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THE ROLE OF LYMNAEIDS (BASOMMATOPHORA: LYMNAEIDAE) IN THE DISPERSAL OF A NEW ZEALAND SNAIL *POTAMOPYRGUS ANTIPODARUM* (GRAY, 1843) (PROSOBRANCHIA: HYDROBIIDAE)

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ABSTRACT: Based on dissection of specimens collected in the field and on laboratory experiments, *Lymnaea stagnalis* (L.) has been found to consume live individuals of *Potamopyrgus antipodarum* (Gray), a prosobranch snail originating from New Zealand. *P. antipodarum* is not digested by the lymnaeid and passes undamaged through its gut. The phenomenon may be of significance for the expansion of *P. antipodarum* in European waters.

KEY WORDS: aquatic snails, *Lymnaea stagnalis*, *Potamopyrgus antipodarum*, expansion

INTRODUCTION

The prosobranch snail from New Zealand – *Potamopyrgus antipodarum* (Gray, 1843) [= *P. jenkinsi* (E. A. Smith, 1889)] is at present among the most common and most abundant snails in Poland. The species was first found in freshwaters of our country in 1933 by URBAŃSKI, in the lake Trląg near Inowrocław (URBAŃSKI 1938). Since then, its rapid expansion has been observed, in both flowing and stagnant waters of Poland. The snail has colonised, among others, considerable areas of the lakelands of northern and western Poland, and recently also Upper Silesia (STRZELEC 1993). *P. antipodarum* is an unusually euryoecious species: it occurs in brackish sea and inland waters, small and large rivers, lakes, ponds and anthropogenic reservoirs (PIECHOCKI 1979, STRZELEC 1993). It appears to find the most favourable conditions in a shallow lake littoral, where its density may even exceed 100,000 individuals/m^2 (WOLNOMIEJSKI & FURYK 1969).

Also in Western and Northern Europe *P. antipodarum* is now widespread and very common (JAECKEL 1962, FRETTER & GRAHAM 1978, WILLMANN & PIEPER 1978, GLÖER & MEIER-BROOK 1994, GITTENBERGER et al. 1998, KERNEY 1999). According to a common opinion, the expansion of the species in European waters is associated with the fact that it can survive at salinity from 0 to 17‰, its parthenogenetic reproduction and ability to live in a variety of stagnant and flowing waters. As pointed out by FRETTER & GRAHAM (1978), an important role in invasion of new water bodies is played by a passive dispersal: the snail is transported with ballast water of ships, attached to floating objects or clumps of drifting vegetation, or sent over long distances with fish fry or aquatic plants. Birds and fishes may considerably contribute to its dispersal. BONDESEN & KAISER (1949) report that snails may pass alive through alimentary tracts of some fish species, e.g. perch and lake trout.

PIECHOCKI'S (1998) studies have revealed that *P. antipodarum* is sometimes consumed by lymnaeids. Numerous individuals of that snail were found in gut contents of *Lymnaea stagnalis* (L.), *L. auricularia* (L.) and *L. palustris* (O. F. Müller). Dissecting preserved material has not answered the question if the individuals of *Potamopyrgus* devoured by the lymnaeids are digested, or perhaps pass undamaged through their alimentary tract. The answer to this question is provided below.

STUDY AREA, MATERIAL AND METHODS

The material was collected on July 2nd 1999 in the phytolittoral of the lake Śpierewnik (53°46'0''N, 17°41'9''E) in the Tucholski Landscape Park. A total of 17 adult *L. stagnalis* were collected, of which 10 were preserved in 75% ethyl alcohol, and 7 were kept in the laboratory for further observations. The shell height of the snails was 45.0–55.0 mm.

The density of *P. antipodarum* in the collecting site was estimated based on a quantitative sample of 1,000 cm^2. Bottom sediments were taken from a section of 50 cm, with a rectangular dredge net of 20 cm side. The resulting density, converted to 1 m^2, was 34,370 individuals.

The preserved lymnaeids were dissected under stereomicroscope (10×). The contents of all the alimentary tract, from the oesophagus to the rectum, was examined.

In order to check if the swallowed *P. antipodarum* passed alive through the alimentary tract of the lymnaeid, individuals of *L. stagnalis* were placed singly in 3 l water-filled containers. Prior to placing them in the containers, the snails were thoroughly rinsed with a strong water current in order to remove *Potamopyrgus* that might possibly adhere to their bodies or shells. The faeces of the lymnaeids and the container walls were checked for the presence of *Potamopyrgus* after 8, 22, 34 and 40 hours. Live *P. antipodarum* found during consecutive controls were removed from the containers and preserved in alcohol.

RESULTS

The examination of the contents of the alimentary tracts of the preserved lymnaeids revealed that 9 of them (90%) contained individuals of *P. antipodarum* (Table 1). Besides usually numerous *P. antipodarum* with soft parts intact, the alimentary tracts contained also their empty shells, sand grains (50–60% gut contents), cladoceran ephippia, ostracods, fragments of live and dead tissues of macrophytes, as well as diatoms and other algae. The most numerous *P. antipodarum* (27 individuals) were found in a *Lymnaea* of 48.2 mm shell height.

The observations on the lymnaeids kept in the laboratory demonstrate unequivocally that *P. antipodarum* passes alive through the alimentary tract of *L. stagnalis* (Table 2). Among the individuals collected from the faeces or crawling in the containers, adult snails of 4.0–5.0 mm shell height, medium-sized (2.0–3.9 mm) and very small individuals (<2.0 mm) were found, some of them having only the embryonic shells. Live *P. antipodarum* were found in all the containers with controlled lymnaeids, their number per snail ranging from 1 (individual No. 3) to 30 (individual No. 5) (Table 2).

The passage through the alimentary tract did not seem to affect the condition and activity of *P. antipodarum* in any unfavourable way. All individuals of *Potamopyrgus* were crawling vigorously on the walls of the containers, examining the substratum in search of food. Both fully grown individuals and medium-sized or small snails easily freed themselves from the mucus surrounding the faecal pellets.

The analysis of the data from Table 2 indicates that the food consumed by *L. stagnalis* remains in the gut for ca. 20–24 hrs. During the control after 8 and 22 hrs, large and medium-sized *Potamopyrgus* prevailed in

Table 1. Presence of *P. antipodarum* in the alimentary tract contents of *L. stagnalis*

No.	Shell height of *L. stagnalis* (mm)	Number of *P. antipodarum*	Remarks
1	50.1	5	all *Potamopyrgus* in oesophagus
2	55.0	–	–
3	48.5	15	in various parts of alimentary tract
4	50.0	4	as above
5	48.2	27	as above
6	53.0	8	as above
7	47.3	6	as above
8	45.0	15	as above
9	47.2	8	as above
10	49.0	18	as above

Table 2. Results of observations on survivorship of *P. antipodarum* consumed by *L. stagnalis*; experiment started on July 2nd 1999, at 19.30. a – adult individuals, m – medium-sized individuals, j – juvenile individuals, s – empty shells

No. of individual of *L. stagnalis*	*P. antipodarum* after 8 hrs	*P. antipodarum* after 22 hrs	*P. antipodarum* after 34 hrs	*P. antipodarum* after 40 hrs
1	5 (a, m)	5 (a, m)	0	0
2	12 (a, m, j)	0	1 (a)	3 (j)
3	0	0	1 (j)	1 (s)
4	4 (m, j)	0	1 (j)	1 (j)
5	2 (a)	24 (a, m)	4 (m)	0
6	2 (m)	4 (a, s)	0	1 (m)
7	11 (a, m, j)	13 (a, m, j, s)	1 (m)	0

the containers; after 34 and 40 hrs almost exclusively juvenile or medium-sized individuals were found. It is likely that small *P. antipodarum*, found after 34 or even 40 hrs, were actually individuals swallowed by *Lymnaea* for the second time; their presence might have been overlooked during the previous control. This is evidenced by their shell surface, cleaned by digestive juices.

Besides *P. antipodarum*, two juvenile, live individuals of *Valvata piscinalis* (O. F. Müller) were found, as well as cladoceran ephippia, ostracods and a live tick (*Ixodes ricinus*)!

DISCUSSION

Laboratory experiments and dissection of preserved *L. stagnalis* demonstrate that the snail often devours *P. antipodarum* in considerable numbers. The phenomenon is associated with the omnivorous mode of feeding of the Lymnaeidae (GITTENBERGER et al. 1998). According to FRÖMMING (1956), the basic food of *L. stagnalis* consists of bacteria and algae taken up from the surface membrane and aquatic vascular plants consumed as living or dead; the author emphasises that *L. stagnalis* often eats protein of dead animals, especially fishes, amphibians and molluscs. SPORLENDER (1858) and ALSTERBERG (1930) (cited after FRÖMMING 1956) report that *L. stagnalis* consumes also live snails, e.g. *Armiger crista* (L.) and *L. truncatula* (O. F. Müller). However, the authors do not comment on the further fate of the devoured snails.

The analysis of gut contents of *L. stagnalis* indicates that the snail does not feed selectively, but consumes all mineral particles that can be detached from the substratum (e.g. sand grains), plant tissue (algae, fragments of macrophytes) and small invertebrates. It can be supposed that the proportion of various kinds of food depends directly on their availability on the feeding ground. For this reason individuals of *P. antipodarum*, present in masses in the phytolittoral of the lake Śpierewnik, were eaten by *L. stagnalis* and by other lymnaeid species (PIECHOCKI 1998).

The composition of digestive enzymes of the Lymnaeidae enables them to digest animal proteins (PURCHON 1977). It can be conjectured that live *P. antipodarum* are effectively protected from the action of these enzymes by the operculum that tightly closes the aperture. This pertains also to another prosobranch – *V. piscinalis* (see above). The observations indicate that the shells of small prosobranchs (*Potamopyrgus, Valvata*) are sufficiently strong to resist the intense grinding (sand grains!) movements in the lymnaeid stomach (ZAWIEJA 1979).

The ability of *P. antipodarum* to pass unharmed through the lymnaeid alimentary tract may be of importance for the dispersal of the species and invasion of new lakes or river systems. *P. antipodarum*, trapped in a lymnaeid, may be transported with it to new habitats. Transport by birds, mammals and humans, or by water currents is also conceivable. Due to its parthenogenetic reproduction mode, even a single individual of *P. antipodarum*, released with the faeces from the lymnaeid consumer, may give rise to a new population. It is very likely that the Lymnaeidae have contributed to the quick expansion of the New Zealand snail in European waters.

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