

Over thirty years of *Physella acuta* (Draparnaud, 1805) expansion in the Upper Silesia and adjacent regions (Southern Poland)

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Abstract. Before 1974 the mediterranean freshwater snail *Physella acuta* (Draparnaud, 1805) was never found in natural conditions of Upper Silesia. During next thirty years it has invaded the area of about 15.000 km², on the altitudes from 150 to 450 m a.s.l. In this region, where natural lakes are completely absent it settled the rivers and anthropogenic water bodies of various origin and different level of pollution. From among about 500 freshwater habitats observed permanently in last three decades, *Physella acuta* appeared in 22 rivers and 46 water-bodies, mainly sand pits. In settled habitats the density of its populations was never higher than 270 individuals/m². The appearance of *Ph. acuta* in no case influenced the diversity and abundance of native snail fauna.

Kurzfassung. Über dreißig Jahre Ausbreitung von *Physella acuta* (Draparnaud, 1805) in Oberschlesien und den angrenzenden Regionen. – Vor 1974 wurde die mediterrane Süßwasserschnecke *Physella acuta* (Draparnaud, 1805) in Oberschlesien nicht unter natürlichen Bedingungen angetroffen. Während der nächsten dreißig Jahre besiedelte sie eine Fläche von etwa 15.000 km² in Höhenlagen von 150 bis 450 m ü. NN. In dieser Region, in der natürliche Seen völlig fehlen, besiedelt sie Flüsse und anthropogene Gewässer verschiedener Art und mit unterschiedlichem Verschmutzungsgrad. *Physella acuta* bewohnt von über 500 in den letzten dreißig Jahren permanent untersuchten Süßgewässern 22 Flüsse und 46 stehende Gewässer, hauptsächlich Sandgruben. In den besiedelten Habitaten betrug die Populationsdichte nie mehr als 270 Individuen/m². Das Auftreten von *Ph. acuta* beeinflusst die Diversität und Abundanz der einheimischen Gastropodenfauna in keiner Weise.

Key words. *Physella acuta*, expansion, anthropogenic habitats, Upper Silesia.

Introduction

In the last century the over-industrialized area of Southern Poland (Upper Silesia and neighbouring regions) was the scene of very intensive invasion of three alien species of freshwater snails: *Physella acuta* (Draparnaud, 1805), *Potamopyrgus antipodarum* (Gray, 1843) and *Ferrissia clessiniana* (Jickeli, 1882). The rapid invasion of *P. antipodarum* was studied in details, and the results were published several times (STRZELEC & KRODKIEWSKA 1994, STRZELEC & SERAFIŃSKI 1996, STRZELEC in press) whereas the data concerning the expansion of *Ph. acuta*, despite of the fact, that it started more than thirty years ago, were given in general malacological publications only (REMBECKA et al. 1986; STRZELEC, 1993; SERAFIŃSKI et al. 1994). However the details of its expansion in Southern Poland were not presented as yet. For the first time *Physella acuta* was found in Upper Silesia in the dead arm of the Odra river near Opole by BOETTGER (1913). The single specimens were gathered in artificially heated water. Similarly in Łódź (FELIKSIAK 1939) and Kraków (DUTKIEWICZ 1959) it was found in water-bodies of artificially heated water. Most probably the individuals were introduced into this habitat together with removed aquarium plants.

In thermally undisturbed waters the living individuals of *Physella acuta* were found not before the early seventies and from this time its expansion in rivers and various artificial water-bodies in the Upper Silesia was observed. Two sites (Prudnik and Chybie) where the single specimens were found before 1970 are fish ponds, to which they were introduced probably with fry.

From 1970 the almost whole study area experienced the very intensive industrialization, in effect of which very numerous water bodies appeared and many of them were quickly colonised by freshwater snails, *Physella acuta* among others.

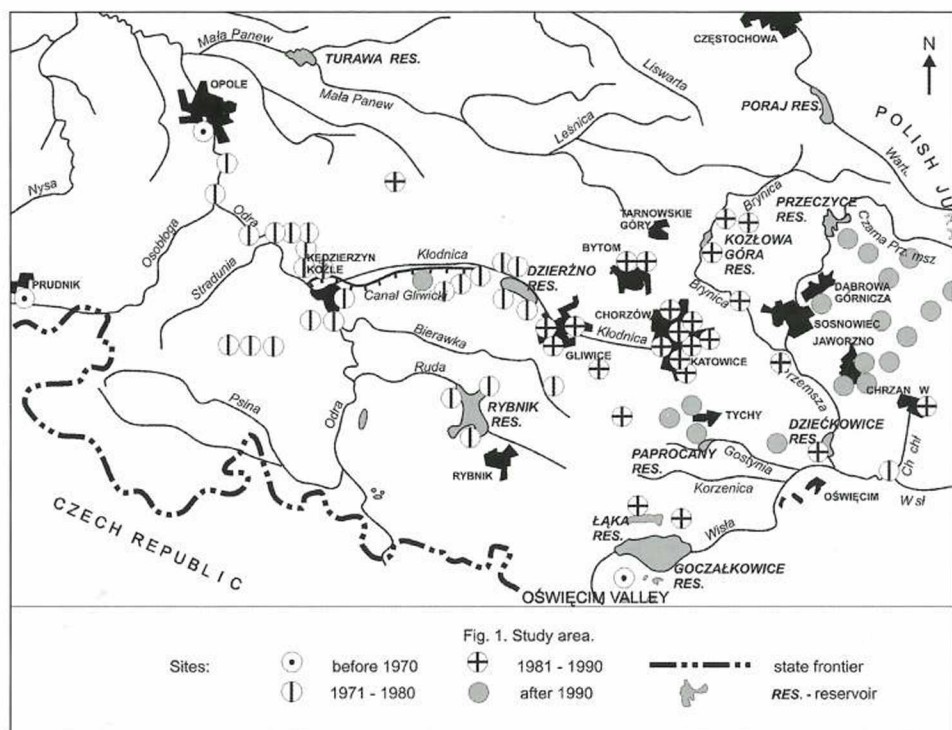


Fig. 1. Study area.

Study area

The study area (about 20.000 km²) includes the whole Upper Silesia, surrounded from West by eastern part of Lower Silesia, adjoining to the left bank of the Odra river, from South- by the northern part of Oświęcim Valley, from East- by the western part of the Polish Jura, and from North by the very small southern area of Greater Poland province (Fig. 1). It is the region devastated from years by the metallurgical and mining industries, very heavily polluted with harmful wastes and devoid completely of the natural water-bodies. The role of absent lakes play the numerous anthropogenic water-bodies, created as a by-product of human activity. In the study area the number of such water-bodies is estimated on about 900, from which 369 were under permanent observation. Moreover 42 rivers and streams were studied during three last decades (MICHALIK-KUCHARZ et al. 2000). The investigated water-bodies belong to the following habitat types: 25 dam reservoirs, 131 fish ponds, 61 sand pits, 111 subsidence ponds, 16 clay pits and 25 ditches. The bottom kinds in sampling sites are shown in Table 1. The vegetation of freshwater anthropogenic habitats in the study area is monotonous but in some cases very abundant. Particularly dense are the rushes (mainly both species of *Typha* and *Phragmites australis*). The most common plant species occurring in habitats occupied by *Physella acuta* are shown in the Table 2. It may serve as the illustration of general floral conditions in studied water environments.

Material and methods

The samples of *Physella acuta* were collected together with other freshwater snails from the bottom area of 0.25m² in each site, from plants, stones, concrete banks or submerged objects by hand, and from bottom sediments using the Eckman's grab. The density of specimens

Tab. 1. Percentage of different substrates in sampling sites in general and in occupied by *Physella acuta*.

	Sand + silt	Silt	Sand	Plants	Concrete banks	Clay
% of all sites	34,2	24,2	17,1	9,7	9,7	4,9
% of sites occupied by <i>Ph. acuta</i>	36,9	23,5	5,9	17,4	11,6	4,4

Tab. 2. The occurrence of common freshwater plants in habitats occupied by *Physella acuta*.

Plant species	Occurrence	
	N habitats	% of studied habitats
<i>Typha</i> sp.	49	72.0
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	44	65.0
<i>Lemna minor</i> L.	36	54.0
<i>Potamogeton natans</i> L.	35	52.5
<i>Alisma plantago-aquatica</i> L.	32	48.0
<i>Elodea canadensis</i> Mich.	29	43.5
<i>Acorus calamus</i> L.	28	42.0
<i>Juncus</i> sp.	26	39.0
<i>Ceratophyllum demersum</i> L.	19	28.5
<i>Myriophyllum verticillatum</i> L.	16	24.0

collected with both methods was recounted for the surface of 1m². During study period about 5.000 living individuals of *Ph. acuta* have been gathered.

Materials were sampled monthly from April to September in the period 1974–2004. Individuals were determined conchologically and preserved in ethanol. Only specimens of doubtful taxonomic position (because of untypical shell morphology) were tested anatomically. For the reason, that recently *Ph. heterostropha* (Say) has been synonymised with *Ph. acuta* (DILLON et al. 2002), it refers to the discrimination of the last from *Ph. fontinalis*. The shell-height of collected specimens never exceeded 14.5 mm.

Results

During thirty years of the expansion *Physella acuta* settled 68 different freshwater habitats, covering about 15.000 km² of the study area, i.e. 4.5 sites on each 1.000 km². It invaded the rivers and various anthropogenic water-bodies in low altitudes, below 450 m a.s.l., and the most finding sites were localised on 201–300 m a.s.l. (Fig. 2). It is noteworthy that the expansion stopped in front of the western slopes of the Polish Jura hills, where the altitude become higher than 450 m a.s.l. The less intensive, in comparison with the case of *Potamopyrgus antipodarum*, invasion (STRZELEC in press) is probably the result of slower adaptation of this snail to difficult conditions of postexploitation water-bodies. However in artificially heated industrial reservoirs, as e. g. Rybnik dam reservoir of a power plant or a pond receiving the discharges of heated water from the Knurów coal mine, the populations became very abundant in a short time. In water-bodies of the same region but with unheated water the density of *Ph. acuta* populations remains at low level for years, reaching several or tens individuals per 1m².

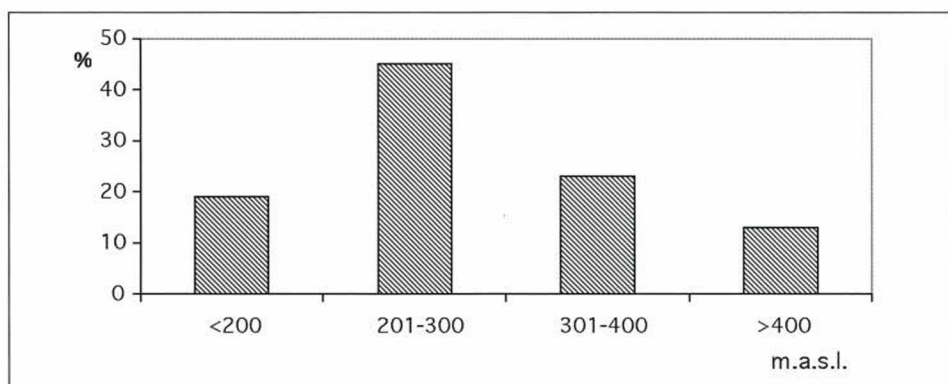


Fig. 2. Distribution of *Physella acuta* sampling sites according to altitude (from 175 to 435 m a.s.l.).

Tab. 3. The rate of *Physella acuta* expansion in succeeding periods.

Period	Before 1970	1971–1980	1981–1990	1991–2005	Total
New sites	3	25	22	18	68
%	4.4	36.8	32.4	26.4	100

Tab. 4. Percent of *Physella acuta* in snail collections from different habitats.

%	N of habitats							Total
	Rivers	Dam reservoirs	Fish ponds	Sands pits	Subsidence ponds	Clay pits	Ditches	
< 1	2	2	2	2	4	0	1	13
1–10	5	3	2	9	2	3	2	26
10.1–50	4	2	0	9	1	0	4	20
> 50	4	2	0	3	0	0	0	9

Tab. 5. The density (indiv./m²) of *Physella acuta* in different habitats.

Density	Habitat						
	Rivers	Dam reservoirs	Fish ponds	Sand pits	Subsidence ponds	Clay pits	Ditches
Indiv./m ²	15–88	10–68	1–2	4–264	3–12	1–13	1–9

The expansion was most intensive in the decades of rapid industrialization (1971–1990). In the next years the recession of industry caused the decrease in the number appearing post-industrial water-bodies and in effect the lesser number of new *Ph. acuta* findings (Tab. 3).

During invasion *Ph. acuta* settled most frequently the slow-flowing small rivers and the sand-pits, and avoided the fish-ponds and subsidence-ponds. Comparing the share of different freshwater habitats among occurring in study area and among these occupied by this species, its environmental preferences become evident (Fig. 3).

The percentage of *Ph. acuta* specimens in the total number of snails from different habitats varies to a great extent. It achieved more than 50% in some rivers, dam reservoirs and sand-

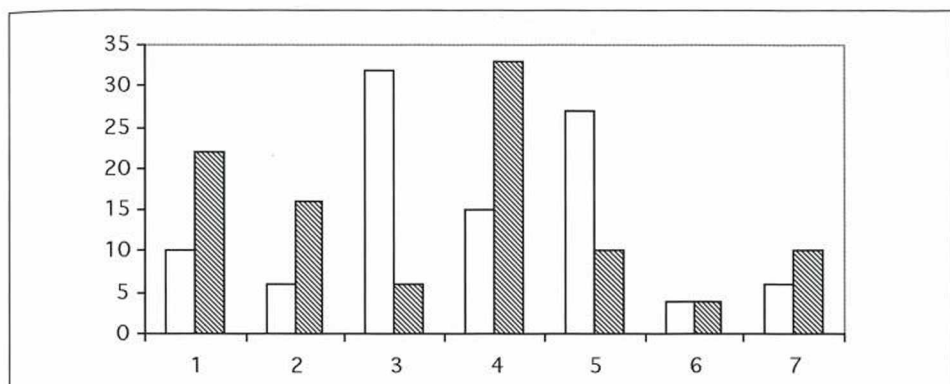


Fig. 3. Percent of different habitat types occurring on study area and among settled by *Physella acuta* ; 1-rivers, 2-dam reservoirs, 3-fish ponds, 4-sand pits, 5-subsidence ponds, 6-clay pits, 7-ditches.

pits. In most habitats it makes 1–10% and in 13 habitats was below 1% of snail collection (Tab. 4).

Much the same deals with the variation of population densities in different habitats: the highest were observed in sand-pits and the lowest in fish-ponds and ditches (Tab. 5).

It seems, that both mentioned differences in distribution of *Ph. acuta* are conditioned only in small degree by bottom types occurring in the studied habitats, except the evident avoidance of sandy bottom, which occurs three times more frequent in water environments of study area than among sites occupied by *Ph. acuta*. It was more often observed in old sand-pits, where the sandy bottom was covered with the thin layer of silt and detritus than on pure sand in younger pits. Similarly in rivers it occupied the small coves with still water and the cover of silt and plant detritus on sand. In such habitats most individuals have been sampled from plant remains and stems of reeds (mainly *Typha latifolia*, *T. angustifolia* and *Phragmites australis*). It is noteworthy that in almost all habitats occupied by *Ph. acuta* the rushes are present and abundant (Tab. 2).

On concrete banks *Ph. acuta* was found in 5 dam reservoirs and 3 rivers.

In physico-chemical respect water of most habitats occupied by *Physella acuta* is generally hard, slightly alkaline with great content of calcium and magnesium ions. The effect of particular water characters were not stated in relation to *Ph. acuta* occurrence. It seem that the excess of Mg ions (above $50 \text{ mg} \times \text{dm}^{-3}$) is the only factor limiting the living possibilities of *Ph. acuta* in post-industrial habitats. It may be the cause of its rare occurrence in subsidence ponds, where the content of Mg ions is as a rule very high: in many cases above $120 \text{ mg} \times \text{dm}^{-3}$).

One should expect, that the further expansion of *Ph. acuta* in Upper Silesia and in neighbouring regions will include the colonisation of more and more numerous water-bodies rather, than the spread of its range to the east or south.

Discussion

The confrontation of *Physella acuta* expansion in Upper Silesia with this one in other Central-european countries shows that its mode and rate are roughly similar. In all cases the invasion took place in the lowland regions only. BERAN (2002) in Czech Republic found most habitats with *Ph. acuta* on altitudes to 280 m a.s.l., JAECKEL (1962) and GLÖER & MEIER-BROOK (1998) in Germany on altitudes to 280 m a.s.l., thus almost identically as in Upper Silesia. In Czech Republic *Ph. acuta* settled during expansion 239 habitats on the area of 79.000 km² and in Upper Silesia 68 habitats on 15.000 km². From other countries similar data are absent.

In all known instances the expansion of *Ph. acuta* began from accidental introduction of some individuals removed with aquarium plants from fish cultures (GEYER 1909, BOETTGER 1913, BERAN 2002) to various freshwater habitats. In Poland it was found for the first time in the tanks of greenhouse of Warsaw Botanical Garden as early as 1906 (POLINSKI 1917).

The very small sensitivity of *Ph. acuta* to unfavourable environmental conditions, particularly to water pollution (MOUTHON & CHARVET 1999) is the main factor facilitating the colonisation of different freshwater habitats, even in most industrialised and devastated regions. In the Czech Republic, similarly as in Upper Silesia, habitats preferred by this snail are the old, big sand-pits (BERAN 2002), particularly these with poor and monotonous vegetation. On the other hand, inversely as in Upper Silesia, the expansion in rivers and streams was very rarely observed there.

According to BERAN the most frequently inhabited by *Ph. acuta* substrates are: plant detritus, living rush plants and concrete plates and stones.

Ph. acuta is resistant to high water temperature, and e.g. in artificially heated water-bodies lives in places, where the temperature is higher than 35°C, as in Rybnik Dam Reservoir. In the zone of warm water discharge from the power plant it is the sole living snail species (STRZELEC, 1999). However it is sensitive to the drying up of the habitat, which limits the settlement possibility in temporary water-bodies (COSTIL et al. 2002). Similarly as in Upper Silesia, the reduction of native snail fauna in consequence of *Ph. acuta* introduction was never observed in other countries (e.g. COPE & WINTERBOURN 2004).

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