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DISTRIBUTION OF *POTAMOPYRGUS ANTIPODARUM* (GRAY, 1843) IN WATERS OF THE WIGRY NATIONAL PARK (NE POLAND) AND THE EFFECT OF SELECTED HABITAT FACTORS ON ITS OCCURRENCE

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ABSTRACT: The occurrence of the snail *Potamopyrgus antipodarum* (Gray) in the waters of the Wigry National Park was studied, and the factors, affecting its distribution and dispersal, were analysed in 1997–1998. *P. antipodarum* was recorded from 7 out of the 24 examined water bodies of the Park and from the river Kamionka. The snail occurred in bottom deposits, on submerged and emerged macrophytes and in mats of filamentous algae in the lake Wigry, and clearly dominated in its malacofauna. In the remaining lakes, where it was present, it was not abundant. Active dispersal is not sufficient to explain the distribution of *P. antipodarum* in the lake Wigry. Its dispersal is probably a result of passive introduction by animals and humans, and to a lesser extent by water currents. An increased chlorophyll concentration in the pelagial has a positive effect on the occurrence of *P. antipodarum*. In much polluted habitats the vertical distribution and density of the species are limited. Significance of the trophy of water for the occurrence of *P. antipodarum* in the area is still unclear.

KEY WORDS: *Potamopyrgus antipodarum*, eutrophication, pollution, filamentous algae

INTRODUCTION

Potamopyrgus antipodarum (Gray, 1843) originating from New Zealand, has been spreading in Poland since 1933 (URBAŃSKI 1935). It was found in some water bodies of the Baltic Coast, Pomeranian Lakeland, Wielkopolsko-Kujawska Lowland (JACKIEWICZ 1973), Iławskie Lakeland (WOLNOMIEJSKI & FURYK 1970), Mazurian Lakeland (KOŁODZIEJCZYK 1984), and also of Upper Silesia (STRZELEC & SERAFIŃSKI 1996). Due to its considerable fertility and parthenogenic reproduction, *P. antipodarum* can within a short time invade a water body where it has been introduced (STRZELEC & SERAFIŃSKI 1996), however it later disappears from some lakes, e.g. the Mikołajskie Lake (KOŁODZIEJCZYK 1984). Abundance fluctuations observed in populations of the species are difficult to interpret. It is unknown if biotic factors affect populations of *P. antipodarum* in newly-invaded areas. According to WINTERBOURNE (1970), in New Zealand the abundance of the species does not depend significantly on biotic, but on physical factors of catastrophic character (e.g. floods – HOLOMUZKI & BIGGS 1999). DORGELO's (1987) studies revealed no differences between populations of *P. antipodarum* inhabiting two lakes of different trophy. The snail may live in strongly polluted waters (STRZELEC & KRODKIEWSKA 1994).

In the waters of the Wigry National Park, *P. antipodarum* was first found by LEWANDOWSKI (1992) who recorded it from the lake Wigry and classified it as a rare species. In 1993, KOŁODZIEJCZYK (1996) found it in the lake Białe Wigierskie. GRUŻEWSKI (1997) recorded it from the river Kamionka. Preliminary information on the distribution of the species in the waters of the Wigry National Park was presented by BRZEZIŃSKI (1999).

The aim of our study was to assess the frequency and abundance of *P. antipodarum* in the waters of the Wigry National Park, and to estimate the significance of trophy, degree of pollution and presence of mats of filamentous algae for its occurrence.

STUDY AREA AND METHODS

The Wigry National Park is located in the mid part of the Czarna Hańcza River basin. The hydrographic system of the Park includes 42 lakes which vary considerably in size, depth, trophy, degree of isolation and vegetation, as well as 6 water-courses. The malacofauna was sampled in 1997 and 1998, at the end of July/beginning of August, from 24 lakes (Table 1) and 5 water-courses of the area. In each water body, depending on its size and diversification, from 1 to 21 sites were selected (Fig. 1). At each site, samples of emerged and submerged macrophytes were taken, of filamentous algae and bottom deposits from a depth of 0.5 m. In some localities, samples of bottom deposits were taken as vertical profiles: from the shoreline (when possible) and depths of 0.5, 1.0–1.5, 2.0–4.0, 7.0–10.0 and 10.0–14.0 m. The bottom deposits were sampled with Ekman-Birge grab of catching area of 225 cm^2 (3–5 samples). At each locality, 5 samples were taken of each plant present. One macrophyte sample included: 10 shoots of reed (*Phragmites australis* Trin. ex Steud.) or *Schoenoplectus lacustris* L., 10 shoots of *Potamogeton perfoliatus* L. or *P. lucens* L., a portion of Characeae, a single specimen of *Stratiotes aloides* L. – swept with a net under water, a portion of filamentous algae (of mixed species composition, *Mougeotia* sp. being the dominant – studied only in 1998) swept with a container of ca. 400 cm^3 volume. In small forest and polyhumus lakes, and in the Wigierski Pond, only qualitative samples were taken. The samples were washed on a benthis sieve of 1 mm mesh, sorted macroscopically and preserved with methyl alcohol or formalin.

The density of *P. antipodarum* was converted to 1 m^2 substratum (bottom, reed shoots, *Potamogeton* shoots) or 100 g fresh weight of filamentous algae. The surface area of submerged macrophytes based on their fresh weight was calculated according to HARROD & HALL (1962), KOWALCZEWSKI (1975) and

Table 1. Selected parameters of investigated lakes in the Wigry National Park (ZDANOWSKI et al. 1992)

Lake	Area [ha]	Depth [m]		Secchi disc visibility [m]	PO_4-P [mg × dm^{-3}]	Plant-covered area [%]
		maximum	mean			
Białe Pierciańskie	6.0	24.0	6.0	4.4	0.06	–
Białe Wigierskie	100.2	34.0	13.2	6.65	0.017	29.2
Czarne	6.4	10.0	10.3	1.47	0.1	64
Czarne Huciańskie	7.8	24.0	2.3	–	–	21.4
Długie	80.0	14.8	6.4	3.0	0.015	23.8
Gałęziste	3.9	14.3	5.2	3.74	0.174	–
Koleśne	25.5	15.0	15	–	–	–
Królówek	9.9	4.5	2.2	–	–	54.5
Leszczewek	21.0	6.5	3.6	1.1	–	31
Muliczne	25.7	11.3	4.7	3.65	–	49
Omółówek	14.2	5.5	3.0	2.5	–	63.3
Okrągłe	12.2	12.8	6.7	2.6	0.004	32
Pierty	228.2	38.0	10.4	1.35	0.034	25.5
Samle Wielkie	2.1	11.0	5.5	2.7	0.108	–
Staw Wigierski	30.0	11.0	11	–	–	–
Suchar I	0.9	4.0	5.5	1.75	–	–
Suchar II	2.6	9.5	2.5	1.9	0.048	–
Suchar III	0.33	4.0	3.6	2.0	–	–
Suchar IV	1.15	8.0	1.9	1.55	0.072	–
Suchar V	0.5	5.7	3.2	2.0	–	–
Suchar Dembowski	3.3	7.5	4.3	2.9	0.021	–
Suchar Wielki	8.9	9.0	3.6	2.6	0.006	–
Wądołek	1	15.0	8.6	1.5	0.24	–
Wigry	2118.3	73.0	15.8	2.3	0.096	23.8

– lack of data

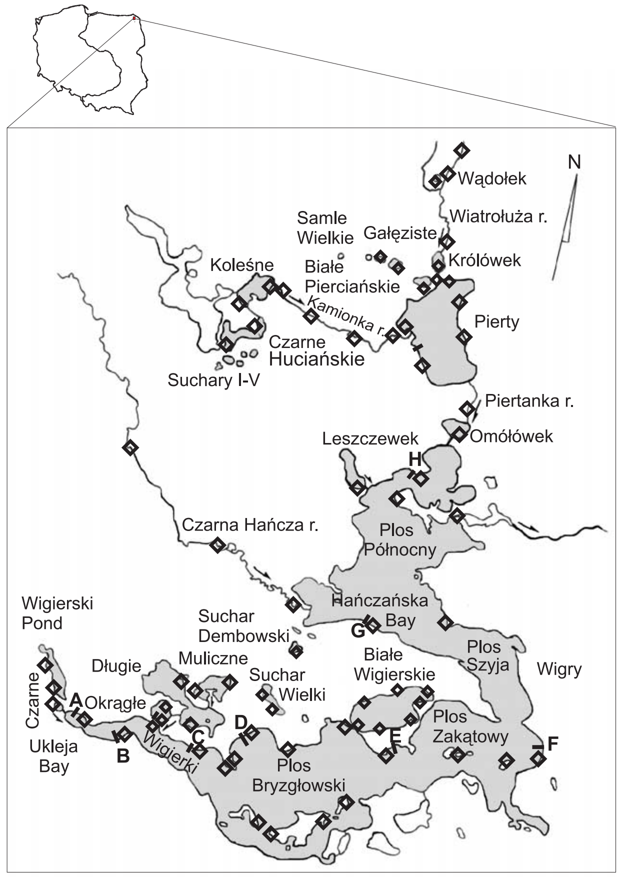

Fig. 1. Study area. Sample sites indicated with squares, water flow indicated with arrows, location of the depth profiles indicated with capital letters

PEREYRA-RAMOS (1981). The occurrence of *P. antipodarum* was analysed in detail only on reed, *P. perfoliatus*, in the bottom sediments and on filamentous algae, which were sampled at most sites.

To analyse the dependence between the occurrence of *P. antipodarum* and habitat pollution and trophy, we used CHMIELEWSKI's (1991) data on annual load of organic and inorganic matter, in particular shoreline sections of the lake Wigry, provided by each of 97 micro-basins of the lake, data of BAJKIEWICZ-GRABOWSKA et al. (1992) on annual total phosphorus load in the lake and its bays, and HUTOROWICZ's (1998) data on summer concentration of chlorophyll *a* in particular parts of the lake. Using in our analysis pollution data from earlier years is justified, since: 1. because of protection regulations and the lack of funds to reclaim private grounds that are located within the Park, the land usage in the direct drainage area of the lake has not changed (KAMIŃSKI, pers. com.); 2. concentration of biogenic substances and pollution load in the lake have not changed significantly within the last 4 years (HUTOROWICZ 1998, ZDANOWSKI 1998); 3. evaluation of the trophy levels based on zooplankton indices revealed no changes in 1996 compared to 1986 (EJSMONT-KARABIN & KARABIN 1998, KARABIN & EJSMONT-KARABIN 1998).

Coefficients of correlation were calculated for the dependence between the density of *P. antipodarum* and the values of trophy and pollution indices. The results were statistically analysed with the programme Statistica v. 95 (Wilcoxon tests for tied pairs, R-Spearman correlations) and Statistics (Kolmogorov-Smirnov test). When necessary the data were transformed as recommended by PARKER (1978) and ŁOMNICKI (1995).

RESULTS

HORIZONTAL DISTRIBUTION OF *P. ANTIPODARUM*

P. antipodarum was found in 7 of the examined lakes: Wigry, Białe Wigierskie, Czarne Huciańskie, Koleśne, Okrągłe, Pierty and Wigierski Pond, as well as in the river Kamionka. In 6 of them (Czarne Huciańskie, Koleśne, Okrągłe, Pierty and Wigierski Pond), the snail was not recorded prior to 1998 or there were no data on its occurrence (BRZEZIŃSKI 1999). *P. antipodarum* was not found in small isolated lakes – neither eu- nor mesotrophic (Samle Wielkie, Gałęziste, Białe Pierciańskie), or dystrophic (Suchar I–V, Wądołek, Suchar Wielki, Suchar Dembowski); likewise it was not found in some of the lakes connected with the lake Wigry (Leszczewek, Omółówek, Długie, Muliczne), and in the lake Królówek, though it is connected with Pierty.

In the lake Wigry, *P. antipodarum* was present at 15 out of 21 sites, on all the analysed substrata. Its frequency in the lake, calculated for all the substrata, was 63% in 1997 and 77% in 1998 (Table 2). In the bottom deposits at the depth of 0.5 m, the mean density of the snail at particular localities varied considerably from 14±25 indiv. × m^{-2} to 28,500±25,700 indiv. × m^{-2} (Fig. 2). The highest mean density was observed in sites at Plos Zakątowy (for the topography of the lake see Fig. 1) (10,400 indiv. × m^{-2} in 1997, 220–28,500 indiv. × m^{-2} in 1998); the density was clearly lower in Plos Bryzgłowski, Plos Północny and the bay Wigierki (22–800 indiv. × m^{-2} in 1997 and 14–2,010 indiv. × m^{-2} in 1998). *P. antipodarum* was not found in the Hańczańska Bay and Plos Szyja. Within the two years of studies, neither the density distribution of the snail within the lake Wigry, nor its mean density in the littoral deposits (2,270 indiv. × m^{-2} and 3,570 indiv. × m^{-2}, respectively) changed statistically significantly (Table 2). On reeds the highest mean density of *P. antipodarum* was noted in sites in Plos Bryzgłowski

Table 2. Frequency and mean densities of *Potamopyrgus antipodarum* in investigated lakes of the Wigry National Park

Lake	Frequency [%]		x̄±SD sediments (0.5 m) [ind.×m^{-2}]		*Phragmites australis* [ind.×m^{-2}]		*Potamogeton perfoliatus* [ind.×m^{-2}]		filamentous algae [ind.×100 g f.w.$^{-1}$]
	1997	1998	1997	1998	1997	1998	1997	1998	1998
Białe Wigierskie	–	4	–	0	–	84±225	–	0	–
Czarne Huciańskie	–	6	–	266±462	–	0	–	0	0
Koleśne	–	12	–	59±145	–	37±106	–	0	0
Okrągłe	–	12	–	15±26	–	0	–	0	–
Pierty	–	5	–	4±13	–	21±71	–	0	0
Staw Wigierski	–	11	–	0	–	0	–	0	–
Wigry	63	77	2,270±5,040	3,570±8,350	1,210±2,750	3,5000±8,7700*	250±500	63±82	496±462

– lack of data
* density of *P. antipodarum* differs significantly in following years (Wilcoxon's test, p<0,05)

(38–6,520 indiv. × m^{-2} in 1997, 42–15,200 indiv. × m^{-2} in 1998) and Plos Zakątowy (222 indiv. × m^{-2} in 1997, 11,200–20,400 indiv. × m^{-2} in 1998). The mean density in sites in Plos Północny were clearly lower (2–437 indiv. × m^{-2} in 1997, 353 indiv. × m^{-2} in 1998). *P. antipodarum* was not found on reeds in Plos Szyja and the bays Hańczańska and Wigierki (Fig. 3). In 1998, compared to 1997, the mean density of the snail on reed in the lake Wigry increased statistically significantly (Table 2), from 1,210 to 35,000 indiv. × m^{-2}.

On *Potamogeton perfoliatus* (Fig. 4), the highest mean density of *P. antipodarum* was observed at sites in Plos Bryzgłowski and Plos Zakątowy (39–602 indiv. × m^{-2} in 1997, 12–158 indiv. × m^{-2} in 1998); it was also high in Plos Północny (8–832 indiv. × m^{-2}) while in the bay Wigierki the mean densities were by an order of magnitude smaller (2–14 indiv. × m^{-2}). Its mean density did not change in 1998 compared to 1997 (Table 2).

P. antipodarum was also numerous on other macrophytes sampled in the lake Wigry: *Schoenoplectus lacustris*, *Potamogeton lucens* and *Stratiotes aloides.*

In the mats of filamentous algae (Fig. 5), the highest density of *P. antipodarum* was found in sites of the eastern part of Plos Zakątowy (845–2,040 indiv. × 100 g^{-1}). In the other parts of the lake, the densities were lower and ranged from 19 to 373 indiv. × 100 g^{-1}. The species clearly dominated in all the samples of filamentous algae, constituting from 65% to 99% molluscs.

In the remaining studied lakes where *P. antipodarum* was found, it was present on some of the substrata sampled, its general frequency being lower (4–12%) and its density by two or three orders of magnitude lower compared to the lake Wigry (Table 2). In the lake Czarne Huciańskie, the snail occurred in the bottom deposits on one of the two studied localities (Fig. 2), and its total frequency in the samples was only 6%. In the lake Białe Wigierskie, it was present on one of the seven localities examined, on reeds near the neck separating the lake from Wigry (Fig. 3), and its total frequency in the lake was only 4%. In the lake Koleśne, *P. antipodarum* occurred in the bottom deposits (Fig. 2), on reeds (Fig. 3) and on Characeae on both localities, its frequency being 12%. In the lake Okrągłe, it was found in the bottom deposits at one of the two sites, close to the outflow to the lake Wigry (Fig. 2), the total frequency in the samples being 12%. In the lake Pierty, it was present in the bottom deposits (Fig. 2) and on reeds (Fig. 3), the frequency being 5%. In the Wigierski Pond, *P. antipodarum* was found to occur on Characeae at one of the two sites (close to the fish stocking station), its frequency being 11%. In none of the lakes, except Wigry, was it noted on *Potamogeton perfoliatus* (Fig. 4) or mats of filamentous algae (Fig. 5). In the Wigierski Pond and the lake Koleśne, *P. antipodarum* occurred on Characeae, at densities of 0.1 indiv. × 100 g^{-1} and 0.6 indiv. × 100 g^{-1}, respectively.

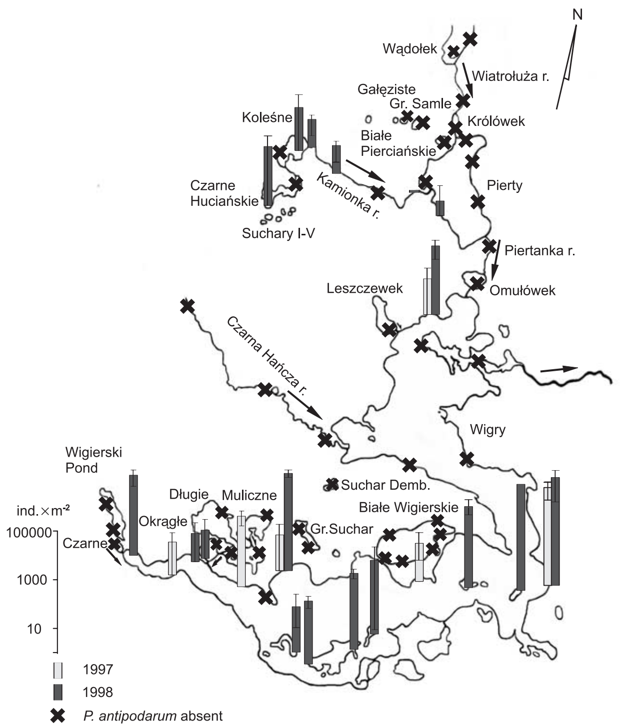

Fig. 2. Density of *Potamopyrgus antipodarum* in sediments (0.5 m) ($\overline{x}$±SD)

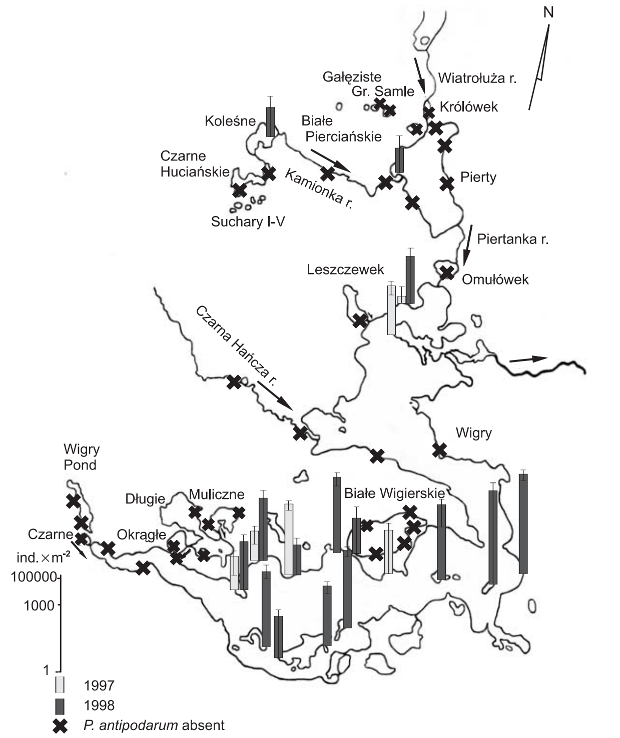

Fig. 3. Density of *Potamopyrgus antipodarum* on *Phragmites australis* ($\overline{x}$±SD)

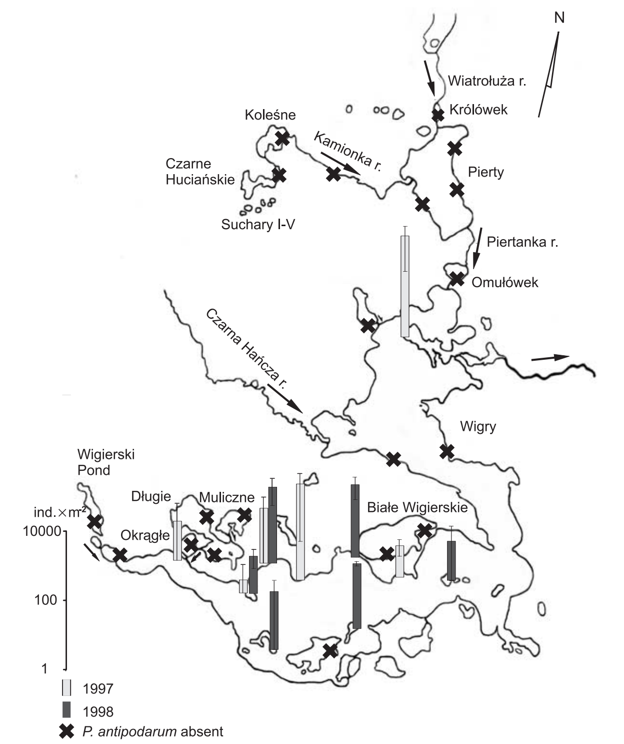

Fig. 4. Density of *Potamopyrgus antipodarum* on *Potamogeton perfoliatus* ($\overline{x}$±SD)

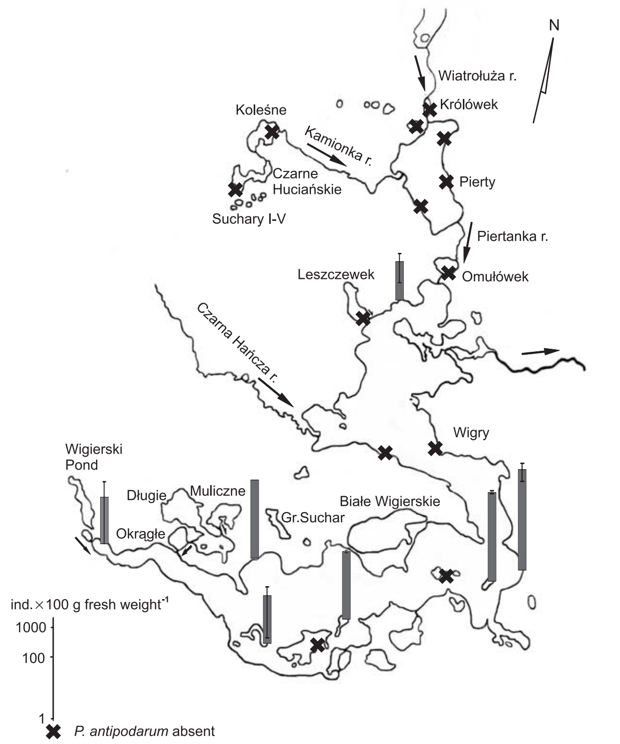

Fig. 5. Density of *Potamopyrgus antipodarum* in mats of filamentous algae ($\overline{x}$±SD)

OCCURRENCE OF *P. ANTIPODARUM* IN BOTTOM DEPOSITS DEPENDING ON DEPTH

In the lake Wigry, the maximum depth where *P. antipodarum* was found ranged from 6 m in Plos Bryzgłowski (1997 and 1998) to 1 m in 1997 and 0.5 m in 1998 in Plos Północny (Fig. 6). The distribution of density in depth profiles in consecutive years differed statistically significantly; the mean densities of *P. antipodarum* in 1998 were higher than those observed in 1997, showing an increase from 10,400 indiv. × m^{-2} to 80,900 indiv. × m^{-2} (Kolmogorov-Smirnov test, $p<0.001$), the calculated mean depth where the density was the highest decreased from 1.3 to 0.8 m. The highest densities of *P. antipodarum* were noted in Plos Zakątowy (profiles E, F) and Plos Bryzgłowski (profile D) (Fig. 6). In one of the two profiles in the bay Wigierki (profile B of 1997) and in the Hańczańska Bay (profile G in 1998), *P. antipodarum* was not found. In the lake Okrągłe, the snail occurred at shallow depths, 1 m at the maximum; the calculated mean depth where its density was the highest was 0.8 m. In the lake Pierty, it was found to occur down to the depth of 4 m, and the mean calculated depth, at which the density was the highest, was 2.2 m. In bottom deposit samples from those lakes, the snail was found only sporadically – in 2 out of 14 samples from the lake Okrągłe and 2 out of 15 samples from the lake Pierty, and its vertical distribution was discontinuous.

WATER POLLUTION AND EUTROPHICATION AND THE OCCURRENCE OF *P. ANTIPODARUM*

A negative, statistically significant correlation was found between the pollution influx from local microbasins of the lake Wigry and the density reached by *P. antipodarum* on plants (Table 3). The correlation was the most pronounced in case of filamentous algae and *Potamogeton perfoliatus*, less so in case of reed. No statistically significant correlation was found between the occurrence of *P. antipodarum* in the bottom deposits at the depth of 0.5 m and the pollution load. There was also a significant, negative correlation between the total phosphorus load and the density of *P. antipodarum* (Table 4). The correlation was the most pronounced in case of filamentous algae mats and reed, less so for *P. perfoliatus* and bottom deposits. Likewise, the maximum depth of occurrence of *P. antipodarum* was negatively correlated with phosphorus load (Fig. 7).

A positive, statistically significant correlation was found between the density of *P. antipodarum* in particular sites in the lake Wigry and chlorophyll a concentration in the pelagial (Table 5). The correlation involved all the analysed susbtrata.

However, correlation between the mean density values in particular lakes of the Park and the trophic type of the lake, expressed as categorized values (1 – α-mesotrophic, 2 – β-mesotrophic, 3 – eutrophic, 4 – hypertrophic) was statistically insignificant ($R=0.495$, $p<0.06$, $N=16$).

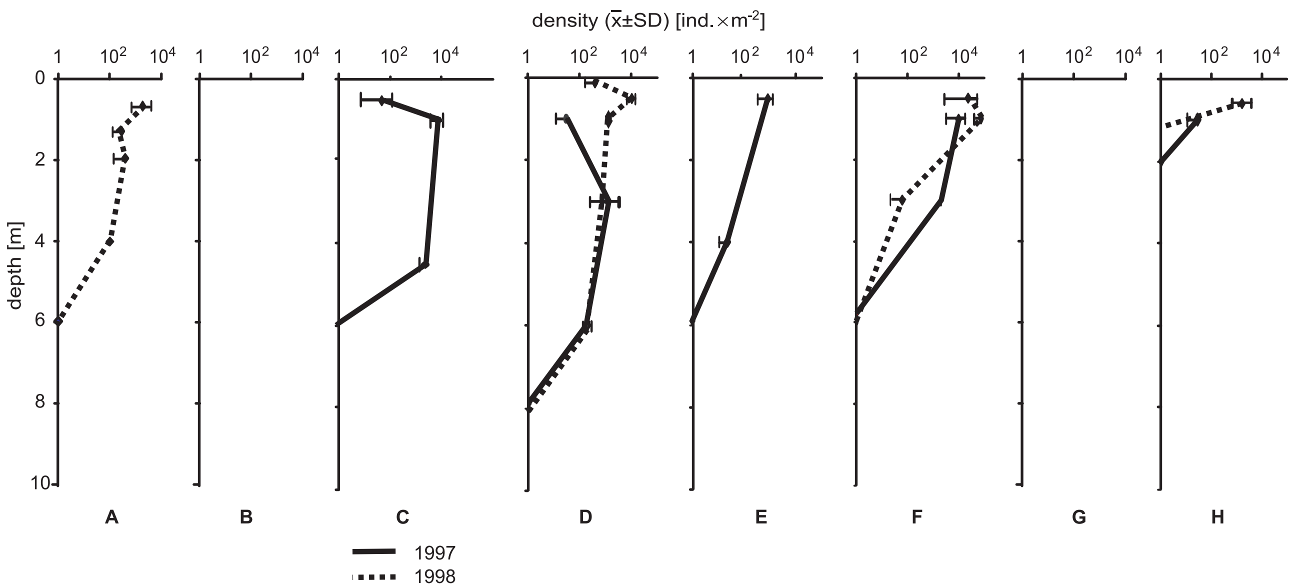

Fig. 6. Vertical distribution of *Potamopyrgus antipodarum* in the Wigry Lake. For location of profiles see Fig. 1. In profile A samples were taken in 1998 only, in profiles B, C and E – in 1997 only

Table 3. Correlation coefficient between densities of *Potamopyrgus antipodarum* and local pollution load along the shoreline of the Wigry Lake. Pollution load [$kg \times m^{-1} \times year^{-1}$] according to CHMIELEWSKI (1991). R – Spearman's correlation coefficient, p – significance, N – number of samples analysed

substratum	R	p	N
sediments (0.5 m)	0.079	0.4	92
Phragmites australis	-0.352	<0.001	137
Potamogeton perfoliatus	-0.531	0.01	30
filamentous algae	-0.698	<0.001	19

Table 4. Correlation coefficient between densities of *Potamopyrgus antipodarum* and P_{tot} load in the respective parts of the Wigry Lake. P_{tot} load [$g\ P_{tot} \times m^{-2} \times year^{-1}$] according to BAJKIEWICZ-GRABOWSKA et al. (1992). R – Spearman's correlation coefficient, p – significance, N – number of samples analysed

substratum	R	p	N
sediments (0.5 m)	-0.325	0.01	57
Phragmites australis	-0.547	<0.001	100
Potamogeton perfoliatus	-0.497	<0.008	30
filamentous algae	-0.63	0.003	19

Table 5. Correlation coefficient between densities of *Potamopyrgus antipodarum* and chlorophyll *a* concentration in the respective parts of the Wigry Lake. Chlorophyll *a* concentration [$mg \times m^{-3}$] according to HUTOROWICZ (1998). R – Spearman's correlation coefficient, p – significance, N – number of samples analysed

substratum	R	p	N
sediments (0.5 m)	0.481	<0.001	57
Phragmites australis	0.416	<0.001	100
Potamogeton perfoliatus	0.471	<0.001	30
filamentous algae	0.468	<0.001	19

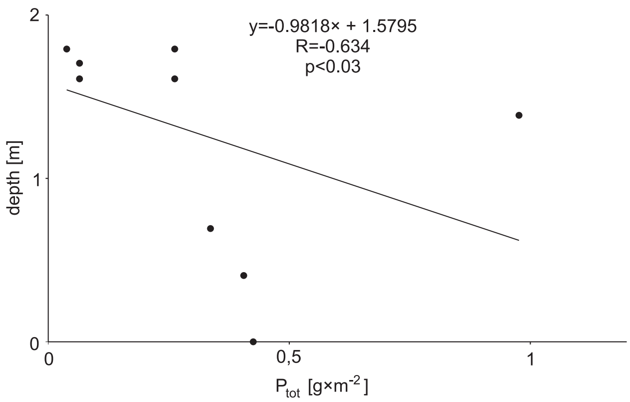

Fig. 7. Maximum vertical range of *Potamopyrgus antipodarum* as a function of P_{tot} load in the respective parts of the Wigry Lake. P_{tot} load [$g \times m^{-2} \times year^{-1}$] according BAJKIEWICZ-GRABOWSKA et al. (1992). R – correlation coefficient, p – significance value

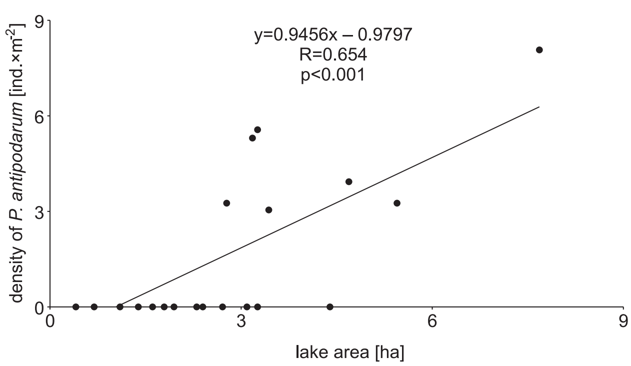

Fig. 8. Density of *Potamopyrgus antipodarum* in the waters of the Wigry National Park as a function of the lake area. R – correlation coefficient, p – significance value

DISCUSSION

P. antipodarum in the Wigry National Park was found to occur in lakes, which differ considerably among themselves (Table 1). In the studied area, the snail occurs mainly in large and medium-sized water bodies (Fig. 8), irrespective from whether they are isolated or connected by water-courses. Since it was not found in the Czarna Hańcza River drainage area above the lake Wigry, or in other water bodies of the northern part of the Suwalskie Lakeland (KOŁODZIEJCZYK 1989, own unpublished observations), it could not have invaded the lakes actively, along water-courses. It was most probably introduced by humans or animals. BOAG (1986) demonstrated experimentally a possibility of introducing snails by water birds; three routes of bird seasonal migrations cross over Wigry (WOŁK 1979). With this mechanism of dispersal, *P. antipodarum* has the greatest chance of being introduced into large lakes, not only for probability reasons, but also because such lakes are more attractive to waterfowl (JĘDRASZKO-DĄBROWSKA 1992). Large water bodies are also more prone to penetration by humans. Near the lake Wigry and Wigierski Pond, there are fish stocking stations, and thus introduction with fishing equipment or stocking material is also possible. HAYNES et al. (1985) observed that individuals of *P. antipodarum* could pass undamaged through fish alimentary tracts.

The observed considerable differences in the occurrence and abundance of *P. antipodarum* within the lake Wigry may result from different pollution load in particular parts of the lake (Table 3) and different trophy levels (Tables 4, 5). Contrary to the data suggesting a great resistance of *P. antipodarum* to pollution (STRZELEC & SERAFIŃSKI 1996), the negative correlation between its density at particular localities in the lake Wigry and the local pollution load (Table 3) may indicate a negative effect of pollution on its distribution. *P. antipodarum* occurs in masses in rather unpolluted Plos Bryzgłowski and Plos Zakątowy (Figs 2–5), while it is less numerous in Plos Północny and the bay Wigierki which receive pollutants from the nearby villages: Stary Folwark, Czerwony Folwark, Cimochowizna and Gawrych Ruda. The snail is absent in the strongly eutrophicated Hańczańska Bay receiving, through the Czarna Hańcza river, sewage from Suwałki and Sobolewo. In 1986, *P. antipodarum* occurred mainly in Plos Północny and there LEWANDOWSKI (1992, per. com.) noted its highest density. At present *P. antipodarum* is rare there and reaches low densities, while the present pollution load there is thrice higher than it was in 1986 (ZDANOWSKI 1998). Likewise, the wide range of maximum depth at which *P. antipodarum* was noted within the lake Wigry (Fig. 6) may result from different habitat conditions, which in turn follow from different pollution load (Fig. 7). In the heavily polluted Plos Północny, the vertical range is small (Fig. 6 – profile H), in relatively little polluted Plos Bryzgłowski, *P. antipodarum* reaches the greatest depths (Fig. 6 – profile D). It seems likely that oxygen deficits near the bottom observed by ZDANOWSKI et al. (1992), as well as other negative aspects of eutrophication associated with anthropogenic transformations of the lake basin, may deteriorate the living conditions of the snail. On the other hand, the positive correlation between the density of *P. antipodarum* and chlorophyll *a* concentration in the water (Table 5) indicates that a moderately high trophy may favour this snail in consequence of increasing its food resources: biomass of periphyton and planktonic algae. The density of *P. antipodarum* increases with chlorophyll *a* concentration, however, only up to a certain value. This may result from the fact that increase in chlorophyll content is only one of the many aspects of eutrophication, and the other aspects may have a negative effect on the occurrence of the snail.

The increase in maximum and mean densities of *P. antipodarum* in the bottom deposits in 1997 and 1998 compared to their values of 1986, when the mean density in the lake Wigry was only 72±251 indiv. × m^{-2} bottom (LEWANDOWSKI pers. com.), may result both from chlorophyll *a* concentration, which is at present 4–10 times higher (HUTOROWICZ 1998) and from invasion of more favourable habitats – in 1986, the species was limited to Plos Północny, and was not found in Plos Bryzgłowski or Plos Zakątowy (LEWANDOWSKI 1992), where now it reaches its highest densities.

Besides the local pollution level and trophy, the distribution and abundance of *P. antipodarum* may be significantly affected by the presence of drifting mats of filamentous algae and winds, mainly the prevailing, moderately strong (4 m × s^{-1}) westerly and south-westerly winds (BAJKIEWICZ-GRABOWSKA 1992), which push the mats with their animal inhabitants towards the eastern shores of the lake. The high density of the snail in Plos Zakątowy may result from this situation. On such mats *P. antipodarum* could get to some islands on the lake Wigry which are situated outside the shore shallows (island Kamień, islands Brzozowe). It is unknown if the snail prefers staying in the mats of filamentous algae, or is trapped there. According to RYBAK (1996), algal mats do not limit the mobility of copepods and cladocerans; PIECZYŃSKA et al. (1998) demonstrated that the substratum may be attractive to organisms of various taxa, including snails. The range of mean densities of snails reported by these authors for filamentous algal mats in the lake Roś (61–3,500 indiv. × 100 g^{-1}) is comparable to the values reached by *P. antipodarum* in the mats of the lake Wigry (18–2,040 indiv. × 100 g^{-1}), while the size of young individuals of *Lymnaea* (*Stagnicola*) sp. which dominate in the lake Roś is similar to that of adult *P. antipodarum*. The presence of mats of filamentous algae increases the surface available for invasion, periphyton developing in algal filaments and the dying fragments of the filaments may constitute a food source; the mats may provide shelter from predators (knowing that a predator – fish – is around, individuals of *P. antipodarum* stay in their shelters longer and feed for shorter periods; LEVRI 1998). Low values of frequency and density of *P. antipodarum* in the remaining lakes of the Wigry National Park may result from the fact that the snail has been present there since recently or that the habitat conditions are not suitable for it. Observations of STRZELEC & KRODKIEWSKA (1994) from small reservoirs of Upper Silesia indicate that the "conquest" of a water body by *P. antipodarum* takes 2–3 seasons. However, in the lake Białe Wigierskie the snail has been present at least since 1993 (KOŁODZIEJCZYK 1996) but in spite of this its occurrence is limited to the single, and always the same locality near the neck separating the lake from Wigry. Besides, densities it reaches in that site are still very low (1 individual in 5 samples of Characeae in 1993, 7 in 5 reed samples in 1998). It is possible that the five-year period is too short for a conquest of a lake of this size. Though DORGELO's (1987, 1990) data do not indicate any density differences between populations of different trophy, it is conceivable that this α-mesotrophic, isolated lake does not ensure a proper food basis for the snail; it was demonstrated that the density of *P. antipodarum* was positively correlated with chlorophyll *a* concentration in the water (Table 5). However, the positive correlation between the trophy and the density of *P. antipodarum*, calculated generally for the lakes of the Wigry National Park, was statistically insignificant. The lack of statitical significance may result from the number of lakes included in the analysis being relatively low (16) and their categorization with respect to trophy which does not reflect their differentiated concentration of biogenic substances. It was, however, necessary to apply such a general classification since there is no single parameter that would unambiguously inform about the trophy level of a lake. The result may be also biased by the fact that *P. antipodarum* is still invading the lakes of the Park, and hence its densities in particular lakes may be far from those potentially possible. Eutrophic lakes, such as Czarne Huciańskie and Koleśne, where the presence of *P. antipodarum*, though discovered in 1998, according to GRUŻEWSKI's (1996) conjectures dates back to at least 1995, seem to conform to the invasion scenario described by STRZELEC & KRODKIEWSKA (1994) – the species is still not an absolute dominant, like in the lake Wigry, but seems to play an important role, especially in the malacofauna of bottom deposits. The distribution pattern of *P. antipodarum* in the waters of the Wigry National Park suggests that the species spreads between water bodies in a "lake-hopping" way, irrespective from the lack or presence of connection through water-courses, most probably introduced by animals or humans. Local dispersal within large water bodies may be significantly aided by passive dispersal on drifting algal mats. HERBOLD & MOYLE (1986) maintain that anthropogenic disturbance of ecosystems creates favourable conditions for invasion of alien species, occupying niches vacated as a result of extinction or decreased abundance of native species. The abundance of snails in eutrophicated lakes is lower than in mesotrophic ones which results, among others, from the limited surface, range and diversity of suitable substrata – macrophytes (PIECZYŃSKA et al. 1998). The changes may be less deleterious to *P. antipodarum*, because of its biology and habitat requirements. The success of invasion of *P. antipodarum* depends probably on the degree of ecosystem disturbance, and neither the lack of any anthropopressure nor its excess favour existence of stable populations of the species. LODGE (1993) pointed to ecological results of invasion of alien species. KRODKIEWSKA et al. (1998) suggest a possibility of dislodging of authochthonous snail species by *P. antipodarum* from water bodies of Upper Silesia. The invasion of *P. antipodarum* requires more detailed studies on its effect on native biocoenoses, if only because of the scale of the phenomenon.

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