Malacologica Bohemoslovaca (2005), 4: 41–47
ISSN 1336-6939

The long-term transformations of Gastropod communities in dam-reservoirs of Upper Silesia (Southern Poland)

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STRZELEC M., SPYRA A., KRODKIEWSKA M. & SERAFIŃSKI W., 2005: The long-term transformations of Gastropod communities in dam-reservoirs of Upper Silesia (Southern Poland). – Malacologica Bohemoslovaca, 4: 41–47. Online serial at <http://mollusca.sav.sk> 19-Dec-2005.

Studies on snail communities in nine dam reservoirs in Upper Silesia were carried out in two periods: 1980–90 and 1995–2004. The observed changes referred to domination patterns. There was found that after introduction of two alien gastropods *Physella acuta* and *Potamopyrgus antipodarum* they became the dominants in four reservoirs by the simultaneous percentage decrease of earlier native dominants. The species density decreased in second study period in five reservoirs, mainly in effect of alien species invasion, but in some cases in consequence of various human interventions. Taking into account the whole collection the commonest species in the first study period were *Radix peregra* and *Planorbis planorbis*, while *Radix peregra*, *Potamopyrgus antipodarum*, and *Physella acuta* in the second. Inexplicable is however the mass occurrence of *Valvata piscinalis* in Żywiecki dam reservoir, because in whole Soutern Poland it is one of rarest snail species both in rivers and stagnant water bodies.

Introduction

The dam reservoirs originate by the damming of riverbed with different earth or concrete dams, which cause the water over-flow on adjacent area. It can take place in river valley if the borders are sufficiently high or in specially excavated deep pits. The characteristic feature of all dam reservoirs is the permanent water flow, periodically retarded or even stopped when necessary. The regulation of water flow is the cause of water-level fluctuations and of temporary exposure of bottom area, normally flooded. It results in the lack of permanent biocoenoses in the shallow littoral of many reservoirs.

Characteristic for these reservoirs is the distribution of grain size in bottom sediments along their length: the greatest grains are deposited in upper part and the smallest by the dam. It affects in great measure the distribution of benthonic plants and animals in particular zones.

The serious difficulty for organism living in dam reservoirs is the repeated water replacement, causing that its retention time can last no longer than several months. Thus the water differs in succeeding periods, according to the conditions in catchment area. The periodical or irregular fluctuation in water level affect negatively the formation of littoral zone, what is then the cause of poor vegetation development in it.

Water retention in reservoirs does induce the physical, chemical and biological changes in the stored water and in bottom sediments. The chemical composition of water in reservoirs can differ from that of the inflows (BERGCAMP et al. 2000, STRZELEC et al. 1999). Some reservoirs require more than 20 years developing stable condition. Eutrophication of dam reservoirs may be a result of great influxes of organic loads and nutrients, what is many cases in the consequence of anthropogenic influences in the catchment (BERGCAMP et al. 2000), and it is just the situation in the region of our studies.

As yet the impact of environmental specificity of dam reservoirs on living organisms was studied in single reservoirs of southern Poland in relation to some plant and animal communities (particularly fish).

Our materials collected during two decades made possible the comparison of gastropod communities from reservoirs of various sizes and different utilization ways as well as the statement of changes, which occurred during twenty years. It is noteworthy to say that from late 1980s the industry recession in southern Poland (mainly in Upper Silesia and adjacent area) resulted in improvement of environmental conditions particularly in reduction of water pollution. One of the aims of this study is therefore the estimation of the importance of these changes for the snails in dam reservoirs.

Study area and study sites

The Upper Silesia is a southern area of Poland, where the natural lakes are absent, while the rivers of various size and types are numerous. Most of them are uncontrolled, what results in frequent floods of various consequences. As the protection against floods the numerous retention reservoirs of different size and volume were built during two last centuries. On our study area between Odra and upper Wisła (49°30'–50°30'N, 18°-19°30'E), which is one of most industrialized regions in Poland, more than 30 dam reservoirs were constructed. Some of them play significant role in energetics. All studied reservoirs are situated on 300–400 m a.s.l.

Among 9 reservoirs investigated by us (their characteristics are given in Table 1) some serve the industrial purposes, other the flood control, communal water supply and recreation, but most are of multipurpose type.

According to the surface area only one of them may be classified as big (more than 1000 ha), six are of medium size (100–1000 ha) and two are small (below 100 ha). All are limnic, with water exchange 2–4 times per year.

Table 1. General characteristics of investigated dam reservoirs. Main task: S – water supply, R – recreation, L – flood control, E – electricity generation. Remarks: Rybnik – artificially elevated water temperature; Gzel – on montane river; Przeczyce – leaking bottom.

Reservoir	On river	Year of construction	Main task	Area in ha	Max. depth	Years of investigations
Rybnik	Ruda	1972	E+R+L	470	11	1984, 1995
Gzel	Gzel	1974	R	30	5	1982, 1995
Żywiec	Soła	1967	R+L+S	1060	21	1987, 1998
Paprocany	Gostynia	1870	R+L	130	2	1984, 2004
Kozłowa Góra	Brynica	1937	S+L	580	6	1986, 1999
Przeczyce	Czarna Przemsza	1963	S+L	510	11	1984, 1997
Poraj	Warta	1978	R+L	550	12	1980, 1997
Chechło	Chechło	1945	R	54	4	1980, 2001
Łąka	Pszczynka	1986	L+R+S	420	6	1992, 2004

Similarly as in majority of dam reservoirs the vegetation was poor and slightly diversified in both study periods. It resulted from frequent and considerable water level fluctuation, impeding the development of greater masses of water plants and reed swamps in effects of periodical bottom exposure in littoral zone. The number of plant species ranged in particular reservoirs from 5 to 22. Totally in all reservoirs 35 plant species have been found.

In comparison with other anthropogenic water bodies of the same region water in studied habitats was in study period of rather good quality (STRZELEC & SERAFIŃSKI 2004).

Material and methods

The investigations were carried out in nine dam reservoirs in Upper Silesia during two periods: the first in years 1980–1990 and the second in years 1995–2004. In the first study period 14 252 specimens, belonging to 24 gastropod species and in the second 13439 specimens from 24 species have been collected. Only living individuals were taken into account in order to avoid the including of dead shells of river species in collection. The snails were gathered from rush and water plants, bottom sediments and various submerged objects in the littoral zone of reservoirs to the depth of about 1 m. Individuals were identified morphologically and only doubtful specimens were checked anatomically too.

Most specimens were released after identification and only some of them (first of all the doubtful) preserved in alcohol. In all collections the domination patterns, diversity (by the use of Simpson's index) and the percentage similarities of snail communities were estimated.

Results

During both periods of investigations 25 species of freshwater snails were foud in nine dam-reservoirs. In particular habitats in the first period 6–19 species and in the second 8-20 species occurred (Tables 4 and 5). The snail species number is highly correlated with plant species richness ($r=0.94$, $t=7.18$, $p<0.001$), but not with area of the reservoir. Despite of small differences in total species number the species diversity in different study periods is significantly unlike in almost all reservoirs. In five reservoirs it increased, and in four decreased in the second period in comparison with the first one (Table 2). It seems, that the main cause of diversity decrease was the mass occurrence of single snail species, in the first place *P. antipodarum*. Impossible to explanation is the enormous increase in abundance of *Valvata piscinalis* in the second study period in Żywiecki reservoir, what caused the fivefold decrease of snail species diversity during 11 years. It is noteworthy to say that the decrease in species diversity is not always interrelated to decrease in species number.

Table 2. Values of Simpson's diversity index in different periods of investigation.

	Study period		
Dam reservoirs	First	Second	Mass appearance of
Rybnik	0.50	0.60	*P. antipodarum*, *Ph. acuta*
Gzel	0.80	0.52	*P. antipodarum*
Żywiec	0.81	0.09	*V. piscinalis*
Paprocany	0.55	0.46	*Ph. acuta*
Kozłowa Góra	0.59	0.77	
Przeczyce	0.80	0.75	
Poraj	0.59	0.81	
Chechło	0.81	0.84	
Łąka	0.87	0.40	*P. antipodarum*

The snail species number increased during study period in 4 reservoirs, among which three, namely Gzel, Przeczyce, and Chechło serve mainly recreational purposes, and Kozłowa Góra was in the late 1990s repaired and recultivated. The inflow of communal savages was reduced significantly, what over several years produced the enlargement of snail community composition to 20 species. The opposite effect was observed in Łąka dam reservoirs after its incorporation in communal water-supply system, when the number of snail species dropped from 19 in early 1990s to 7 in 2004. May be that in this case it was likewise the result of mass appearance of *P. antipodarum*, observed there from the beginning of recent century. Generally the species similarity between collections from two periods amounted to from 30% in Kozłowa Góra and Łąka to 73.3% in Gzel. It seems that the lesser environmental manipulations the greater communities similarity.

The more striking differences were found in relation to domination pattern in gastropods communities both in the whole collection and in particular reservoirs. As dominants were classified these species which contribute in the collection in at least 20% of the individuals sum. Taking into account the whole collection the dominants in the first study period were *R. peregra* and *P. planorbis*, whereas in the second *P. antipodarum* only. In particular reservoirs these changes were as shown in Table 3.

Table 3. Changes in domination in particular reservoirs in two study periods.

	Dominations in study period	
Reservoir	First	Second
Rybnik	*P. planorbis*	*P. antipodarum, Ph. acuta*
Gzel	*P. planorbis, A. vortex*	*P. antipodarum*
Żywiec	*R. peregra, G. albus*	*V. piscinalis*
Paprocany	*P. planorbis*	*Ph. acuta*
Kozłowa Góra	*L. stagnalis*	*R. peregra, P. planorbis*
Przeczyce	*L. stagnalis*	*G. albus, P. planorbis*
Poraj	*R. peregra*	*P. planorbis*
Chechło	*R. peregra*	*G. albus*
Łąka	*P. planorbis*	*P. antipodarum*

The changes in domination pattern caused that percentage similarity of snail communities in two study periods were very low. They amounted to in: Rybnik 0.03, Gzel 0.28, Żywiecki 0.09, Paprocany 0.14, Kozłowa Góra 0.56, Przeczyce 0.52, Poraj 0.44, Chechło 0.43, Łąka 0.28. However the percentage similarity of both total collections amounted to 0.50.

Comparing the commoness indexes of snail species in two study periods one may notice, that it increased only in two prossobranch species (*P. antipodarum* and *V. piscinalis*) and from among pulmonates only in the Physids. All other pulmonate snails, most common in the first study period, lost their high values of commoness index in the second (Fig. 1).

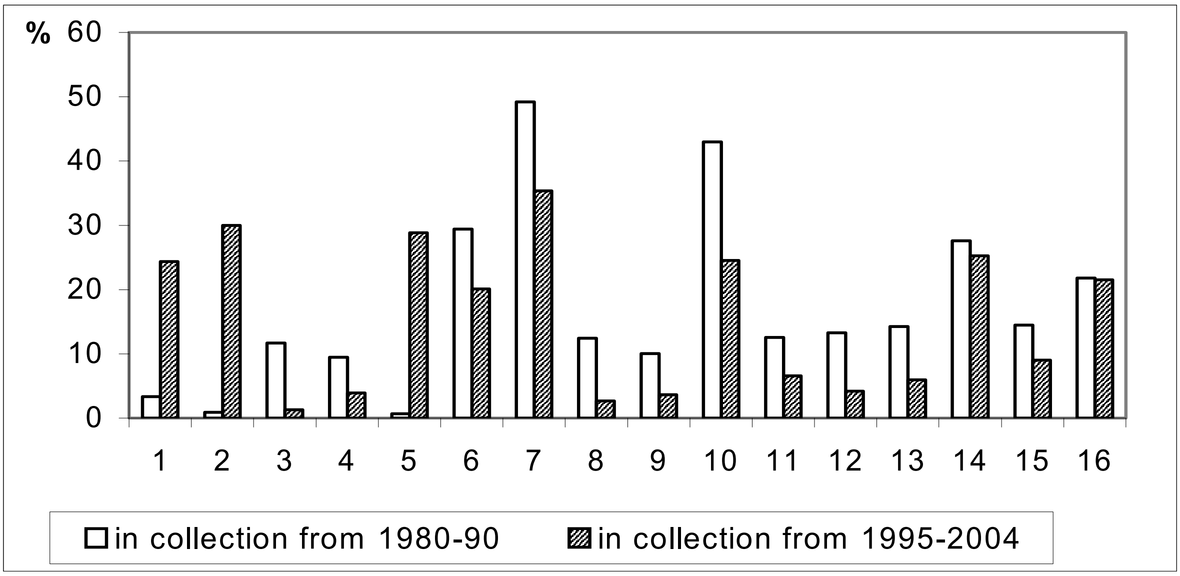

Fig. 1. Commoness index of 16 most common snail species in nine dam reservoirs. Explanations: 1 – *V. piscinalis*, 2 – *P.antipodarum*, 3 – *A. hypnorum*, 4 – *Ph. fontinalis*, 5 – *Ph. acuta*, 6 – *L. stagnalis*, 7 – *R. peregra*, 8 – *R. auricularia*, 9 – *G. truncatula*, 10 – *P. planorbis*, 11 – *A. spirorbis*, 12 – *A. vortex*, 13 – *B. contortus*, 14 – *G. albus*, 15 – *S. nitida*, 16 – *P. corneus*.

Discussion

Data concerning the qualitative and quantitative transformations of Gastropod communities in dam reservoirs with time are very scarce in malacological literature. Most publications refer to species composition and abundance of mollusc communities or particular species occurring in large dam reservoirs (e.g. PETR 1972, ARMITAGE 1977, HARMAN 1997, DVOŘÁK & BERAN 2004, BERAN 2005). In Poland the gastropods in these habitats were investigated chiefly together with other zoobenthos components or even only marginally treated (ZAĆWILICHOWSKA 1965a, b; KRYŹANEK 1979, 1991) or the studies refer to the malacofauna of single dam reservoirs in differently long time periods (JURKIEWICZ-KARNOWSKA 1998, 2001, STRZELEC 1999, 2000, STRZELEC & MICHALIK-KUCHARZ 2003).

The comprehensive studies of JURKIEWICZ-KARNOWSKA (1998, 2001) summarized the changes that appeared during 15 years in mollusc community inhabiting the lowland Zegrzyński dam reservoir situated near Warszawa on the Narew River. She has found that the snail species number in its littoral zone dropped in this period from 16 to 9, what she attributed to progressive eutrophication of the reservoir. Interesting is, that similarly as in our studies, the loss affected mainly the phytophilous snail species. The snail fauna of Zegrzyński dam reservoir differs from observed in Upper Silesia in the absence of some species dominated in reservoirs investigated by us, namely *P. planorbis*, *B. contortus, A. crista*, and *S. palustris*. Very likely it results merely from the size differences of studied water-bodies. Observed by JURKIEWICZ-KARNOWSKA (1998, 2001) decrease in species diversity during 15 years was similar to found in our investigations. Instead the great differences are between her results concerning the domination patterns in Zegrzyński reservoir and occurring in Upper–Silesian reservoirs. In Zegrzyński reservoir the permanent dominant was *V. viviparus*, completely absent in our study. *B. tentaculata,* species very rare in Upper-Silesian reservoirs, was the constant element in Zegrzyński reservoir. The last was dominated by Bivalves, particularly by *Dreissena polymorpha,* the abundance of which increased during study years (JURKIEWICZ-KARNOWSKA 2001). These molluscs were rare or even absent in Upper-Silesian reservoirs, investigated by us. Similar mussels domination observed KRYŹANEK (1991) in large Goczałkowice dam reservoirs (32 km^2 area) situated on upper Wisła in Upper Silesia. Among snails in first period of its existence most abundant were *L. stagnalis*, *Ph. fontinalis*, and *G. albus*. In early 1990s I. REMBECKA (materials unpublished) collected 20 snail species in its littoral, among which the most abundant on sites overgrown with water plants were *A. vortex*, *L. stagnalis*, *A. spirorbis*, and *P. planorbis*, whereas *R. peregra* dominated in stony littoral only. It is striking that two reservoirs of similar age and size, poor vegetation, almost the same kind of bottom sediments and eutrophication stage as Zegrzyński and Goczałkowice are, differ to so great measure in faunistic relation. For only distinct difference is the water retention time amounting to 15 days in Zegrzyński and 60–120 days in Goczałkowice.

We feel sure that the dam reservoirs, considering their environmental instability are interesting but unappreciated objects for hydrobiological investigation. They enable the estimation of the impacts of particular physical, chemical and biological factors on biocoenose as a whole in various stages of their development and on particular animal and plant species living in controlled conditions.

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Table 4. Domination, frequency and commoness of snail species in materials of first study period.

Snail species	Rybnik	Gzel	Żywiec	Paprocany	Kozłowa Góra	Przeczyce	Poraj	Chechło	Łąka	Frequency %	Domination %	Commoness index %
Viviparus contectus (Millet, 1813)				0.9					0.8	22.2	0.19	2.05
Valvata cristata O.F.Müller, 1774				4.6						11.1	0.50	2.35
Valvata piscinalis (O.F.Müller, 1774)			4.1						0.9	22.2	0.50	3.33
Potamopyrgus antipodarum (Gray, 1843)									0.7	11.1	0.1	0.93
Bithynia tentaculata (Linnaeus, 1758)									0.7	11.1	0.1	0.93
Aplexa hypnorum (Linnaeus, 1758)			15.8	0.6				10.5	0.8	44.4	3.1	11.69
Physa fontinalis (Linnaeus, 1758)		8.2	0.9		3.3				5.6	44.4	2.0	9.48
Physella acuta (Draparnaud, 1805)	0.1									11.1	0.01	0.70
Lymnaea stagnalis (Linnaeus, 1758)	2.4	6.5		7.7	7.1	31.4	19.0	1.5	11.1	88.8	9.74	29.40
Radix peregra (O.F.Müller, 1774)	5.4	2.4	27.1	1.3	60.3	16.3	71.6	34.2	16.0	100.0	24.25	29.24
Radix auricularia (Linnaeus, 1758)	0.7	1.7				0.9	1.0	0.1	0.5	66.7	2.32	12.44
Stagnicola corvus (Gmelin, 1791)		6.5					0.3			22.2	0.75	4.09
Stagnicola palustris (O.F.Müller, 1774)		2.1					0.5	13.8	0.4	44.4	1.87	9.10
Galba truncatula (O.F.Müller, 1774)	3.3		10.3	0.4				1.7	0.6	55.5	1.81	10.02
Planorbis planorbis (Linnaeus, 1758)	67.7	35.6		64.9	10.7	17.7	7.3		20.0	77.7	23.77	42.97
Anisus spirorbis (Linnaeus, 1758)			14.7			0.1		16.8	0.3	44.4	3.54	12.54
Anisus vortex (Linnaeus, 1758)	0.1	20.2				9.8			5.7	44.4	3.98	13.29
Bathyomphalus contortus (Linnaeus, 1758)				1.8	0.3	11.2		13.6	6.0	55.5	3.65	14.24
Gyraulus albus (O.F.Müller, 1774)	0.1	1.5	24.0	1.1	18.3	0.3	0.1	5.3	12.0	100.0	7.63	27.60
Gyraulus rossmaessleri (Auerswald, 1852)			3.1				0.1	1.9		33.3	0.57	4.34
Armiger crista (Linnaeus, 1758)		1.1					0.1			22.2	0.13	1.72
Segmentina nitida (O.F.Müller, 1774)	1.9	10.3		4.7		6.9		0.5	2.9	66.6	3.14	14.47
Planorbarius corneus (Linnaeus, 1758)	18.3	3.6		11.6		5.4	0.1	0.1	14.7	77.7	6.12	21.81
Acroloxus lacustris (Linnaeus, 1758)									0.3	11.1	0.03	0.61
N species	10	12	8	11	6	10	10	12	19			
N specimens	1068	1104	1617	1394	1460	1090	2337	3291	994			
Simpson's diversity index	0.50	0.80	0.81	0.55	0.59	0.80	0.59	0.81	0.87			

Table 5. Domination, frequency and commoness of snail species in materials of second study period.

Snail species	Rybnik	Gzel	Żywiec	Paprocany	Kozłowa Góra	Przeczyce	Poraj	Chechło	Łąka	Frequency %	Domination %	Commoness index %
Valvata cristata O.F.Müller, 1774					1.1					11.1	0.01	0.33
Valvata piscinalis (O.F.Müller, 1774)			95.5		0.2	0.31	0.2		0.1	55.5	10.9	24.37
Potamopyrgus antipodarum (Gray, 1843)	43.0	68.3		1.4					69.1	44.4	20.2	29.95
Bithynia tentaculata (Linnaeus, 1758)	4.2	6.4								22.2	1.2	5.11
Aplexa hypnorum (Linnaeus, 1758)					0.2			0.5		22.2	0.1	1.31
Physa fontinalis (Linnaeus, 1758)		1.1			4.9					22.2	0.7	3.94
Physella acuta (Draparnaud, 1805)	45.9			71.4	15.0			0.3	2.0	55.5	14.9	28.81
Lymnaea stagnalis (Linnaeus, 1758)		2.1		1.4	5.8	13.0	16.9	7.8	3.8	77.7	5.2	20.10
Radix peregra (O.F.Müller, 1774)	0.8	2.7	0.6	13.6	22.9	19.6	18.6	19.4	14.4	100.0	12.5	35.37
Radix auricularia (Linnaeus, 1758)		1.6				0.1		0.2		33.3	0.2	2.65
Stagnicola corvus (Gmelin, 1791)		1.1			0.1	0.4	19.3		0.7	55.5	2.4	11.54
Stagnicola palustris (O.F.Müller, 1774)		2.1			0.9	0.5	4.1	0.3		55.5	0.9	6.98
Galba truncatula (O.F.Müller, 1774)			0.1		0.4	0.1		2.1		44.4	0.3	3.65
Planorbis planorbis (Linnaeus, 1758)	1.5	2.1		5.7	20.3	29.1	22.6			66.6	9.0	24.53
Anisus spirorbis (Linnaeus, 1758)					2.4	0.1		9.3		33.3	1.3	6.61
Anisus vortex (Linnaeus, 1758)		6.4			0.7					22.2	0.8	4.21
Bathyomphalus contortus (Linnaeus, 1758)			0.1	1.4	3.8			1.8		44.4	0.8	5.96
Gyraulus albus (O.F.Müller, 1774)	0.4	0.5	3.7		5.3	32.8	1.0	30.3		77.7	8.2	25.25
Gyraulus rossmaessleri (Auerswald, 1852)		1.1			6.4					22.2	0.8	4.30
Armiger crista (Linnaeus, 1758)					2.7	0.1		4.7		33.3	0.8	5.16
Segmentina nitida (O.F.Müller, 1774)	0.3	1.1		0.7	0.1		0.4	8.4		66.6	1.2	9.02
Planorbarius corneus (Linnaeus, 1758)	0.2	2.1		4.4	0.3	4.2	16.7	9.3	9.9	88.8	5.2	21.49
Ferrissia clessiniana (Jickeli, 1802)	3.6	1.1								22.2	0.5	3.33
Acroloxus lacustris (Linnaeus, 1758)					0.9			0.2		22.2	0.1	1.49
N species	9	15	5	8	20	12	9	14	7			
N specimens	1893	674	1648	1240	2823	1739	854	1708	1360			
Simpson's diversity index	0.60	0.52	0.09	0.46	0.77	0.75	0.81	0.84	0.40			