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Population ecology of *Potamopyrgus antipodarum* (GRAY, 1843) in an recently colonized area: Upper Silesia (Southern Poland) (Gastropoda: Prosobranchia: Hydrobiidae)

With 1 Figure and 4 Tables

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Abstract. Studies on population ecology and fecundity of the New Zealand snail species *Potamopyrgus antipodarum* (GRAY) under European climate carried out in two water habitats in Upper Silesia, result in only very small differences comparing to the ancestor populations. In both habitats investigated, the snail shells are identically high, the shell height of females with embryos in the brood pouch amounts to 3.1-5.0 mm in both populations, the maximal number of embryos found in a femal snail amounts to 66 in the stream and 56 in the pond. The reproduction period starts in the pond one month earlier, probably in result of the lower water temperature in the stream.

Kurzfassung. **Populationsökologie von *Potamopyrgus antipodarum* (GRAY, 1843) in einem neubesiedelten Gebiet: Oberschlesien (Südpolen) (Gastropoda: Prosobranchia: Hydrobiidae).** - In zwei Gewässerbiotopen (einem Teich und einem Bach) Oberschlesiens durchgeführte Untersuchungen über Populationsökologie und Fruchtbarkeit der neuseeländischen Schnecke *Potamopyrgus antipodarum* (GRAY) unter europäischen Klimabedingungen haben nur sehr kleine Unterschiede gegenüber den Ahnenpopulationen erbracht. In beiden untersuchten Biotopen sind ihre Schalen identisch hoch, die Schalenhöhe der weiblichen Schnecken mit Embryonen in der Bruttasche beträgt in beiden Populationen 3,1-5,0 mm, die maximale Zahl der festgestellten Embryonen pro weiblicher Schnecke beträgt 66 im Bach und 56 im Teich. Die Fortpflanzungsperiode beginnt im Teich 1 Monat früher als im Bach, was wahrscheinlich durch die niedere Wassertemperatur im Bach verursacht wird.

Introduction

Since the publication of BOETTGER's (1951) paper whose view has been confirmed by the later studies of WINTERBOURN (1970a, 1972) and PONDER (1988) and recently supported by HAUSER et al. (1992) on genetical basis, there is beyond of all question for most malacologists that the European species *Potamopyrgus jenkinsi* (SMITH) is the younger synonym of *Potamopyrgus antipodarum* (GRAY) from New Zealand. However, its genetical structure in Europe (clonal or not) is the matter of controversy as yet (PHILIPS & LAMBERT, 1990).

Potamopyrgus antipodarum has been introduced to brackish and fresh waters of Europe probably in the first half of XIXth century, when the regular clipper lines have connected from 1840 the British Isles with New Zealand. Because these snails can survive in water to 24.6 ‰ salinity only, the transportation of individuals on outer parts of ships is impossible.

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Therefore one may suppose that they could be brought in tanks or barrels to which drinking water was drawn from natural sources (rivers, streams, ponds and s.o.) in New Zealand. By the renewal of water supply in Thames estuary the parthenogenetic survivors could become the founders of the European populations.

It is noteworthy to add that when in bisexual populations in New Zealand the diploid chromosome number amounts to 34, in unisexual it amounts to 46 or 52, as in all populations in Europe studied (WALLACE, 1992).

The significant biological difference between these genetical strains is that whereas the level of infection by parasitic trematodes is very high in bisexual populations, the flukes are rare (in New Zealand) or absent (in Europe) in parthenogenetic ones (LIVELY, 1992).

In XXth century the expansion of *Potamopyrgus antipodarum* takes place in continental Europe (HUBENDICK, 1950). Recently it lives almost exclusively in fresh waters, what is probably due to the lower oxygen demands in fresh than in brackish environments (LUMBYE, 1958).

In fresh waters of northern and central Poland it is known from 1933, but in the southern regions of the country it has appeared not before the two last decades. From 1985 the rapid expansion of this species takes place in Upper Silesia (STRZELEC & KRODKIEWSKA, 1994), similar to that found by FRANK (1985a, b, 1988, 1990) in Austria and Hungary (FRANK, 1987), by ROTH (1987) in Rhine catchment area and by CEJKA (1994) in Slovakia.

Probably the great thermal tolerance and relatively high resistance to sewages and other pollutants facilitate the colonisation of new areas (QUINN et al., 1994; TOMKINS & SCOTT, 1986).

The occurrence of *Potamopyrgus antipodarum* in Upper Silesia mainly in anthropogenic water bodies and small rivers (STRZELEC & KRODKIEWSKA, 1994) has confirmed the views of HAUSER et al. (1992) and of JOVETT et al. (1992) that it prefers these types of habitats. In some of such habitats, in spite of generally unfavourable environmental conditions *P. antipodarum* occurs very numerously, forming permanent populations.

It seems therefore that investigations on population ecology of this introduced species living under such unnatural for it conditions is a noteworthy task.

Study area

The studied habitats are situated in north-eastern part of Silesian Upland. The comprehensive characteristics of this area is given in a paper of Zięba (1985) and in the malacological monograph of STRZELEC (1993).

The climatic conditions in this region are characterized by short summer (60-70 days with average daily temperature above +15°C), rather long winter (90-100 days with average daily temperature below 0°C) and the vegetation period lasting about 200 days.

The geological bed is formed by dolomites and middle-triassic limestones (KONDRACKI, 1981).

The selected to the study habitats are:
- Pond Rogoźnik in an old sand-pit: Area - 21,5 ha, maximal depth to 2,5 m. Sandy bottom is covered with thin layer of organic mud. - The vegetation consists of *Myriophyllum verticillatum* (L.), *Ceratophyllum demersum* (L.), *Lemna minor* L., *Elodea canadensis* Rich. and *Potamogeton natans* L. The banks protected with stones are overgrown with water-moss

and green algae. - Water is hard (32 dH), by pH 6,6-6,8, slightly polluted with communal wastes.

- Stream Trzebyczka: Length 14 km, maximal width 4 m, maximal depth 0,4 m. It is surrounded by cultivated fields and meadows. The water current is very slow. The sandy bottom is covered here and there with organic mud and aggregations of gravel and stones. The banks are strengthened with concrete protections and stones. - The vascular plants are almost completely absent, whereas the green algae overgrow abundantly the banks and stones in stream-bed. - Water is hard (23,4 dH), by pH 7,6-8,2 and unpolluted.

Material and methods

In both habitats the snails were collected each month during the vegetation period of the year 1994 (from beginning of April till the end of September) by the use of convenient methods. The selection of just these habitats is the result of observations made in former years, that the populations living in both are fully developed and permanent. Moreover, the selected habitats are very similar to those investigated by WINTERBOURN (1970b) in New Zealand.

From each monthly sample 100 randomly selected individuals were measured (to the nearest 0.5 mm) and after dissection the number of embryos in brood pouch was counted. Shell height was used as the sole indicator of snail size.

Totally 5738 snails from the pond and 1288 snails from the stream have been collected during the study period. - A series of specimens from the mentioned localities are deposited in the Staatliches Museum für Tierkunde Dresden.

Results

In the pond as well as in the stream *Potamopyrgus antipodarum* lives almost only in algal layer overgrowing the stones and concrete bank protections, solely on vascular plants in the pond. It occurs in dense agglomerations, therefore the estimation of its average density in whole habitats (given in most cases as number of individuals per 1 m^2) must lead to incorrect deductions. E.g. in the studied stream it occurs in one section (about 100 m long) only, whereas in others is absent, in spite of similar environmental conditions. In the pond it occurs by the concrete dam and was never found along the unaffected banks.

In the pond the active, free-living snails appeared from the beginning of April, whereas in the stream not before the second decade of May. The delay of the life cycle in the stream one can explain by the difference in water temperature, which in the pond exceeded +10°C as early as in April, whereas in the stream only in latter part of May. Because most freshwater snails become active by such temperature, it may refer to *P. antipodarum* as well.

In the whole materials collected in both habitats, not one male has been found. Similarly as in other populations from Upper Silesia (STRZELEC & KRODKIEWSKA, 1994), the ornamented shells are very rare (to 1 % of whole collection).

In both populations the height of the shell has never exceeded 5 mm, but most of biggest shells have no more than 4.5 mm. The smallest free-living snails in both collections are 0.5 mm high and were rarely found. It seems possible, that the youngest individuals live in shelters (e.g. under stones) and by conventional collecting methods the majority of them is overlooked.

Because the fully developed (covered with shells and in shape very similar to tiny *Valvata pulchella*) embryos in the brood pouch are in both populations 0.2-0.3 mm wide and 0.1-

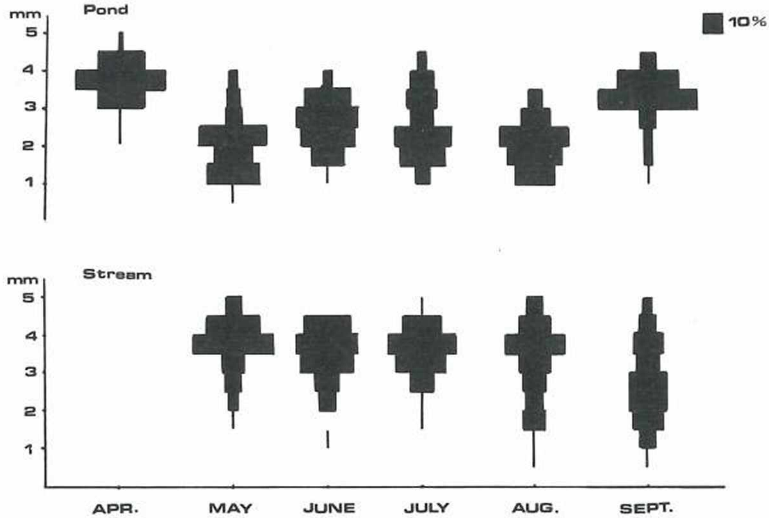

Fig. 1: Size structure of pond and stream population of *P. antipodarum* during the study period.

0.15 mm high, one can estimate their growth in the first month after birth for 1 mm in height, for the majority of young individuals gathered in May in the pond and in June in the stream belong to the size class 1.5 mm. The difference in the time of appearence of young animals in both habitats may be explained by the difference in water temperature, which in the pond in April and May is about 5°C higher than in the stream, what is the effect of the proximity of its cold springs. The biggest individuals were found in the pond only in April and June, whereas in the stream during the whole period, however, always in small numbers in both habitats.

The population size structure in particular month is shown on Fig. 1, and measured materials in Tab. 1.

In both populations the shells of the smallest females with embryos in brood pouch are 3.1 mm high. The number of embryos is significantly correlated with snail size. The correlation coefficient amounts to $r = 0.47$, $p < 0.01$ for 212 individuals from the pond, and $r = 0.79$, $p < 0.01$ for 200 individuals from the stream. Data on distribution of embryos number in particular size classes and months are listed in Tables 2 and 3. However, the apparent difference in average number of embryos per snail between populations studied is statistically insignificant ($t = 0.608$, $p > 0.5$). These data show two main reproductive periods in the pond (April and September) and almost invariable reproductive activity from May to September in the stream.

In order to compare the potential fecundity of both populations we have calculated the number of embryos produced by all mature females in each month, taking into account the number of individuals with embryos per 100 snails and the average number of embryos per one female in each month. The results are presented in Table 4, and they explain why in new population of *Potamopyrgus antipodarum* the increase in number is so rapid one. Simultaneously, they indicate that for the foundation of permanent population the reproduction in spring (thus, by hibernated individuals in our climatic conditions) is of great importance.

mm	April		May		June		July		August		September	
	P	S	P	S	P	S	P	S	P	S	P	S
1.5	0		27	0	1	2	20	0	9	2	1	8
1.6-2.0	0		21	1	19	2	23	2	22	11	2	15
2.1-2.5	1		34	3	17	9	38	2	26	10	2	19
2.6-3.0	1		7	7	29	11	12	14	10	10	6	20
3.1-3.5	23		6	9	15	26	7	24	16	16	52	11
3.6-4.0	51		5	46	3	29	0	37	14	31	28	14
4.1-4.5	22		0	29	14	20	0	20	3	15	9	9
4.6-5.0	2		0	5	2	1	0	1	0	5	0	4

Size-class mm	April			May			June			July			August			September		
	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.
3.1-3.5	-	-	-	0	4.9	15	0	13	18	0	17	24	0	7	23	0	5	12
3.6-4.0	18	38	51	5	9.2	15	8	22.6	36	-	-	-	0	21	45	0	9.5	18
4.1-4.5	14	39	53	-	-	-	12	28	48	15	23	28	22	23.5	24	3	10.3	21
4.6-5.0	25	45	56	-	-	-	6	12	18	-	-	-	-	-	-	-	-	-
Average number of embryos per snail	41			8			19			20			17			8		
Percent of snails with embryos	88			8			30			6			23			80		

Size-class mm	April			May			June			July			August			September		
	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.	Min.	$\bar{x}$	Max.
3.1-3.5				5	8	12	0	4	12	0	0	0	0	8	20	0	1.5	3
3.6-4.0				7	36	50	2	4.6	8	0	0	0	3	14	40	3	13	51
4.1-4.5				15	51	60	4	13	22	4	37	55	3	25	51	7	30	56
4.6-5.0				30	53	66	14	28	51	8	38	58	25	38	53	12	32	60
Average number of embryos per snail				37			13			20			21			19		
Percent of snails with embryos				89			56			79			51			68		

Table 1 (on the left): Distribution of size classes of *P. antipodarum* in particular months in % (P - ponds, S - stream). - Table 2 (in the middle): Number of embryos per snail in the pond population. - Table 3 (on the right): Number of embryos per snail in the stream population.

	April	May	June	July	August	September
Pond	3626	63	565	126	393	641
Stream	-	3293	731	1574	1069	1293

Table 4: Potential fecundity of 100 individuals of *P. antipodarum* in each month.

Moreover, these results confirm the view of ELTON (1958) that the great fecundity and rapid expansion are characteristic of any new colonist „whilst finding its ecological place within the indigenous fauna".

Because, as is indicated by our field observations, the population in the pond is more dense than in the stream, the selection forces must operate more effectively in the stream than in the pond. As selective factors reducing the number of young snails may act the low water temperature, water current and the scarcity of food in the slightly eutrophicated stream.

Discussion

The comparison of ecology of New Zealand and Central European populations of *Potamopyrgus antipodarum* (GRAY) has confirmed the suggestion of WINTERBOURN (1970a) and PONDER (1988) that they are representatives of the same species. Difference in maximal shell size of snails (in New Zealand up to 7.5 mm and in Central Europe up to 5.5 mm) may be explained by the shorter warm period with temperature above +10°C in Central Europe than in New Zealand (90 versus 180 days, respectively). Because as the laboratory experiments and some field observations (WINTERBOURN, 1970b) have shown the increase in height amounts to 1 mm monthly, the cause of such size difference is clear: the „New-Zealanders" grow for a longer time. In this connection very interesting is the observation of BERGER & DZIĘCZKOWSKI (1977) that in the artificially heated Konin Lakes (Central Poland) the specimens of *P. antipodarum* reach 5.8 mm, thus, they are higher than in other habitats in Poland. May be, however, that the smaller size of individuals from small water bodies is due to greater density of populations occurring here, what according to the observations of LUMBYE & LUMBYE (1965) stunts growth in individuals of this species.

DORGELO's (1987, 1988) field and laboratory observations that in more eutrophicated habitats the rate of growth is faster than in oligotrophic ones, is inconsistent with the results of our investigations.

Studies of WALLACE (1978) on Australian *Potamopyrgus* have shown that in this country the shell height of mature snails never exceeded 4.0-4.5 mm, and in some populations it was considerably smaller. May be, therefore, that the reduction in size is one of the consequences of colonizing the new areas.

It seems that the size of snail is the cause of varying number of embryos in the broad pouch. In our study, this number was significantly correlated with the shell height. WINTERBOURN (1970b) found up to 120 embryos per snail in the New Zealand stream population, but the greatest numbers were found in females of 6.5 mm shell height. In our material the maximal number (up to 66 embryos) was found in females of the stream population from the size class 4.6-5.0 mm, whereas in the pond in the same size class it amounts up to 56 embryos.

In other European populations the number of embryos was somewhat smaller than it was found by us: FRETTER & GRAHAM (1962) quoted 35-40 in Great Britain, and FRENZEL (1979) - up to 45 in Germany.

The comparison of size structure in our and New Zealand populations shows some similarities in corresponding year periods (cf. our Fig. 1 with Fig. 2 of the paper of WINTERBOURN, 1970b). It refers particularly to both stream populations.

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