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Fauna of gastropod molluscs in the Curonian Lagoon littoral biotopes (Baltic Sea, Kaliningrad region, Russia)

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A survey of the gastropod mollusc fauna in the coastal waters of the southern part of the Curonian Lagoon (Kaliningrad region, Russia) was carried out. Study revealed 34 aquatic gastropods representing 30% of Prosobranchia and 70% of Pulmonata. Obtained data showed higher mollusc diversity in the littoral biotopes in comparison with open areas of the Lagoon. The fauna is represented by a typical Central European species complex of freshwater gastropods. The reed zone along the coastline in the Lagoon functions as a barrier and provides shallow water habitats with slow moving and warmer water, where maximum gastropod species concentrate.

Key words: gastropods, littoral zone, Curonian Lagoon, Baltic Sea, Russia

Introduction

The Curonian Lagoon is one of the most important highly productive trans-boundary fishing water bodies of NW Russia. It is separated from the Baltic Sea by a thin Curonian spit. The Lagoon is strongly desalinated by the Neman River inflow (90% of water capacity), determining habitats of hydrocoles, including a big number of commercial fish species. Gastropod molluscs are one of the most abundant invertebrate groups inhabiting benthic and phytophilous communities of these coastal waters.
Species composition and gastropod distribution have so far been described only for the Lithuanian northern part of the Lagoon during last fifty years (Gasunas 1959, Zettler et al. 2005). In the southern coastal waters of the Curonian Lagoon, gastropod fauna is still insufficiently investigated. The aim of this research therefore is to describe gastropod species composition, their distribution and biotope preferences in the Curonian Lagoon coastal waters.

Material and methods

The study area was located in the southern part of the Curonian Lagoon (Baltic Sea). Molluscs were collected from 11 sites by hand and sweep net with 0.5 mm mesh sieve from the shore (Fig. 1). All the samples were fixed in 96% ethanol in the field. Approximately more than 1700 gastropod specimens were collected during the investigation period in summer 2010 year.
Nine biotopes of coastal waters were distinguished, five biotopes belonging to the group of open bottom: B1 – sand, B2 – sand-mud, B3 – sand-clay, B4 – sand-stones, B5 – sand-plant (sand and lifeless plant debris) and four biotopes belonging to phytophilous communities: B6 – reed (*Phragmitetalia* sp.), B7 – reedmace (*Typheta* sp.), B8 – pondgrass (*Potamogetoneta* sp.), B9 – hornwort (communities dominated by *Ceratophyllum* sp.) (Table 1).
Molluscs were identified from keys in Glöer & Meier-Brook (2003), Kruglov & Starobogatov (1993a, b), Starobogatov et al. (2004). The nomenclature follows Glöer (2002). The faunistic similarity level was measured by a Chekanovsky coefficient: (I_c,%). Species richness was measured by Shannon's (H), Simpson's (S) and Pielou's (E) indexes (Odum 1986). Cluster-analysis was carried out

Table 1. Characteristics of study sites in coastal waters of the Curonian Lagoon.

Site	Municipality	Coordinates		Biotope
		Longitude, °N	Latitude, °E	
1	Zalivino	54°53'45.99"	21°03'54.29"	Hornwort
2	Zalivino	54°53'58.20"	21°03'11.68"	Sand-stone
3	Zalivnoe	54°54'54.64"	20°50'16.43"	Sand-clay
4	Zalivnoe	54°54'58.31"	20°50'18.07"	Pondgrass
5	Lesnoe	55°00'58.79"	20°37'21.77"	Sand, reed
6	Lesnoe	55°01'08.31"	20°37'39.85"	Sand, sand-mud, reed
7	Lesnoe	55°01'33.89"	20°38'09.37"	Sand-plant, macreed, pondgrass
8	Rybachiy	55°09'17.39"	20°51'34.05"	Sand
9	Rybachiy	55°09'07.75"	20°51'42.57"	Sand-stone, reed
10	Morskoy	55°13'46.76"	20°55'26.74"	Sand, reed
11	Morskoy	55°13'33.95"	20°54'58.30"	Sand-mud

Fig. 1. Locations of the study sites in the coastal waters of the Curonian Lagoon.

in Primer 6 programme and was based on faunistic similarity described by the Chekanovsky coefficient.

Results

The gastropod mollusc fauna is presented by 34 species, which belong to the subclass Prosobranchia (10 species, 30%) and subclass Pulmonata (24 species, 70%), 4 orders, 7 families and 15 genera.

The Rissoiformes (Prosobranchia) order includes four species of the family Bithyniidae, which belong to genus *Bithynia* Leach in Abele, 1818 – *B. leachii* (Sheppard, 1823), *B. tentaculata* (L., 1758), and *B. tentaculata* f. *producta* Moquin-Tandon, 1855.

The Neritopsiformes (Prosobranchia) order is represented by five species of the family Valvatidae, which belong to two genera: *Borysthenia* Lindholm, 1914, including only *B. naticina* (Menke, 1846), and *Valvata* Müller, 1774 with four species – *V. cristata* Müller, 1774, *V. macrostoma* (Mörch, 1864), *V. piscinalis* (Müller, 1774), and *V. piscinalis antiqua* (Morris, 1838).

The order Viviparifomes contains two mollusc species of the family Viviparidae – *Viviparus contectus* (Millet,

Table 2. List of species and occurrence (%) in nine coastal biotopes of the Curonian Lagoon. Biotopes 1-9: B1 – sand, B2 – sand-mud, B3 – sand-clay, B4 – sand-stones, B5 – sand-plant (sand and lifeless plant debris), B6 – reed (*Phragmitetalia* sp.), B7 – reed-mace (*Typheta* sp.), B8 – pondgrass (*Potamogetoneta* sp.), B9 – hornwort (*Ceratophyllum* sp.); C – average occurrence (%) among all the biotopes; s – empty shell only.

Species	B1	B2	B3	B4	B5	B6	B7	B8	B9	C
Acroloxus lacustris	s			2	2	1	2			0.3
Acroloxus rossicus						1	1			0.2
Anisus vortex	1	1				8		3	1	1.6
Anisus vorticulus		1								0.1
Bathyomphalus contortus	3	1			2	3				1.0
Bithynia leachii						1				0.1
Bithynia tentaculata	11	1	6	6	6	8		3		4.6
Bithynia tentaculata f. *producta*			1							0.1
Borysthenia naticina		1								0.1
Gyraulus acronicus		2								0.2
Gyraulus albus	1	1	1		2	1	6	12		2.7
Gyraulus riparius	1									0.1
Lymnaea fragilis	1	1	3		14		10	4		3.7
Lymnaea stagnalis	7	1	1		24		24	15		8.0
Physa fontinalis			4		8		15	15		4.7
Physella acuta		1								0.1
Planorbarius corneus	33	2	5		4	2	3	2	2	5.9
Planorbis carinatus			1			1				0.2
Planorbis planorbis	6	3	8				2		44	7.0
Radix ampla	1			24						2.8
Radix auricularia		6			4	1	13	14		4.2
Radix auricularia f. *tumida*	5									0.6
Radix balthica	19	2	17		26	55	19	32	47	24.1
Radix labiata						1	3			0.4
Radix ovata		3	4						1	0.9
Stagnicola corvus			1							0.1
Stagnicola fuscus	2	1			2					0.6
Stagnicola palustris	3				2	1				0.7
Valvata cristata						1				0.1
Valvata piscinalis	5	70	36			12			5	14.2
Valvata piscinalis antiqua		1			2					0.3
Valvata macrostoma						1				0.1
Viviparus contectus	s	s	12			s				1.3
Viviparus viviparus				64		s				7.1
Number of taxa	**17**	**19**	**14**	**4**	**13**	**18**	**11**	**9**	**6**	**34**

1813) and *V. viviparus* (L., 1758).

The order Lymnaeiformes (Pulmonata) is the largest in species number and represented by 24 species of the families Acroloxidae, Lymnaeidae, Physidae and Planorbidae. The family Acroloxidae includes two species of *Acroloxus* Beck, 1837 genus: *A. lacustris* (L., 1758), *A. rossicus* Kruglov et Starobogatov, 1991.

The family Lymnaeidae contains 11 species, which belong to three genera: *Lymnaea* Lamarck, 1799, *Radix* Montfort, 1810, and *Stagnicola* Jeffreys, 1830. The genus *Lymnaea* includes *L. fragilis* (L., 1758) and *L. stagnalis* (L., 1758). There are *R. ampla* (Hartmann, 1841), *R. auricularia* (L., 1758), *R. auricularia* f. *tumida* (Held, 1836), *R. balthica* (L., 1758), *R. labiata* (Rossmaessler, 1835), and *R. ovata* (Draparnaud, 1809) belonging to *Radix*. The genus *Stagnicola* contains *S. corvus* (Gmelin, 1791), *S. fuscus* (C. Pfeiffer, 1821), and *S. palustris* (Müller, 1774).

The family Physidae is represented by two species belonging to two genera: *Physella* Haldeman, 1842 – one mollusc *P. acuta* (Draparnaud, 1805) and *Physa* Draparnaud, 1801 with the species *P. fontinalis* (L., 1758).

Species composition of the family Planorbidae in the Curonian Lagoon includes molluscs of five genera: *Anisus* Studer, 1820, *Bathyomphalus* Charpentier, 1837, *Gyraulus* Charpentier, 1837, *Planorbarius* Froriep, 1806, and *Planorbis* Müller, 1774.

The genus *Anisus* is represented by two species: *A. vortex* (L., 1758) and *A. vorticulus* (Troschel, 1834). One species belongs to genus *Bathyomphalus – B. contortus* (L., 1758). The genus *Gyraulus* is presented by three species: *G. acronicus* (Férussac, 1807), *G. albus* (Müller, 1774), and *G. riparius* (Westerlund, 1865). The genus *Planorbarius* also contains one species *P. corneus* (L., 1758). Two species, *P. carinatus* Müller, 1774 and *P. planorbis* (L., 1758), belong to the genus *Planorbis*.

The list of species with occurrence in nine coastal biotopes (five biotopes of bottom and four on water macrophytes) is presented in the Table 2.

The most abundant and frequent mollusc species in the Curonian Lagoon were *R. balthica* (from 2 to 47%), *V. piscinalis* (from 5 to 70%), *P. corneus* (from 2 to 33%), *L. stagnalis* (from 1 to 24%), *P. planorbis* (from 2 to 44%) with different occurrence in biotopes.

Faunistic similarity was the highest (more than 50%) among such biotopes as sand-plant bottom, pondgrass and reedmace, combined into one cluster (B5, B7, B8; compare Fig. 2). These biotopes were inhabited mostly by genera *Acroloxus*, *Anisus*, *Lymnaea*, *Physa, Planorbarius*, and *Stagnicola*.

The second cluster of higest similarity includes the gastropod fauna of sand, sand-mud and sand-clay bottoms (B1, B2, B3), which were colonized by genera *Anisus*, *Bithynia*, *Lymnaea*, *Planorbarius*, and *Valvata*. The least similarity is between sand-stones bottom (B4) and other biotopes (less than 20%). This type of bottom has features like a breaker littoral, and is inhabited only by molluscs adapted to influence of water waves and drift from a substrate. Thus this type of biotope is extreme for most of the gastropods. The prevailing species on sand-stones bottom were *V. viviparus*, found only in this biotope, and *R. ampla*. Due to the streamlined shape of their shell these snails are adapted to retention on the substrate. For instance, the aperture ratio of the *R. ampla* shell depends on the impact of water wave strength in the habitat (Fig. 3).

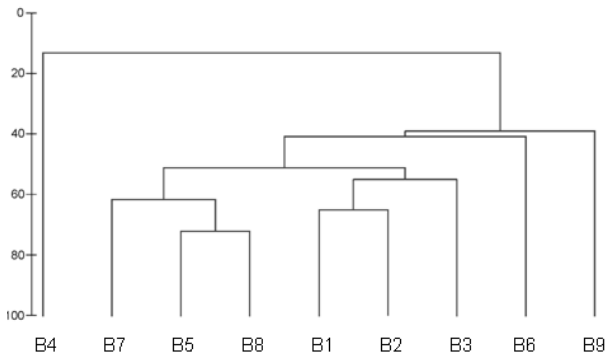

Fig. 2. Cluster-analysis of gastropod communities on the basis of Bray-Curtis index (presence/absence of species). Biotopes 1–9: see Table 2.

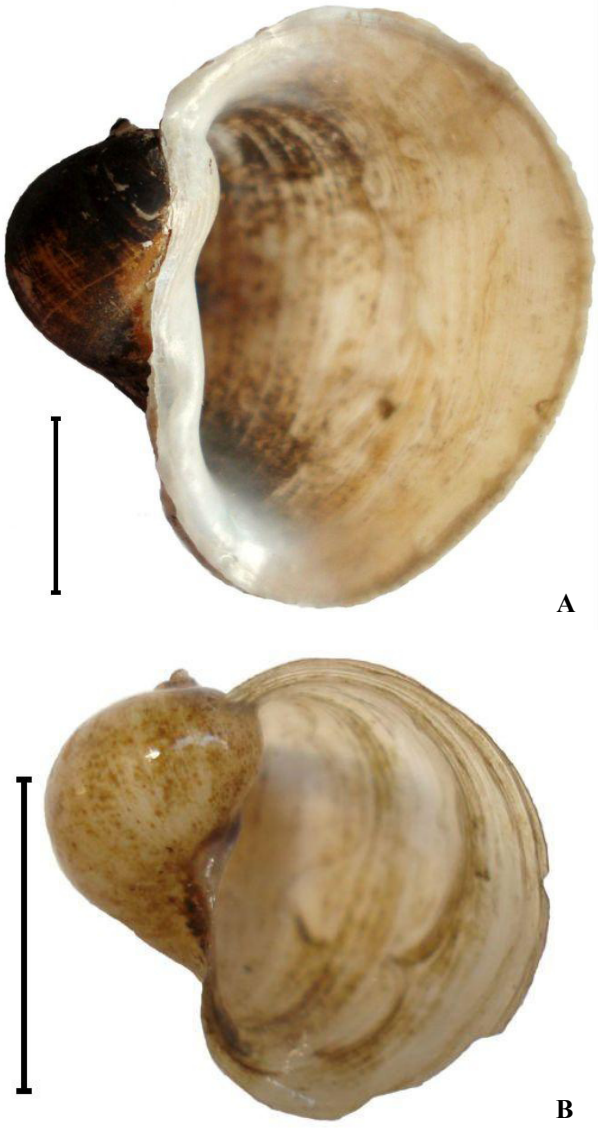

Fig. 3. Shell morphology of *R. ampla* from sand-stones substrate of breaker littoral (A) and from sand bottom, sheltered by reed-zones (B). Date of collection: 24 Jun 2010, site 8 (A), 31 Jul 2010, site 5 (B). Scale bar is 1 cm. (Photos by D. Filippenko).

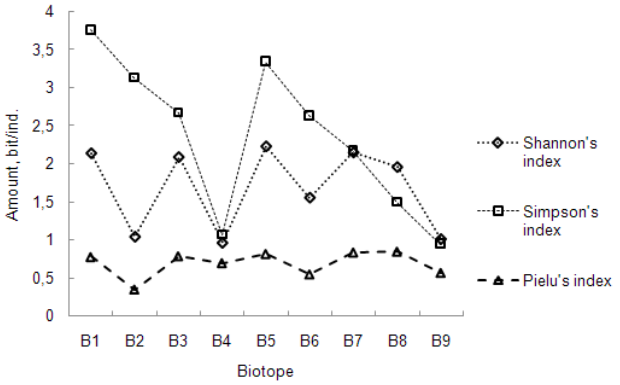

Fig. 4. Indexes characterising mollusc communities in the coastal biotopes of the Curonian Lagoon.

Complexes of species in every biotope are characterized by 3 indexes: Shannon's index of diversity; Simpson's index of species richness and the Pielou's index of uniformity (Fig. 4). These indexes depend on the number of species and their relation in the community. Shannon's index indicates the highest diversity of species in sand (H = 2.13), sand-clay (H = 2.08), sand-plant (H = 2.22) substrates and on pondgrass (H = 2,14), including the biggest number of species (from 14 to 19 species). Simpson's index of species richness also occurs in these same biotopes and additionally on sand-mud bottom. Maximum indexes characterize sand (S = 3.76), sand-mud (S = 3.13) and sand-plant (S = 3.34) substrates. Lower indexes characterize phytophilous communities of molluscs represented on three zones of aquatic macrophytes (reed, reedmace, pondgrass). The lowest indexes are assigned to sand-stones substrate and hornwort habitat including 4 and 6 species.

Pielou's index correlates with dominance of some species in the community. The lowest values for this index are calculated for sand-mud bottom (E = 0.34; biotope B2) because of *V. piscinalis* prevalence with occurrence to 70%, and *R. balthica* dominance on reed (E = 0.54; B6, occurrence to 55%) and on hornwort (E = 0.56; B9, occurrence to 47%). This is in spite of the fact that most of the gastropods species were found in these biotopes.

Discussion

Our study showed 34 gastropod species distributed in coastal biotopes of the Curonian Lagoon. Obtained data revealed higher mollusc diversity in littoral biotopes in comparison with open areas (Bubinas & Vaitonis 2005, Rudinskaja 2004). There are three species first recorded in Kaliningrad region: *A. rossicus*, *S. fuscus*, and *V. piscinalis antiqua* (Fig. 5). Four gastropods are regionally red-listed species: *G. albus*, *A. vorticulus*, *C. riparius*, and *P. carinatus* (Filippenko 2010).

Gastropod communities in the littoral zone of the Curonian Lagoon are not uniform. The reed-zone along the shore in the lagoon functions as a barrier and creates shallow water habitats ("bays") (depth range is 0-1,5 m) with slow-moving and warmer water, where maximum gastropod species concentrate. Naked littoral with fast increasing depth is almost completely uninhabited by littoral groups of gastropods. There are many additional factors like hydrological and hydrochemical features of the water body, salinity, combinations of substrate, which affect of molluscs fauna and define trophical and reproductive strategy of species (Chertoprud & Udalov 1996).

Emergent plants (reed, reedmace) include more suitable local habitats for many gastropod molluscs, because strengthening tissue of macrophyte stems create hard substrate for snails, while submerged plants (hornwort) with flexible shoots do not provide conditions for a small gastropods' holdfast and are inhabited only by large (*P. corneus*) and medium-sized (*R. balthica, P. planorbis*) gastropods, two of latter have phytophage-grazer strategy and are abundant in biotope 9.

Gastropods species found in the Curonian Lagoon fall into three basic trophic groups: phytophages (56%), detritus consumers (31%) and polyphages (13%). Taking into account the absence of highly specialised feeding strategies among these molluscs, the majority of species can be considered as polyphage, however with a dominance of detritophagous strategy at the expense of sediment grazers or similar feeding types (Bithyniidae, Valvatidae, Vivipa-

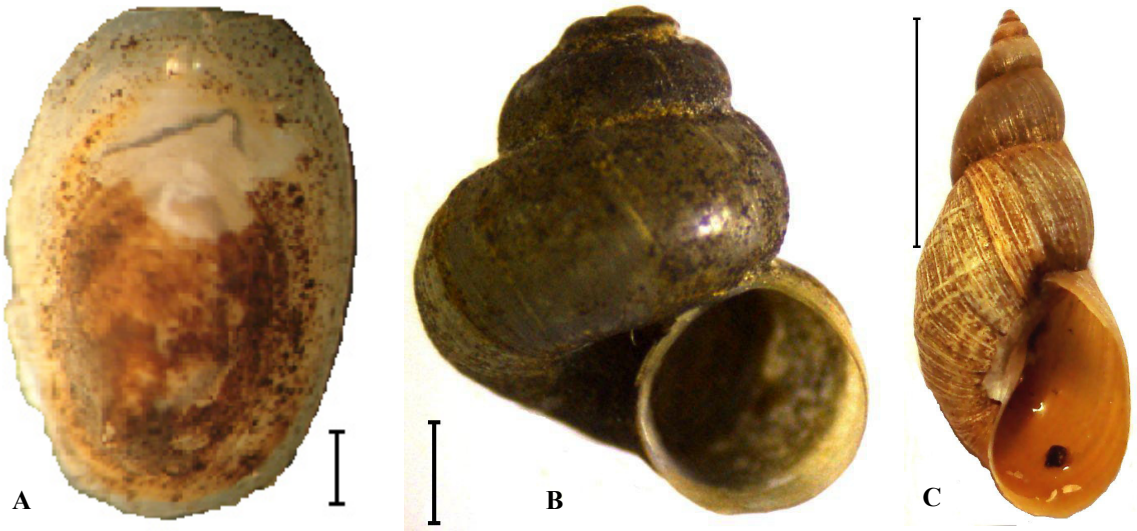

Fig. 5. Shells of gastropods collected for the first time in the Kaliningrad region: **A** – *A. rossicus* (found on reed, site 5); **B** – *V. piscinalis antiqua* (found on sand-mud bottom, site 6); **C** – *S. fuscus* (found on sand bottom). Date of collection: 26 Jun 2011. Scale bar is 1 mm (A, B); 1 cm (C) (Photos by D. Filippenko).

ridae and Physidae). There is also a dominance of phytophagy by pulmonate gastropods due to their grazer feeding strategy (Lymnaeidae, Acroloxidae and Planorbidae). Valvatidae are abundant on sand-mud soils due to their sediment feeding type. They have more than 70% detritus in their diet (Tsikhon-Lukanina et al. 1998). Large pulmonate snails like *P. corneus, L. stagnalis, L. fragilis* have food of plant and animal origin in their diet. The latter food source represents up to 20% of diet (Dillon 2000). These snails were found in almost all the biotopes. Small species and juvenile stages of molluscs are presented in phytophilous communities and inhabit aquatic plants more often than open bottom. Thus, biotope preference of gastropods is defined by feeding strategy of species, the necessity to remain attached to the substrate surface for adult snails and for juvenile stages development.

Faunistic similarity reaches up to 60%, when comparing our data on the southern coastal area gastropod species of the Curonian Lagoon with data on the northern Lithuanian part (Zettler & Daunys 2007). There are *A. lacustris*, *A. vortex*, *B. contortus*, *B. leachii, B. tentaculata*, *C. riparius, G. albus*, *L. stagnalis*, *P. corneus*, *P. carinatus*, *P. fontinalis*, *P. planorbis*, *R. auricularia*, *R. balthica*, *S. corvus*, *S. palustris*, *V. cristata*, *V. contectus*, *V. piscinalis*, *V. viviparus* species found distributed both in southern and in northern littoral of the Curonian Lagoon. In the southern area we did not find molluscs *Bithynia troschelii* (Paasch, 1842), *Marstoniopsis schtoltzi* (A. Schmidt, 1856), *Lithoglyphus naticoides* (C. Pfeiffer, 1828), *Theodoxus fluviatilis* (Linneaeus, 1758), and *Myxas glutinosa* (Müller, 1774), collected from northern part (Zettler at al. 2005).

The Curonian Lagoon, the largest coastal lagoon in the Baltic Sea, is an enclosed shallow water body, which has a narrow connection to the Baltic Sea in the north and is exposed to the freshwater discharge of the Neman River in its central part. The gastropod fauna includes freshwater only species and water exchange with the Baltic Sea and marine water inflow influences insignificantly on gastropod fauna of the south area of the Curonian Lagoon. This community is composed of 15% Holarctic species, 30% of Palaearctic species, 41% of European molluscs and 12% of European-West Siberian snails.

Conclusion

The recent study of the gastropod mollusc fauna in the coastal waters of the Curonian Lagoon revealed 34 species which belong to two subclasses, 4 orders, 7 families and 15 genera. The fauna is represented by a typical central European species complex of freshwater gastropods. Despite the fact that the Curonian Lagoon is a shallow water bay of the Baltic Sea, the high level of desalination determines freshwater conditions. A salinity gradient that influences gastropod fauna structure and species distribution in coastal waters is absent. The maximum number of gastropod species was found on sand, sand-mud bottom and reed zones. Molluscs' biotope preference is defined by feeding strategy of the species, the need for conditions that allow the organism to remain on the substrate and use for egg mass and juvenile stages development. The majority of littoral biotopes created in shallow water conditions and those sheltered by aquatic plants are more similar in gastropod species distribution and colonization, compared to sand-stones substrate inhabited only by species adapted to breaker littoral water conditions.

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