THE SPECIES DIVERSITY OF FRESHWATER SNAILS (Gastropoda) IN DIFFERENTLY MANAGED FISH PONDS IN SOUTH-WESTERN POLAND

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Abstract

Spyra A., Serafiński W., Strzelec M.: The species diversity of freshwater snails (Gastropoda) in differently managed fishponds in south-western Poland. Ekológia (Bratislava), Vol. 26, No. 1, p. 83–89, 2007.

The present study, based on data from one protected and one normally exploited complex of fishponds, illustrates the impact of fish farming on the diversity of snail communities in farm ponds. The periodical drying up and moving of plants and mud are the causes of the decrease in gastropod species number in exploited ponds in comparison to protected ones (5–7 vs. 12–16 species, respectively). Similarly the plant diversity is much lesser in unprotected ponds.
Other environmental factors affect the snail communities to a lesser degree. Significant negative correlations exist between snail species number and total hardness and magnesium ion concentration in the water, as well as a positive correlation between snail species diversity and the number of plant species.

Key words: fishponds, freshwater snails, environmental factors

Introduction

Fishponds belong to the oldest anthropogenic water bodies. In Europe, the first fish farms were founded by the Romans as early as the 5th century B.P. (Bennett, 1971). In Poland, the oldest fishponds were created by Cystercian monks in the 14th century. The biggest of these fish farms were in Southern Poland, particularly in the southern part of Silesian Upland and in Oświęcim valley, and are still present today.

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The environment of fishponds can be difficult for their inhabitants. They are temporary water bodies, more or less regularly drained, chiefly in winter, and subject to various manipulations, that are advantageous to fish production but in most cases probably unfavourable for invertebrates. Such manipulations include periodical emptying and refilling, mud removal, destruction or moving of aquatic vegetation and rushes, fertilisation and liming of the bottom, and permanent fish feeding. All these activities alter the environmental conditions in ponds and lead to repeated recolonisations by plants and animals. The malacofauna is among the groups affected.

When the water from the pond is released and flows out through the outlet valve the animals either are stranded on the exposed bottom or they drift with the water current and form abundant conglomerations in the vicinity of the valve. The snails attempt to crawl in a search for water, but most of them become stranded on the dried bottom and become the food of birds and other land vertebrates. The reconstruction of the invertebrate fauna comes after the refilling of the pond as a result of the survival of some individuals in various shelters on the bottom and in the banks, and by recolonisation with the water from a river or stream supplying the pond. All these factors cause extreme variability of the fauna inhabiting the fishponds.

In the 20th century throughout Europe many fishponds have been drained and the area turned over to agriculture and urbanisation (Williams, 1997; Wood et al., 2001). Together with the ponds the biota disappears, which in some regions has led to significantly reduced biodiversity, and at times to the total extinction of some freshwater animal species (Biggs et al., 1994). In fact, in regions without natural stagnant water bodies (as in the studied area) fishponds are the only habitats of many animal species (Strzelec, 1993).

From a limnological viewpoint, fishponds are very convenient systems to study the patterns of repeated colonisation (Scharf, 2002), the impact of fish farming on formation and structure of macroinvertebrate communities, the relation between environmental factors, macrovegetation and the invertebrate fauna, and the influence of pond area on the abundance and diversity of particular animal groups (Friday, 1987; Painter, 1999; Oertli et al., 2002).

The aim of the present study was to determine the composition and structure of the freshwater snail communities living in protected and unprotected fish farms, their relationships with environmental conditions, and in particular the correlations between the composition of snail communities and factors that differed significantly between the two farm types.

Study sites

Our studies were carried out in 1998–2001 in two fish farms situated in the south-west of Poland. This is an area of underdeveloped industry and a chiefly agricultural landscape. Thus the main chemical threat to pond habitats is the great amount of various fertilizers, herbicides and insecticides that together with surface water flows reach the ponds or rivers supplying the farms.

T a b l e 1. Characteristics of investigated ponds.

					Water chemistry			
Pond	Farm	Area in ha	Bottom sediments	Fish stock (in the farm)	pH	Total hardness mval	Ca^{++} mg/dm^3	Mg^{++} mg/dm^3
1	Zebrzydowice	23.5	sand + mud	Carp	6.8	8.0	56.1	63.2
2		18.5	sand + mud	Tench	7.1	7.9	45.7	69.0
3		4.7	sand + mud	Pike	6.9	7.8	64.4	55.9
4		1.6	sand	-perch	6.4	8.5	68.1	62.7
5	Łężczak	2.0	sand + mud	Carp	6.0	6.5	65.0	39.5
6		14.6	sand + mud	Tench	7.0	8.6	93.0	48.2
7		35.0	sand + mud	Pike	7.0	6.0	69.0	29.3
8		9.0	sand + mud		6.5	7.1	66.0	46.8

The studies included eight ponds, among which four in Zebrzydowice (No. 1–4) are normally exploited as productive carp ponds, and four in Łężczak (No. 5–8) that have been declared as a nature reserve, and are strictly or partially protected. The farms are within 35 km of one another at the same altitude (220–280 m a.s.l), and with the same climate. The physiographical and hydrological characteristics of the ponds are given in Table 1, and the vegetation in Table 2. Plant species numbers in the two farms differ significantly ($t = 9.5$, $n = 8$, $p < 0.001$).

The ponds of Zebrzydowice are exploited for factory fish farming and therefore are intensively stocked with fry every 2–3 years. Fish are abundantly fed. The bottom is periodically limed and submerged vegetation and rushes removed. The smallest pond (No. 4) was not cultivated during the study period and its characteristic trait was frequent algal blooms, chiefly of Cyanophyta.

Łężczak farm is a part of a nature reserve, created in 1957 in order to protect the in Poland very rare water caltrop (*Trapa natans*), in which fish breeding and reclamations are permissible only if they do not disturb the natural environmental conditions. Only the repeated removal of macrophytes and liming of the bottom have been carried out in recent decades. Fish are fed with natural vegetable forage only. The drawdowns are rather irregular and scarce.

The common feature of all the ponds is the high total water hardness, which includes a high magnesium component. However, the protected ponds differ significantly in this respect from the unprotected ponds. The average water hardness is 8.05 mval in the first and 7.05 mval in the second group of ponds. The difference in Mg^{++} ion concentration in water (40.9 ± 8.6 mg/dm^3 in protected and 62.0 ± 5.4 mg/dm^3 in unprotected ponds) is significant, whereas the differences in Ca^{++} content and pH are not. Both groups of ponds are similarly mezotrophic.

T a b l e 2. Vegetation in the studied ponds.

Plant species	Zebrzydowice				Łężczak			
	1	2	3	4	5	6	7	8
Acorus calamus	+	+					+	
Alisma plantago- aquatica						+		
Bidens tripartita					+		+	+
Butomus umbellatus							+	
Carex elata							+	+
Carex riparia							+	+
Elodea canadensis	+	+	+			+		
Equisetum fluviatile			+	+				+
Glyceria maxima		+			+	+	+	+
Iris pseudoacorus					+			+
Lemna minor	+		+		+	+	+	+
Myriophyllum spicatum	+							
Nuphar lutea					+			+
Nymphaea alba					+			+
Phragmites australis	+	+	+	+	+	+	+	+
Potamogeton natans			+					
Ranunculus sceleratus						+	+	
Rumex hydrolapathum							+	+
Salvinia natans							+	+
Schoenoplectus lacustris	+	+	+					
Sparganium erectum	+		+		+		+	
Spirodela polyrhiza						+		+
Trapa natans						+	+	
Typha angustifolia						+	+	+
Typha latifolia	+	+	+	+			+	
Utricularia vulgaris							+	
N of species in pond	8	6	8	3	8	9	16	14
N of species in pond complex	11				23			

Material and methods

Samples were collected in 1998–2001. Each sample was collected from a bottom area of 1 m^2. The study sites were selected to represent the diversity of habitats, occurring in the ponds. In totals 8 samples were collected from each pond.

Snails were gathered by hand from aquatic plants, stones, submerged objects of various kinds, and the bottom sediments were sieved through a sifter of 0.5 mm mesh. Basing on collected materials the domination structure and the density of individuals per 1 m^2 were estimated. The relationships to environmental factors (as the Pearson's correlation) were calculated. The probability of all quantitative data was tested by the use of Student's t-test.

The analysis of abundance, species diversity and domination structure of the snail communities found in particular ponds has enabled the evaluation of the impact of some environmental factors, primarily the influence of habitat protection on the diversity and abundance of the snail fauna.

Results

In total 3869 snails were collected from unprotected ponds and 5886 from protected ponds. These belonged to 17 species. Details are given in Table 3.

In particular ponds the number of species found varied from 5 to 16, although in protected ponds there were 12–16, whereas in unprotected ponds only 5–7. This difference is highly significant ($t = 8.17$, $n = 8$, $p < 0.001$).

The density of individuals per 1 m^2 was 57–170 in unprotected and 179–269 in protected ponds, and the average densities in the two pond groups differed significantly ($t = 16.7$,

T a b l e 3. Composition and structure of snail communities in particular ponds (in %).

Farm	Zebrzydowice				Łężczak			
Snail species / Pond	1	2	3	4	5	6	7	8
Viviparus viviparus (L.)	–	–	–	–	–	–	–	0,01
Viviparus contectus (M i l l e t)	–	–	–	–	0.1	0.02	–	0.03
Bithynia tentaculata (L.)	–	–	–	–	0.8	1.3	4.9	0.9
Valvata cristata (O. F. M ü l l e r)	–	–	–	–	2.2	0.5	5.2	0.4
Acroloxus lacustris (L.)	–	–	–	–	0.1	–		0.01
Lymnaea stagnalis (L.)	16.9	12.8	6.7	74.2	0.1	0.1	0.05	0.1
Stagnicola palustris (O. F. M ü l l e r)	–	–	–	–	0.6	0.8	1.2	0.7
Stagnicola corvus (G m e l i n)	–	0.3	0.2	–	0.8	0.8	1.4	0.7
Galba truncatula (O. F. M ü l l e r)	–	–	–	–	0.05	0.2	0.4.	0.3
Radix peregra (O. F. M ü l l e r)	5.3	2.9	3.9	14.0	0.6	0.2	–	0.05
Planorbis planorbis (L.)	60.4	35.0	82.6	–	11.9	22.2	13.9	18.6
Anisus vortex (L.)	3.4	–	–	–	19.1	39.6	14.2	23.9
Bathyomphalus contortus (L.)	–	–	–	–	37.3	26.7	46.9	35.7
Gyraulus albus (O. F. M ü l l e r)	3.8	3.7	1.1	8.4	0.02	–	–	–
Segmentina nitida (O. F. M ü l l e r)	–	–	–	0.3	18.4	2.0	10.3	14.9
Planorbarius corneus (L.)	9.5	45.1	4.9	2.9	7.4	5.2	1.3	3.0
Physa fontinalis (L.)	–	–	0.5	–	0.4	0.7	0.1	0.5
N individuals	1358	716	1339	456	1432	1641	722	2091
N species	6	6	7	5	16	14	12	16
Density (indiv./m^2)	170	89	167	57	179	205	181	261
Simpson's diversity index	0.63	0.66	0.31	0.42	0.78	0.71	0.72	0.75
Menhinick's species richness index	0.16	0.22	0.19	0.33	0.42	0.34	0.45	0.35

$n = 8$, $p < 0.001$). Similar differences in the average species diversity and species richness indexes were found.

Clear differences were found in the occurrence of eudominants in the snail fauna of particular farms. To the eudominants were included species which contributed in the materials in more than 10% total number of individuals. Some data are worthy of discussion.

Planorbarius corneus and *Lymnaea stagnalis* were the commonest species during the study period, both found in all ponds. *L. stagnalis* occurs in very small number in protected ponds. In seven ponds *Radix peregra* and *Planorbis planorbis* were found. All these species are very common in the snail fauna of Southern Poland and in this respect the studied ponds have not differed from other water bodies of this region.

Bathyomphalus contortus and *Anisus vortex* are the eudominants in four ponds of the Łężczak reserve in which very abundant vegetation was present during the entire study period. Both species were absent or very sparse in unprotected ponds.

The domination of *Planorbis planorbis* in seven ponds, which differ in respect to many traits, is obviously the result of ubiquitous character of this species. It is the only species that dominated in both groups of ponds. Interesting and difficult to explain is the low abundance in the ponds of *Radix peregra*, which is one of the commonest species in Southern Poland, occurring abundantly in all kinds of freshwater habitats.

In order to identify the causes of the differences in snail communities we have calculated the correlations between the faunal and environmental variables. Correlations between species number and total hardness of the water, and between species number and magnesium ion content in the water are both negative ($r = 0.62$ and $r = 0.76$ respectively), and significant ($p < 0.05$). Species number and species diversity were significantly, positively correlated with the number of plant species ($r = 0.53$ and $r = 0.74$, respectively, $p < 0.05$). There was no significant correlation between either species number or density of individuals with bottom type, pH, and pond area.

Discussion

From among 35 freshwater snail species known from the studied area, 12–25 species have been found in fishponds previously (Kownacka ,1963; Rembecka, 1989; Strzelec, 1993).

Kownacka (1963) investigated fish ponds in the same region but in different farms from our study and found only 12 species (5–9 per pond). *Lymnaea stagnalis* and *Gyraulus albus* were dominant but *Planorbis planorbis* was absent.

Strzelec (1993) found 25 species (3–13 per pond) in fishponds in the Silesian Upland. The dominants were *Lymnaea stagnalis, Radix peregra, Gyraulus albus* and *Planorbarius corneus* whereas *Planorbis planorbis* occurred frequently but in small number of individuals in these habitats.

Rembecka (1989) studied 22 fishponds, in several regions of Silesia, one of them (in Łężczak) also included in our study. She found 20 species. The most frequent and numerous were *Lymnaea stagnalis, Gyraulus albus, Planorbarius corneus* and *Planorbis planorbis*.

Very interesting is the comparison of the snails found in pond No. 8 in Łężczak 20 years ago and at present: Rembecka (1989) has found 11 species, whereas our material includes 16 species. The dominants in 1989 were *P. planorbis* (40.6%) and *Anisus vortex* (43.8%) whereas *Bathyomphalus contortus* (35.7%) and *Anisus vortex* (23.9%) were the dominant species in our materials. Also density decreased during this time from 492 to 261 in Łężczak, while Simpson's diversity index increased from 0.63 to 0.75.

All these data point to the temporal as well as spatial variability of snail communities in fishponds. This variability results from changes in habitats induced by human activity, primarily the yearly reduction of aquatic vegetation associated with periodical drainage and bottom reclamation. When the pond is refilled with water from rivers or streams, the animals (snails among others) recolonise. Wood et al. (2001) in investigations on managed and unmanaged artificial ponds obtained similar results.

In consequence it is not possible to describe "typical" or "characteristic" community of freshwater snails in farm ponds as in the case of other temporary water bodies (Painter, 1999). The greater similarity of snail communities in ponds of the same farm may be the result of common sources of water and similar management activity. The difference in snail occurrence between protected and unprotected ponds indicates the primary role of the type and intensity of exploitation in the maintenance of biodiversity in such habitats. Generally, management practices that alter the structure of the vegetation negatively influence the gastropod communities. If such activity is limited (as in the case of Łężczak reserve) then the diversity of the snail fauna will increase.

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Received 16. 11. 2004