Biologia, Bratislava, **59**/2: 159—163, 2004

Factors affecting snail (Gastropoda) community structure in the upper course of the Warta river (Poland)

Małgorzata STRZELEC & Anna KRÓLCZYK

University of Silesia, Department of Hydrobiology, ul. Bankowa 9, PL–40007 Katowice, Poland; e-mail: strzelec@us.edu.pl, krolczyk@us.edu.pl

STRZELEC, M. & KRÓLCZYK, A., Factors affecting snail (Gastropoda) community structure in the upper course of the Warta river (Poland). Biologia, Bratislava, **59:** 159—163, 2004; ISSN 0006-3088.

The impacts of bottom sediments, water flow and macrophytes diversity on gastropod fauna in the Warta river were investigated. Fourteen gastropod species were found. *B. tentaculata, L. stagnalis, R. peregra* and *S. palustris* occurred abundantly, but other species only rarely and in small numbers. Their presence was determined mainly by bottom sediment type. An increase in flow velocity produces a statistically significant decrease in species number and density. Vegetation diversity was not reflected in gastropod species richness, except in the case of *E. canadensis*, which in some places was the only site of snail occurrence in the river.

Key words: Gastropoda, river, vegetation, water flow, bottom sediments, Poland.

Introduction

The riverine environment consists of patches and habitats linked by diverse process and supporting highly complex communities (MALMQVIST, 2002). Their distribution is governed by ecological factors, which act differently in diverse habitats. The fluctuation in water depth both temporal and spatial, different shape of river bed, varying current velocity, diversity of mostly allochtonic sediments and the scarcity of vegetation make the life of most animals extremely difficult. According to MALMQVIST (2002): "the local community structure can be seen as the result of continuous sorting processes. . . ". In spite of difficulties the river fauna is quite rich, what refers to the gastropods as well (MICHALIK-KUCHARZ et al., 2000). According to DILLON (2000) the snail species seem to segregate in distinct communities on different bottom types and along the river bed.

The concept of a river continuum (VANNOTE et al., 1980; MINSHALL et al., 1985) defines the increase in number of species down-stream from springs to the middle course as a result of environmental specialization of animals living in rivers. The distribution of gastropod species in rivers is specific, in spite of the fact that many of them are tolerant to most physicochemical water parameters and their occurrence is affected by the quality of bottom sediments and vegetation abundance.

The aim of the present study is the recognition of qualitative and quantitative differentiation of gastropod fauna in the upper section of the Warta river and of the factors influencing their communities' structure.

Table 1. The macrovegetation and sediments on study sites.

	Study sites							
Sediments	1 Sand-mud	2 Mud	3 Sand with detritus	4 Sand with detritus	5 Sand-mud	6 Mud	7 Sand-mud	8 Sand-mud
Plant species								
Polygonum amphibium L.			X					
Ceratophyllum demersum L.	X		X					
Sagittaria sagittifolia L.			X					
Alisma plantago-aquatica L.			X					
Hydrocharis morsus-ranae L.	X							
Elodea canadensis Rich. in Michx.			X		X	X	X	X
Potamogeton perfoliatus L.	X						X	X
Potamogeton natans L.							X	X
Glyceria maxima (Hartm.) Holmb.						X	X	
Spirodela polyrhiza (L.) Schleid.	X		X					X
Lemna minor L.	X		X					X
Species number:	5	0	7	0	1	2	4	5

Material and methods

The river Warta is the longest right-bank tributary of the Odra river. It is a typical lowland river with a very small slope and fluctuating water level. The present study examines the upper section of this river (51°04′ N, 19°10′ E), flowing in the extensively pine forested valley, unchanneled, meandering, with many old-beds, formed as the result of meander cut-off. The maximum bed width was 60 m, and the water depth 1.5 m. The study sites in the river were selected according to the quality of bottom sediments, the diversity and abundance of macrovegetation and flow-rates (Tab. 1).

The water flows with a velocity of 0.1 m s^{-1} (site 2) to 1.5 m s^{-1} (site 4).

Materials were sampled from eight study sites in the period from April to September 1998. Eight samples were taken, each from 1 m^2 area. The gastropods were gathered by hand from the live and dead plants, stones and submerged objects and the sediments were sieved using a sieve-mesh of 0.5 mm. Only living specimens were considered.

The taxonomy and nomenclature of Gastropoda are after Glöer & Meier-Brook (1998). Specimens of *Stagnicola palustris* and *S. corvus* were identified anatomically. In the community analysis the dominance and constancy indices were applied. In consequence the snail species were divided into two classes in relation to each index, so that each species belongs to one of four classes. This method (after Dobrowolski, 1963) was applied in all our previous papers, so that the obtained results are comparable.

The species diversity was calculated according to Simpson's equation. The dominance classes are: d – < 5% individuals in the collection and D – > 5% individuals. The constancy classes are: c – species found in less than 50% of samples; C – species found in 50% samples or more.

Correlations between flow-rate and the number of species and specimens were calculated using Pearson's correlation coefficient r. Faunistic similarity (d_t) was calculated in terms of taxonomic distance, used by construction of the dendrite.

Physicochemical water analysis was carried out using conventional methods.

Results

In total, 2,581 living specimens, belonging to 14 snail species were sampled during the study period.

The most varied snail community occurred on a sand-muddy bottom (11 species) and on the sand bottom covered with detritus (10 species). Faunal poverty was characteristic of muddy bottom, where only eight species were found.

The greatest species diversity (according to Simpson's index S) was observed at sites with sandy bottom with a layer of detritus ($S = 0.79$), and a considerably smaller one on the sand-muddy and muddy bottom ($S = 0.47$ and $S = 0.48$, respectively).

The majority of the specimens were sampled on a sand-muddy bottom (76.3% of collection), and the fewest on the sand with detritus (7.1%).

The investigations indicated, that together with an increase in flow-velocity, a statistically significant decrease in snail species number ($r =$

Table 2. Constancy (*C*) and dominance (*D*) structure of Gastropoda communities in the upper course of the Warta river.

Species	Whole material	Sand-mud	Sediments		Occurence of *E. canadensis*	
			Mud	Sand with detritus	With	Without
Valvata cristata (O.F. Müller, 1774)	*Cd*	–	–	*cd*	*Cd*	–
Valvata piscinalis (O.F. Müller, 1774)	*Cd*	*cd*	*cd*	*cD*	*Cd*	–
Bithynia tentaculata (L., 1758)	*CD*	*cD*	*cD*	*cD*	*CD*	*cd*
Physa fontinalis (L., 1758)	*Cd*	*cd*	-	*cd*	*Cd*	-
Lymnaea stagnalis (L., 1758)	*CD*	*cD*	*cd*	*cD*	*CD*	*cD*
Stagnicola palustris (O.F. Müller, 1774)	*CD*	*cD*	*cD*	–	*CD*	*cD*
Stagnicola corvus (Gmelin, 1791)	*Cd*	*cd*	–	–	*Cd*	–
Radix peregra (O.F. Müller, 1774)	*CD*	*CD*	*cd*	*cD*	*CD*	*cD*
Planorbis planorbis (L., 1758)	*Cd*	*cd*	–	–	*Cd*	–
Anisus vortex (L., 1758)	*Cd*	*cd*	–	*cD*	*Cd*	–
Gyraulus albus (O.F. Müller, 1774)	*Cd*	*cd*	*cd*	*cd*	*Cd*	–
Segmentina nitida (O.F. Müller, 1774)	*Cd*	–	*cd*	–	*Cd*	–
Planorbarius corneus (L., 1758)	*Cd*	*cd*	*cd*	*cd*	*Cd*	*cd*
Ancylus fluviatilis (O.F. Müller, 1774)	*Cd*	–	–	*cD*	*Cd*	*CD*
Number of species:	14	11	8	10	14	6

Key: Dominance classes: *d* – < 5% individuals, *D* – > 5% individuals in the collection; constancy classes: *c* – species found in less than 50% of samples, *C* – species found in 50% of samples.

-0.36, $P < 0.001$) and specimens number ($r = -0.23$, $P < 0.05$) occurred.

Taking into account the constancy and dominance of the sampled snail species, *Bithynia tentaculata, Lymnaea stagnalis, Radix peregra and Stagnicola palustris* belong to the class *cD*. On other kinds of substrate these species were different: on the sand-muddy bottom *R. peregra* belonged to the *CD* class, on the mud bottom *R. peregra* and *L. stagnalis* – to *cd* and on a sandy bottom with detritus *S. palustris* was never found (Tab. 2).

The other 10 species represented the *cd* class (Tab. 2) and their presence was related to specific microhabitats, e.g. to the detritus layer on the sandy bottom. They live mostly on macrophytes and were found mainly in quiet places with abundant vegetation, as well as on specific substrata, e.g. stones. Some of these species are adapted to survive considerable fluctuations in water level. In total, the small, rare species formed 6.3% of the total collection.

The conditions of local habitats play an essential role in gastropod communities' differentiation. The greatest diversity was found in quiet, slowly flowing river sections, where the flow-velocity was 0.3–0.5 m s^{-1}, on a sand-muddy bottom with *Elodea canadensis*, sometimes with other macrophytes. On particular sites with *E. canadensis* 5–10 snail species were sampled, at densities of 12 to 193 individuals per 1 m^2, and with a diversity index $S = 0.22$. Two final values are the result of a mass occurrence of *R. peregra*. More than 98% of collected snails were found in habitats with *E. canadensis*.

In the upper section of the Warta river two characteristic snail communities were identified (Fig. 1). The first consists of two subgroups: one including sites 1 and 8, of sand-muddy bottom and poor vegetation. On both sites the dominant snail species was *R. peregra*, which was the only species on the 1st site, and very abundant (83.6% of collection) on site 8, co-occurring with eight other species.

The second subgroup includes the sites 3 and 5, of a sandy bottom covered with detritus or mud respectively. On both sites *E. canadensis* was present, on the site 5 as the only plant species. The dominant snail species were *R. peregra* (33.5% of collection from the site 3 and 52.1% from the site 5) and *B. tentaculata* (25.4 and 27.1%, respectively).

The second community consisted of the sites 6 and 7, of different bottom sediments. The common features are the layer of mud, the presence of *E. canadensis* and *Glyceria maxima* on both sites, and the dominance of *B. tentaculata.*

The distinctness of sites 2 and 4 is the result of the absence of macrophytes and the thick layer of mud at site 2 and the greatest flow-velocity at

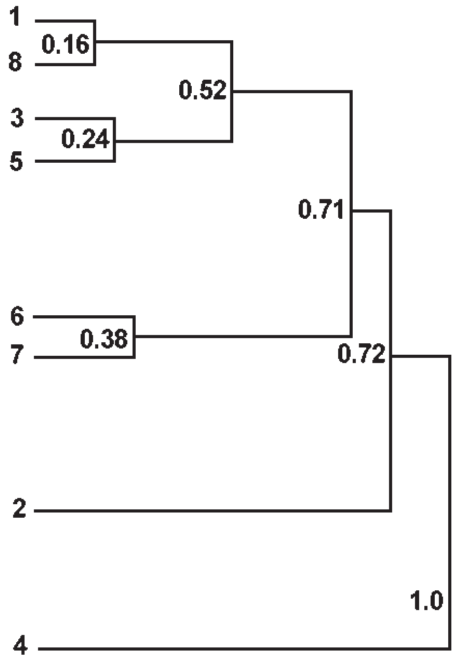

Fig. 1. Dendrite of taxonomic distances between particular communities. 1–8 – numbers of sites.

site 4. The dominant species at site 2 was *S. palustris* (57.9% of collection) and at 4 *Ancylus fluviatilis* occurred abundantly, as the only species.

Discussion

The great variety of habitats in rivers is the cause of the concentration of snails in some sites only, where they meet the conditions for life. These conditions in rivers are the result of the physicochemical characteristics of water, flow-velocity, type of bottom sediments in addition to the diversity and abundance of macrovegetation. Crowl & Schnell (1990) found that the environmental conditions in a stream, mainly flow-velocity, affect snail density in particular places. In our investigations this is confirmed by the statistically significant negative correlation between flow-velocity and the density of snails in the Warta river.

Only a few snail species can be considered inhabitants of lotic conditions (Dillon, 2000). In most cases their occurrence is limited to still water. In the Warta river, the upper section with the smallest flow-velocity (to 0.3 m s^{-1}) contained the greatest snail species richness (8–10 species) confirming the importance of this factor for snail communities.

The type of bottom sediment is equally important in this respect. The impact of various bottom sediments on freshwater snail diversity has been known for some time (Strzelec, 1993; Chertoprud & Udalov, 1996), as has the preferences of particular species to certain bottom types (Strzelec, 1993; Collier et al., 1998; Dillon, 2000). Snail density is negatively correlated with a sandy and muddy bottom. The most suitable substrate for snails in rivers, according to previous studies, is a sandy bottom covered with a thin layer of organic silt. The richest snail fauna was found on this kind of bottom many times (Strzelec, 1993; Michalik-Kucharz et al., 2000). Similar preferences were also observed in the Warta river.

Specific microhabitats such as the individual stones on the sandy bottom covered with detritus are sometimes places of rare species occurrence, e.g. of *A. fluviatilis* in present study. Its occurrence is usually limited to rocky and lotic habitats (Calow, 1973), or to the stony bottom. Dillon (2000) is of the opinion that it is a litophilous rather than rheophilous species. In the Warta river *A. fluviatilis* was collected both in places of quick water flow (1.5 m s^{-1}) and places with a flow of 0.5 m s^{-1}. It inhabited the sides of stones covered with algae, as in other habitats (Calow, 1973).

The relationship of macrovegetation diversity and abundance to bottom sediments has been know for some time (Bailey, 1988). In our investigations the most diverse vegetation was observed on a sand-muddy bottom. Brönmark (1985) and Costil & Clement (1996) found that the richness of snail fauna in stagnant waters was significantly correlated with diversity of plant assemblages. Lodge & Kelly (1985) showed the positive influence of macrophytes abundance on the number of freshwater snails. However, Patzner & Isarch (1999) have not observed such dependence.

The positive impact of macrophytes lies in the slower water flow in vegetated places, consequently causing an increase in the number of gastropod species. This relationship is not even to observe. E.g. in the upper section of the Warta river the number of snail species was not correlated with vegetation richness. On study site 1, where only *R. peregra* was found, these plant species occurred, which are often inhabited by many snail species. Plants such as *Ceratophyllum demersum, Hydrocharis morsus-ranae, Potamogeton natans, Lemna minor* and *Spirodela polyrhiza* were present on this site. However, in habitats where only *E.*

canadensis occurred, eight snail species were found.

According to VINCENT et al. (1991) the number of snail species is correlated not with diversity but with biomass of macrophytes. CALOW (1973) and COSTIL & CLEMENT (1996) stressed the role of plant morphology: species with dissected leaves are usually inhabited by the richest snail fauna.

In the habitats studied the biggest biomass was reached by *E. canadensis*, which in some places covers the great part of the river bed. Its persistence, and great amounts of periphyton and detritus connected with it, is the cause of the abundance and diversity of the snail community occurring on this plant. Gastropods find here shelter against harmful environmental factors and rich food resources.

References

BAILEY, R. 1988. Correlation between species richness and exposure: Freshwater molluscs and macrophytes. Hydrobiologia **162:** 183–191.

BRÖNMARK, C. 1985. Interactions between macrophytes, epiphytes and herbivores an experimental approach. Oikos **45:** 26–30.

CALOW, P. 1973. Field observations and laboratory experiments on the general food requirements of two species of freshwater snails *Planorbis contortus* and *Ancylus fluviatilis*. Proc. Malacol. Soc. Lond. **40:** 483–489.

CHERTOPRUD, M. V. & UDALOV, A. A. 1996. Ecological groups of freshwater Gastropods in the central part of European Russia. The influence of the type water body and substrate. Zool. Zh. **75:** 644–676.

COLLIER, K. J., WILLCOCK, R. J. & MEREDITH, A. S. 1998. Influence of substrate type and physicochemical conditions on macroinvertebrate faunas and biotic indices of some lowland Waikato, New Zealand, streams. N. Z. J. Mar. Freshwat. Res. **32:** 1–19.

COSTIL, K. & CLEMENT, B. 1996. Relationship between freshwater gastropods and plant communities reflecting various trophic levels. Hydrobiologia **321:** 7–16.

CROWL, A. T. & SCHNELL, C. D. 1990. Factors determining population density and size of a freshwater snail in streams effects of spatial scale. Oikos **59:** 359–367.

DILLON, R. T., Jr. 2000. The ecology of freshwater molluscs. Cambridge University Press, Cambridge, 509 pp.

DOBROWOLSKI, K. 1963. Próba analizy pojęcia "rzadki gatunek". Ekol. Pol. B **3:** 207–212.

GLÖER, P. & MEIER-BROOK, C. 1998. Süsswassermollusken. Deutscher Jugendbund für Naturbeobachtung, Hamburg, 136 pp.

LODGE, D. M. & KELLY, P. 1985. Habit disturbance and the stability of freshwater gastropods populations. Oecologia **68:** 111–117.

MALMQVIST, B. 2002. Aquatic invertebrates in riverine landscapes. Freshwat. Biol. **47:** 679–694.

MICHALIK-KUCHARZ, A., STRZELEC, M. & SERAFIŃSKI, W. 2000. Malacofauna of rivers in Upper Silesia (Southern Poland). Malak. Abh. **20:** 101-109.

MINSHALL, G., PETERSON, R. & NIMZ, C. 1985. Species richness in streams of different size from the same drainage basin. Amer. Natur. **125:** 16–38.

PATZNER, R. A. & ISARCH, E. G. 1999. The water molluscs of the "Leopolds-Kroner Teich" a pond in the City of Salzburg, Austria (Gastropoda et Bivalvia). Malak. Abh. **19:** 273–279.

STRZELEC, M. 1993. Ślimaki (Gastropoda) antropogenicznych środowisk wodnych Wyżyny Śląskiej [Snails (Gastropoda) of anthropogenic water environments in Silesian Upland]. Prace Naukowe U.Śl. 1358, Katowice, 104 pp.

VANNOTE, R., MINSHALL, G., CUMMINNS, K., SEDELL, J. & CUSHING, C. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. **37:** 130–137.

VINCENT, B., RIOUX, H. & HARVEY, M. 1991. Factor affecting the structure of epiphytic gastropod communities in St. Lawrance River (Quebec, Canada). Hydrobiologia **220:** 57–72.

Received December 13, 2002
Accepted April 10, 2003