) representing 15.23% and the species with the lowest density values are *A. balthica*, *R. acicularia* and *Hydrobia sp.* (Table 3). The species with the highest dominance are *Succinea* sp. which has the highest dominance, reinforcing its significant ecological role, followed by *B. tentaculata* (and *Valvata* sp. (14.39%), which are also dominant (Table 3). *Succinea sp.* (WD= 34.388) is the most ecologically important species (Table 3).

Table 3. Main ecological indices characteristic of mollusc populations in the analysed lakes by species.

Species	F%	Dind.m-2	DD%	WD
Acroloxus lacustris	40	174.75	4.30	1.722
Stagnicola palustris	30	21.36	0.53	0.158
Viviparus sp.	15	5.03	0.12	0.019
Succinea sp.	95	1469.78	36.20	34.388
Radix sp.	40	84.14	2.07	0.829
Ampullaceana balthica	5	1.26	0.03	0.002
Radix acicularia	5	1.26	0.03	0.002
Physa sp.	45	374.34	9.22	4.149
Physella acuta	5	1.26	0.03	0.002
Anisus sp.	5	28.98	0.71	0.036
Gyraulus sp.	20	20.16	0.50	0.099
Valvata sp.	50	584.32	14.39	7.195
Segmentina nitida	5	7.56	0.19	0.009
Bithynia tentaculata	75	618.32	15.23	11.421
Lymnaea stagnalis	25	12.6	0.31	0.078
Hydrobia sp.	5	1.26	0.03	0.002
Planorbarius corneus	50	290.11	7.14	3.572
Planorbis planorbis	15	44.1	1.09	0.163
Planorbis carinatus	5	15.12	0.37	0.019
Pseudamnicola sp.	10	12.6	0.31	0.031
Dreissena polymorpha	40	288.31	7.10	2.840
Sphaerium corneum	5	3.78	0.09	0.005

These findings highlight the ecological functions of freshwater molluscs as key contributors to ecosystem services in the study's vegetated lakes. Gastropod distributions, including dominant taxa like *Succinea* sp., *B. tentaculata*, and *Valvata* sp., were strongly influenced by vegetation type, and macrophyte association such as leaves of *Nymphaea alba* (Linné, 1753), rhizomes of *Phragmites australis* (Cavallines, 1799), and submerged plants like *Stratiotes, Potamogeton*, and *Characeae* (Cioboiu, 2005).

Aquatic gastropods (*Lymnaea, Planorbarius, Valvata,* and *Viviparus* sp.), abundant in this study, serve as primary bioindicators in stagnant waters (Antonescu, 1964). Their presence signals epibiont development and oxygen levels, with surface-layer occurrences indicating low oxygen key for assessing water quality and ecosystem health (Cope *et al.*, 2008).

Succinea sp., *B. tentaculata*, and *Valvata* reflect their significant roles in nutrient cycling, periphyton grazing, and habitat structuring within shallow lacustrine environments (Vaughn, 2018).

Bivalves like *D. polymorpha* and *S. corneum* perform vital water filtration, reducing phytoplankton biomass, algae, diatoms, bacteria, fine particulate organic matter, silt, and even absorbing heavy metals and large organic molecules (Alpine & Cloern, 1992; Kimmerer, Gartside & Orsi, 1994). Their shells provide microhabitats for other organisms and contribute to biogeochemical cycling (Strayer & Malcom, 2007). As sessile filter feeders with high population densities and long lifespans, mussels act as sentinels or biomonitors, bioaccumulating particles to track historical and ongoing environmental change (Vaughn, 2018), ideal for long-term water quality monitoring in the Danube Delta ecosystems.

3.2. Diversity indices

Across 20 sites, species richness (S), abundance (N), and diversity indices showed strong spatial variability (Table 4). Richness ranged from 1 species (Bogdaproste L., S5-station) to 11 species (Babina L., S10-station; La Amiază L., S20-station), averaging 6 ± 3 species/sample. Abundance spanned 9 individuals (Bogdaproste L., S5-station) to 310 individuals (Trei Ozere L., S9-station), with a mean of 122.6 ± 69.5 ind./sample. This heterogeneity likely reflects habitat-driven differences in resource availability, microhabitat diversity, and anthropogenic pressures.

The Margalef richness index (d) reached its highest value at Lungu L. (S16-station, d=2.00), indicating a relatively high proportion of species relative to individuals in this lake. Conversely, the lowest value was observed at Miazăzi L. (S15-station, d=0.56). Pielou's evenness index (J') was generally high across most samples, with an average of 0.85± 0.22. Maximum evenness values (J'=1.00) were recorded at Babina L. (S13 station) and Miazăzi L. (S15 station), suggesting an almost equal distribution of individuals among species at these sites. The lowest evenness value was found in Babina L. (S12 station), (J'=0.00), corresponding to a monodominant community.

Table 4. Main ecological indices characteristic of the mollusc populations in the lakes analyzed by stations.

Lakes	ID Sample	S	N.m-2	d	J'	H'(loge)
Bogdaproste	S1	6	178	0.96	0.7	1.38
	S2	7	86	1.35	0.8	1.64
	S3	4	70	0.71	0.9	1.28
	S4	5	107	0.86	0.9	1.57
	S5	1	9			
Trei Ozere	S6	6	143	1.01	0.9	1.66
	S7	6	147	1.00	0.9	1.65
	S8	7	152	1.19	0.7	1.40
	S9	6	310	0.87	0.9	1.69
Babina	S10	11	160	1.97	0.9	2.20
	S12	5	25	0.00	0.0	0.00
	S13	5	146	1.24	1.0	1.61
Miazăzi	S14	3	35	0.80	0.8	1.42
	S15	10	90	0.56	1.0	1.10
Lungu	S16	4	106	2.00	0.9	2.07
Rădăcinosul	S17	7	106	0.64	0.8	1.17
Matița	S18	9	207	1.29	0.9	1.78
Ciorticuț	S19	5	97	1.50	0.9	2.09
La Amiază	S20	11	155	0.87	0.8	1.42

These results highlight variations in species richness and community structure across the sampling sites, reflecting differences in ecological dynamics such as species dominance and population distribution.

The Shannon diversity index (H', natural logarithm) exhibited a mean value of 1.51 ± 0.48, reaching maximum values in Babina L. (S10-station), (H'=2.20), Ciorticuț L., (S19-station) (H'=2.09), and Lungu L. (S16-station) (H' =2.07), indicative of communities characterized by high species richness and relatively balanced species abundances. Monospecific community (H'=0) was recorded at Bogdaproste L. (S5-station) and Babina L. (S12-station), corresponding to dominance by a single species.

When aggregated by lake, Ciorticuț L. (H'=2.09) and Lungu L. (H'=2.07) displayed the highest mean Shannon diversity values, whereas Rădăcinosul L. had the lowest mean diversity (H'=1.17). La Amiază L. exhibited the greatest mean species richness (S=11), while Matița L. registered the highest mean individual abundance (N=207). Overall, the results indicate pronounced heterogeneity in species composition and distribution across the study area, likely reflecting variations in habitat structure, hydrological connectivity, and local ecological conditions within the lacustrine system of the Danube Delta.

Species richness varied widely, from zero at station S11 (Table 5) to eleven at stations S10 and S20, highlighting significant habitat heterogeneity in the study area. Stations S10, S15, S18, and S20 showed the highest diversity, likely due to favourable conditions, i.e., stable hydrology and abundant aquatic vegetation. Conversely, sites with low or absent molluscan fauna suggest disturbed or otherwise unsuitable environments conditions.

3.3. Multivariate analysis

Dendrogram analysis based on the Bray-Curtis similarity index did not reveal a clear differentiation of benthic mollusc communities between the studied lakes (Fig. 2). Samples from Lake Trei Ozere (S6, S7) formed a distinct and cohesive cluster, indicating a relatively homogeneous community structure, likely reflecting similar environmental conditions and stable habitat characteristics. Likewise, samples from Lake Babina (S11, S12) exhibited high internal similarity, reinforcing the ecological coherence of this lake.

Samples from Lake Lungu (S16) and Lake Rădăcinosul (S17) were separated from the main clusters, suggesting distinct community compositions shaped by localized environmental drivers, i.e., differences in hydrological connectivity with the Danube River, substrate characteristics, turbidity, and dissolved oxygen variability (Catianis *et al.*, 2022).

The occurrence of mixed clustering between samples from Bogdaproste L. (S4) and Trei Ozere L. indicates ecological affinities, potentially linked to shared hydrological regimes or similar habitat features.

Overall, these results suggest that benthic community structure in the Matița-Merhei Depression is governed by a combination of regional-scale factors, including lake position within the Delta's hydrological network, and site-specific environmental conditions. This pattern underscores the importance of a comparative, multi-lake approach when assessing the ecological status of aquatic ecosystems in the Danube Delta.

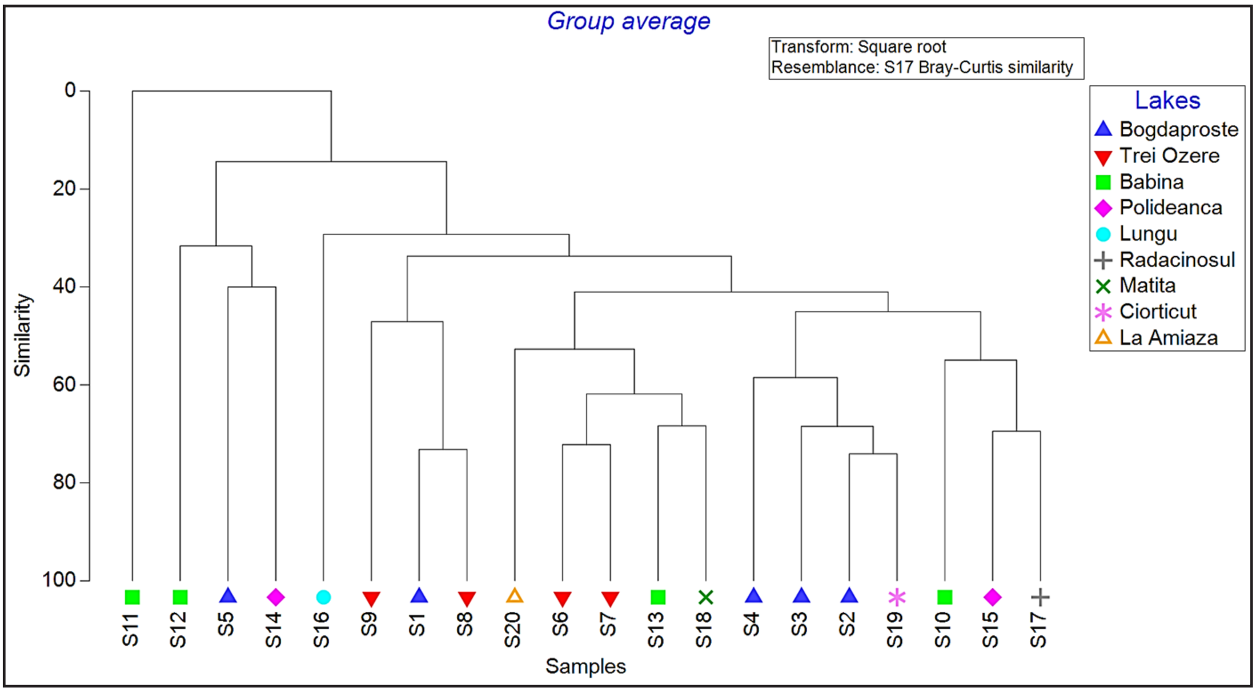

Fig. 2. Dendrogram for hierarchical grouping of stations.

Table 5. The number of species in each sampling station.

Species/Stations	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Acroloxus lacustris	+	+	-	-	-	+	+	-	+	-	-	-	-	+	-	-	-	+	-	+
Stagnicola palustris	-	-	-	-	-	-	-	+	-	+	-	-	+	-	+	-	-	+	-	+
Viviparus sp.	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Succinea sp.	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
Radix sp.	+	-	-	-	-	-	+	+	-	+	-	-	-	-	+	-	-	+	+	+
Radix ovata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Radix acicularia	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Physa sp.	-	+	-	+	-	+	+	-	-	-	-	-	+	-	-	+	-	+	+	+
Physa acuta	-	-	-	-	-	-	-	-	-	-		+	-	-	-	-	-	-	-	-
Anisus sp.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Gyraulus sp.	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	+	-	-	-
Valvata sp.	-	+	+	+	-	+		+	+		-	-	-	-	+	-	+	+	+	-
Segmentina nitida	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Bithynia tentaculata	+	+	+	+	-	+	+	+	+	+	-	-	+	-	+	-	+	+	+	+
Lymnaea stagnalis	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	-	+	-	-	-
Hydrobia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Planorbarius corneus	-	+	+	-	-	+	+	+	-	+	-	+	+	-	-	-		+		+
Planorbis planorbis	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Planorbis carinatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Pseudamnicola sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Dreissena polymorpha	+	-	-	-	-	-	-	+	+	+	-	-	-	-	+	-	+	+	-	+
Sphaerium corneum	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Total species	**6**	**7**	**4**	**5**	**1**	**6**	**6**	**7**	**6**	**11**	**0**	**5**	**5**	**3**	**10**	**4**	**7**	**9**	**5**	**11**
Share of the total number of species in the area, %	**27.27**	**31.81**	**18.18**	**22.72**	**4.54**	**27.27**	**27.27**	**31.81**	**27.27**	**50**	**0**	**22.72**	**22.72**	**13.63**	**45.45**	**18.18**	**31.81**	**40.90**	**22.72**	**50**

Hierarchical clustering dendrogram and heatmap (Fig.3) illustrate the distribution and clustering of mollusc species across multiple sampling sites within various Danube Delta lakes.

The heatmap reveals pronounced spatial variation in species abundance across the study sites. The greatest diversity and abundance are concentrated in the central cluster of locations, especially within the Trei Ozere Lake, suggesting that these environments provide the most favourable conditions. This pattern likely reflects the combined influence of factors such as vegetation structure, substrate composition, and water quality. In contrast, lakes like Babina and Lungu exhibit lower species richness and abundance, indicating distinct ecological characteristics among the different water bodies.

Overall, the figure demonstrates that mollusc communities are not-randomly distributed but form distinct lake-specific assemblages, driven by habitat heterogeneity. Species with similar ecological requirements cluster together, and certain lakes act as biodiversity hotspots, while others host more specialized or depauperate communities. This pattern underscores the strong environmental filtering shaping mollusc distribution in these wetlands.

The dendrogram groups mollusc species according to similarity in their abundance patterns across the lakes, revealing distinct ecological assemblages. The heatmap highlights lake-specific species distributions, with Trei Ozere L. hosting the most diverse and abundant communities.

3.4. Distribution of invasive molluscs zebra mussels – Dreissena polymorpha

The specimens of *D. polymorpha* studied are juveniles, found attached to the stems and stalks of submerged plants. The abundance of *D. polymorpha* exhibits marked spatial variation across the surveyed lakes (Fig. 4). Trei Ozere L. shows the highest densities, exceeding 3000 individuals, suggesting that this lake offers optimal environmental conditions for the zebra mussel. These favourable factors likely include stable water levels, increased oxygen availability, or water clarity (Karatayev *et al.*, 1997). Babina and Bogdaproste lakes recorded moderate abundance levels, indicating that while zebra mussels can establish viable populations there, they do not achieve the dominance observed in Trei Ozere L. The remaining lakes maintain very low or near-zero densities, implying that factors such as turbidity, macrophyte coverage, or hydrological disturbances limit successful colonization by *D. Polymorpha*. Overall, the data indicate that *D. polymorpha* exhibits habitat selectivity, prospering only in lakes where substrate and water quality meet its specific ecological requirements.

D. polymorpha was recorded at eight of the twenty sampling stations, confirming its status as a Pontocaspian species widely distributed along the Danube River (Pavel *et al.*, 2023) and present in several lakes of the Danube Delta, including Golovița and Zmeica lakes (Paraschiv *et al.*, 2010b), as well as in the Razim-Sinoe Lagoon System (Begun *et al.*, 2020; Popa & Murariu, 2009).

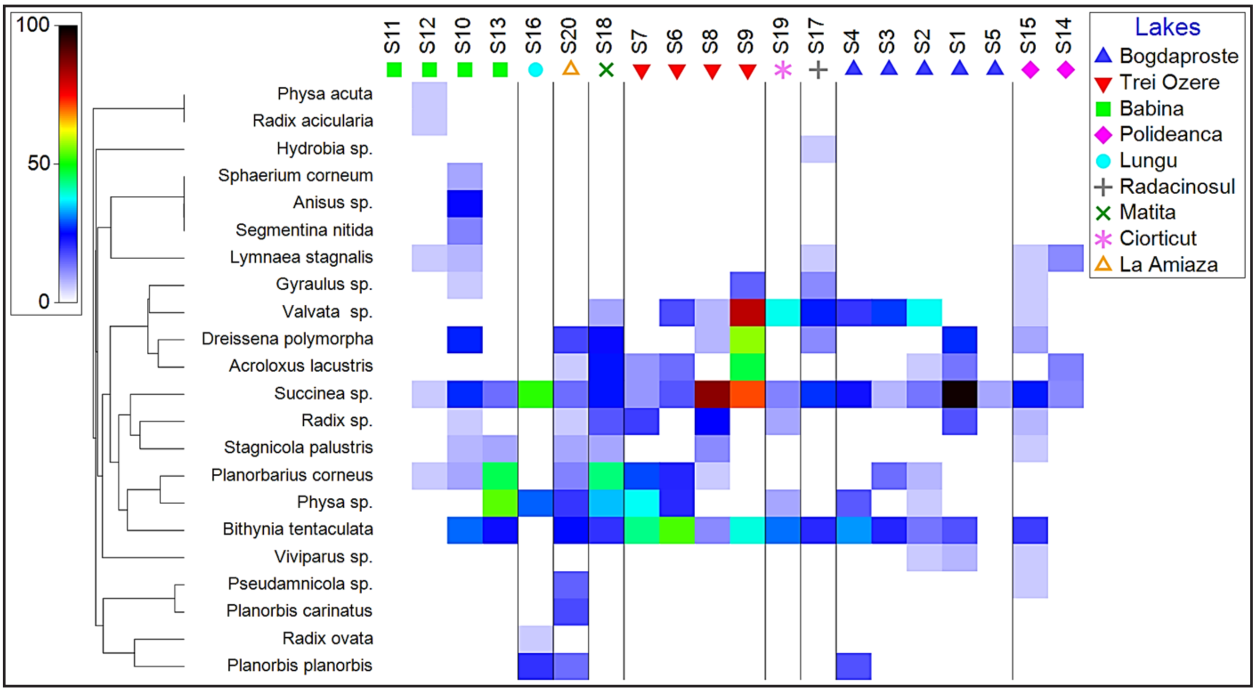

Fig. 3. Hierarchical clustering dendrogram and heatmap showing mollusc community structure across 20 sampling sites from nine lakes in the Danube Delta.

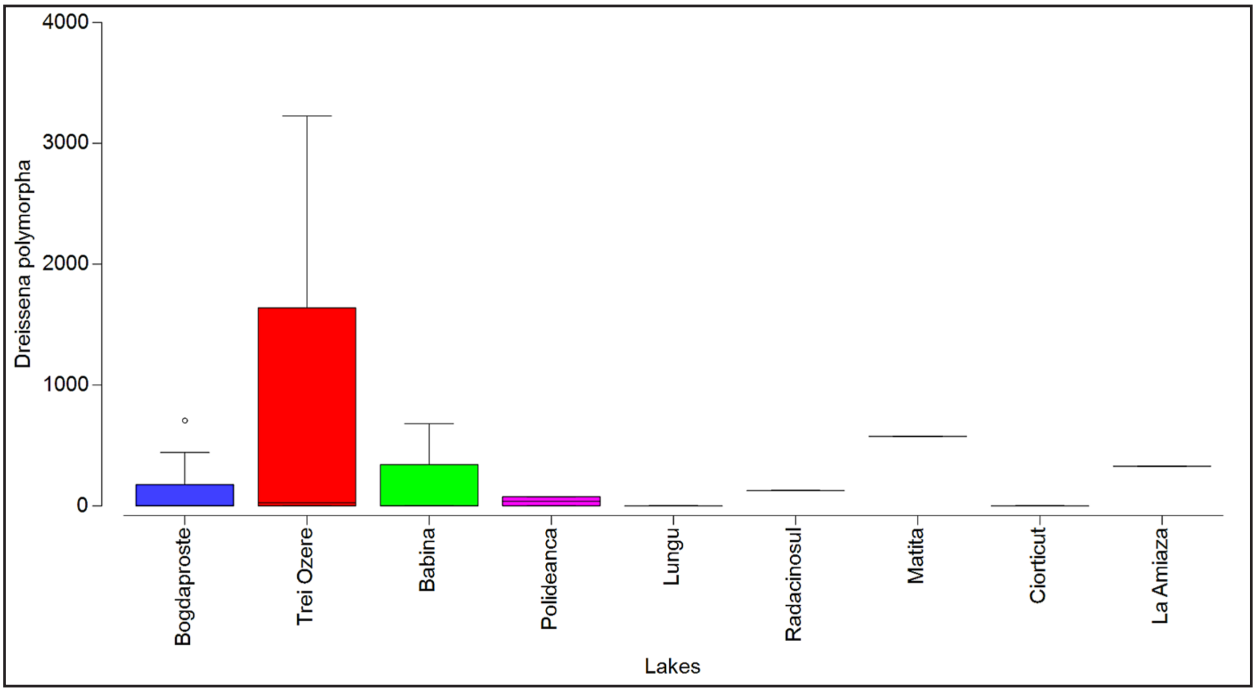

Fig. 4. Abundance of *Dreissena polymorpha* across lakes in the Danube Delta.

4. CONCLUSIONS

The lakes of the Matița-Merhei Depression host a total of 22 mollusc taxa, reflecting a relatively diverse and healthy aquatic ecosystem within the Danube Delta. *Succinea* sp. was identified as the dominant species, while other taxa, such as *B. tentaculata* and *Valvata* sp., contribute significantly to community structure. Future research should implement long-term monitoring of mollusc communities combined with measurement of key environmental factors, in order to detect temporal trends, understand population dynamics, and better inform conservation and management of the Danube Delta ecosystems.

However, mollusc communities face ongoing pressures from pollution, hydrological alterations, habitat degradation, and the spread of the invasive zebra mussel (*D. polymorpha*), which threaten native biodiversity and ecosystem functioning. The observed heterogeneity in species distribution and community composition highlights the influence of local habitat conditions, hydrological connectivity, and substrate characteristics on mollusc assemblages.

Conservation and management efforts, including habitat restoration, water quality monitoring, and invasive species control, are critical to maintaining the biodiversity and ecological resilience of the Danube Delta. Protecting mollusc populations is particularly important, given their central role in sustaining water quality, supporting food webs, and enhancing ecosystem stability.

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