FOLIA MALACOLOGICA
Folia Malacol. 25(4): 281–285
ISSN 1506-7629 (print) • ISSN 2300-7125 (on-line)
The Association of Polish Malacologists
Faculty of Biology, Adam Mickiewicz University
Bogucki Wydawnictwo Naukowe
Poznań, December 2017
https://doi.org/10.12657/folmal.025.019

A POSSIBLE PHORETIC RELATIONSHIP BETWEEN SNAILS AND AMPHIBIANS

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ABSTRACT: We describe five observations of possible phoretic relationship between snails and amphibians in south-western Poland: two individuals of European tree frog *Hyla arborea* (Linnaeus, 1758) with juvenile snails attached to various parts of their bodies, common toad *Bufo bufo* (Linnaeus, 1758) with copse snail *Arianta arbustorum* (Linnaeus, 1758), pair of common toads in amplexus with two individuals of *Balea* sp. or *Laciniaria plicata* (Draparnaud, 1801), and common toad with succineid species eggs and developing snail embryos attached to them. These are the first such observations ever.

KEY WORDS: phoresy, *Hyla arborea*, *Bufo bufo*, land snails

INTRODUCTION

Phoretic relationships between organisms are widespread. They consist in one organism carrying another thus enabling its spread and finding the favourable habitat (for review see FARISH & AXTELL 1971). Such relationships have been described to occur between mites and beetles (BAJERLEIN & BŁOSZYK 2004), bumblebees (GUERRA et al. 2010), small mammals (KRANTZ & WHITAKER 1988) or birds (SILVA et al. 2015). Likewise, leeches (KHAN & FRICK 1997), midges (CALISTO & GOULARD 2000), nematodes (ENG et al. 2005), pseudoscorpions (SANTOS et al. 2005) and snails (PURCHON 1977, SIMONOVÁ et al. 2016) have been observed to use other animals as vehicles. However, to the best of our knowledge, there are no reports on similar relationships between amphibians and snails. Herein, we present the first description of five field observations of such interaction between these two taxa.

STUDY AREA, MATERIAL AND RESULTS

On the first occasion, during a clear night of April 11th 2016 in a green area with artificial pond in Wrocław (51°03'29.37"N, 17°04'49.66"E) we found two individuals of common toad *Bufo bufo* (Linnaeus, 1758), three green toads *Bufotes viridis* (Laurenti, 1768), five European tree frogs *Hyla arborea* (Linnaeus, 1758), and approximately 20 individuals each of water frog *Pelophylax esculentus* (Linnaeus, 1758) complex and smooth newt *Lissotriton vulgaris* (Linnaeus, 1758). One European tree frog hosted a juvenile individual of unknown species of the Helicidae which was attached to the top of its head (Fig. 1). A similar situation was observed on April 23rd 2017 (cloudy and rainy day, 9°C) in the same site. This time a European tree frog was caught with one juvenile individual of an unknown helicid spe-

Ministry of Science and Higher Education
Republic of Poland

Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland, under agreement no 747/P-DUN/2017 of May 19th, 2017 allocated to the activities for disseminating science:
Task 1: Preparation of English versions of publications (sum funded by DUN 9,000 PLN) and
Task 2: Digitalisation of publications and scientific monographs to enable their open access in the Internet (sum funded by DUN 7,000 PLN).

cies glued to the side of its body (Fig. 2). None of the four common and four green toads, two water frogs and three other European tree frogs which were also captured that day was found to carry "passengers". The third example of phoresy was observed on March 22nd 2017 (clear evening, 6°C), when 35 common toads migrated to a fish pond in the village of Domaszczyn (Natura 2000 area Kumaki Dobrej, 51°11'32.39"N, 17°09'37.76"E). One pair of toads in amplexus hosted two individuals of *Balea* sp. or *Laciniaria plicata* (Draparnaud, 1801). One was attached near the female's mouth, another to the male's back (Fig. 3). Fourth, on 31st March 2017, on a quite warm (13°C) and clear evening, among approximately 70 common toads migrating in the same locality, one individual was found to carry a juvenile copse snail *Arianta arbustorum* (Linnaeus, 1758) on its back (Fig. 4). The last case was observed on a cloudy night (10°C) of May 2nd, 2016. In total, we examined five common toads migrating on the grass near an artificial fish pond in the town of Raszków (51°43'42.66"N, 17°43'14.98"E). One male was carrying 58 snail eggs on the entire dorsal part of its body (head, back, hind limbs and forelimbs). Some of the eggs contained developing embryos (Fig. 5). These eggs, uncalcified and translucent (diameter ca. 1.8–2 mm), were laid by *Succinea putris* (Linnaeus, 1758), *Oxyloma elegans* (Risso, 1826) or *O. sarsi* (Esmark, 1886) (the nomenclature of succineid species follows Welter-Shultes 2012).

DISCUSSION

So far, there are only few reports on snails acting as either phoretic and host organisms. Darwin (1859) observed hatchlings of freshwater snails attached to a duck's foot. There are also some observations concerning accidental relocation of gastropods as food of birds or other snails. Piechocki (1999) found that *Lymnaea stagnalis* (Linnaues, 1758) transported juvenile and adult *Potamopyrgus antipodarum* (Gray, 1843) in its alimentary tract; live snails were found in the lymnaeid's faeces. Another example of snail-bird phoretic relationships was provided by Simonová et al. (2016). Live *Alinda biplicata* (Montagu, 1803), *Cochlodina laminata* (Montagu, 1803) and *Discus rotundatus* (O. F. Müller, 1774) were fed to 10 bird species (Corvidae, Turdidae, Sturnidae and Columbidae). Several snails passed intact through the bird alimentary tract and were alive. In two of the described cases the dispersal was endozoic, but *A. biplicata* and *C. laminata* were found attached to birds' legs by pedal adhesion (Simonová et al. 2016). Accidental transport of molluscs may take place during foraging of amphibians as well. Land snails and slugs are often eaten by frogs and toads (Juszczyk 1987). A gastropod can get glued to the foraging toad or frog and be relocated to a new place. However, it seems that it is more common for snails to serve as vehicles for dispersal of small invertebrates such as midges (Vinikour 1982, Prat et al. 2010) or beetles (Vaz-de-Mello 2007). Some juvenile aquatic snails may also increase their success rate by shifting the cost of their obligatory upstream migration onto other snails (Kano 2009).

Ecological interactions between amphibians and other animals are also poorly known. The best described cases are anurans using bromeliads as breeding sites; the bromeliads host ostracods, ciliates and annelids which use the anurans as vehicles (Lopez et al. 1999, 2005, Sabagh et al. 2011). Some reports suggest phoretic and/or, more likely, parasitic relationship between leeches and anurans or urodeles (Platt et al. 1993, Tiberti & Gentilli 2010, Maia-Carneiro et al. 2012, Zimić 2015).

There are also two described interspecific relationships between bivalves and amphibians. Kwet (1995) observed two individuals of the common toad with mussels on their toes causing no harm. However, Wood et al. (2008) found many individuals of four newt species affected by mussels which caused local tissue and bone damage to their hosts; they suggested a novel form of parasitism.

Our observations present an as yet undescribed, possibly phoretic relationship between snails and anuran amphibians. It can be observed especially during spring when mating seasons of both taxa coincide. Indeed, all of the described cases were observed between the end of March and the beginning of May.

During numerous field trips conducted in 2016–2017 for our scientific projects, we observed only few instances of phoresy. However, two of them came from the same urbanized site. This may be caused by the fact that the water body is concerned under anthropogenic pressure, and as an abandoned open pool also constitutes a trap for amphibians and other small animals (mammals, reptiles, invertebrates) whose density may be relatively higher in relation to the surrounding area. This animal-threatening situation may promote the occurrence of phoresy.

The most interesting example seems to be the common toad covered with snail eggs and developing embryos. We suggest two possible explanations: (i) the toad passed through the egg mass and some of the eggs stuck to its skin, however we did not observe any snail egg batches nearby, or (ii) an attached adult snail moved over the toad's body and laid the eggs directly on the skin. There was no evidence of any

Figs 1–5. Snails attached to: 1–2 – European tree frog (*Hyla arborea*) (1 – with juvenile helicid on its head, 2 – on its side); 3–5 – common toad (*Bufo bufo*) (3 – two specimens in amplexus with two individuals of *Balea* sp. or *Laciniaria plicata*, 4 – with juvenile Copse snail (*Arianta arbustorum*), 5 – an individual covered with eggs of *Succinea* sp.). White arrows show snails, yellow arrows – eggs and red arrows – developing embryos. Photos by A. NAJBAR (1, 2), N. KUŚMIEREK (3) and K. KOLENDA (4, 5)

external injuries so we presume that snail eggs do not harm the toad skin. Many snails, when suddenly captured, lay eggs in a situation of stress (MALTZ, unpublished data) which might lend support to the second conjecture. The toad's skin is much thicker and more resistant compared to other native amphibian species, but a negative influence cannot be excluded, for example, for *Rana* sp. Supposing that originally the toad had only eggs on its body, our observation may indicate that their hatching could be possible also on an atypical substratum, and that the eggs may have been carried for a relatively long time (and distance?). In *Succinea putris* the development from egg-laying to hatching takes 11–28 days (KUŹNIK-KOWALSKA et al. 2013).

We think that such interactions may be of advantage to the phoretic animals without any evidence of harm to their "vehicle". However, there is no clear indication that the reported cases are not exclusively accidental. Further research on the phenomenon is needed.

ACKNOWLEDGEMENTS

We thank Prof. BEATA M. POKRYSZKO for her valuable comments on the first draft of the manuscript, two anonymous reviewers for their constructive remarks and Prof. ANDRZEJ LESICKI for editing. PAWEŁ T. DOLATA, MARZENA FRYDLEWICZ, ALEKSANDRA PUCHTEL and AGATA STARZECKA helped us during field work.

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Received: September 29th, 2017
Revised: October 9th & 12th, 2017
Accepted: October 16th, 2017
Published on-line: November 20th, 2017