Arion slugs as nest predators of small passerine species – a review

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Abstract

Arionid slugs have been reported to attack nestlings of some ground- or shrub-nesting passerine birds, mainly in Europe. We review these reported cases and consider their effects. The slugs can cause grave or even fatal injuries to the nestlings. Surprisingly, no brood defence by the parents has been described. The information on the frequency of slug predation in bird populations is scanty, and the scale of the phenomenon is unknown. The expansion of the invasive *Arion vulgaris* Moquin-Tandon, 1855 (synonymously *A. lusitanicus* or *A. lusitanicus* auct. non Mabille, 1868) in Europe may result in an increase of the negative influence of slugs on the breeding success of some passerines in the near future.

Introduction

Predators are rare among terrestrial gastropods (Wiktor 1958, 2004, Urbański 1984). In Europe, they can be found in a few families, e.g. Testacellidae, Daudebardiidae, or the genus *Poiretia*. Their diet is based on invertebrates, mainly on earthworms and other molluscs (Barker and Efford 2004), and they show an array of adaptations to carnivory. Although regarded as omnivorous, mainly feeding on plant tissues, mushrooms, faeces or carrion, some slugs (including *Arion* species) can attack live slow-moving invertebrates or even vertebrates (Wiktor 1958, 2004). There are incidental observations of slugs attacking birds, but most of these lack any assessment of frequency (Diesselhorst 1953, Schmidt and Hantge 1954, Bock 1961, Martin 1980, Pätzold 1983, Dittberner and Dittberner 1984, Bezzel and Stiel 1977, Biassioli 2009). There has been little research on defined populations of birds in this context (Flinks 2008, Sklepowicz 2008, Bijlsma 2012).

We summarise the available knowledge concerning slug predation on small passerine nestlings in order to draw attention to this unusual phenomenon and its possible influence on local bird populations. While some reports are single observations of unidentified slugs, others refer to the larger species in the genus *Arion*: the Red slug *Arion rufus* (Linnaeus, 1758), the Black slug *Arion ate*r (Linnaeus, 1758) and the invasive slug *Arion vulgaris* Moquin-Tandon, 1855 – called the Spanish slug, *Arion lusitanicus* Mabille, 1868 or *Arion lusitanicus* auct. non Mabille, 1868 (the taxonomic status of the species from family Arionidae is unclear; Kappes et al. 2012, Roth et al. 2012, Pfenninger et al. 2014). Identification of these species in the field is difficult, indeed often impossible (Wiktor 2004, Welter-Schultes 2012, Rowson et al. 2014).

Slugs as predators

The first report on the negative influence of slugs on birds' breeding success comes from the 1920s. Floericke (1922) called slugs "the enemies" of the Skylark *Alauda arvensis*, able to damage skulls of its nestlings ("bite through the brain"; Floericke 1922: 189). Further evidence that slugs can kill nestlings has been provided by a number of authors (Diesselhorst 1953, Marbot 1959, Bock 1961, Sklepowicz 2008, Biassiolli 2009, Leniowski et al. 2013, Turzańska and Chachulska 2015).

A few papers (some with photographs) describe the actual attack; these unequivocally prove that slugs are able to predate on passerine nestlings. Others describe the injuries, different from those left by other known bird predators, which together with mucus trails and droppings, strongly indicate a slug as the cause of death (Diesselhorst 1953, Schmidt and Hantge 1954, Bock 1961, Martin 1980, A. Wuczyński, personal communication – Fig. 1).

The injuries caused by the slugs are usually grave, e.g. bleeding wounds, holes in the stomach with viscera exposed, vast skin lesions on wings, back, neck or head, partially eaten muscles or bills, even loss of eyes. Both soft tissues and bones may be damaged and the carcass is usually heavily covered with mucus (Marbot 1959, Sklepowicz 2008, Biasiolli 2009, Leniowski et al. 2013, Turzańska and Chachulska 2015). Injuries caused by slug foraging do not always lead to the nestlings' death – the attacked nestlings may even successfully fledge (Bock 1961, Flinks 2008). However, the mere presence of the slug may affect the nestlings, e.g. by decreasing their body temperature (Martin 1980, Bijlsma 2012).

Eggs may also be predated by the slugs as gastropods require considerable quantities of calcium normally obtained from rocks or shells of other snails (Wiktor 1958). There are two described cases of gastropod feeding on a free-living bird's egg. Turzańska and Chachulska (unpublished) found a Whitethroat's *Sylvia communis* egg (from an abandoned brood) with a small hole in the shell where the *Arion* slug was previously attached with its mouth. Diesselhorst (1953) described an unidentified snail trying to get inside a Bluethroat's (*Luscinia svecica*) egg which had fallen out of the nest, in this instance however the shell was still intact.

Lack of nest defence against slugs

All reports describe a lack of parental defensive reaction or abandoning the brood (Bock 1961, Martin 1980, Sklepowicz 2008, Turzańska and Chachulska 2015). Leniowski et al. (2013) showed that instead of attempting to prevent slug predation, the Blackcaps *Sylvia atricapilla* behaved irrationally, incubating the slug which was feeding on the nestlings' carcasses. Bock's (1961) hypothesis that the slugs move too slowly to attract the birds' attention seems implausible as the Blackcap usually cleans the nest of unnecessary objects (Leniowski et al. 2013). The slugs predate bird broods very rarely, probably entering their nests accidentally (Diesselhorst 1953, Flinks 2008, Sklepowicz

2008). This may be the reason why birds do not recognize slugs as a danger to their young and have not yet developed a defensive response against this occasional predator.

When do slugs enter bird nests?

Biasiolli (2009) suggested that slug predation may occur in some atypical circumstances, e.g. when the nestlings fall out of the nest to the ground or when one of the parents abandons the brood. However, there are only two described cases of the male desertion combined with slug predation, and it seems that most of the incidents happen in usual conditions (Table 1).

Some authors stress cold, wet weather as factors favouring slug predation (Flinks 2008, Bijlsma 2012). Flinks (2008) reported that the lowest percentage of nests with slug mucus was found in the warmest and driest of the five years of his study. He also suggested that the weather during the period when nestlings stay in the nest was crucial for the level of slug predation. High humidity is indeed favourable for this group of gastropods (White 1959, Grimm et al. 2000, Kozłowska and Kozłowski 2004). However, in temperatures below 4-5°C slugs are inactive (White 1959, Kozłowski 2007) and they also avoid overheating and drying, escaping from places warmer than 22°C (Dainton and Wright 1985). In wet and cool years slug activity – and thus predation – may be greater than in dry and hot ones.

Despite being omnivores, the *Arion* slugs show preferences for certain plant species (Briner and Frank 1998, Kozłowski and Kozłowska 2004). The question arises if slugs would prefer animal matter to plants and if they can detect the scent of nestlings and recognise it as indicating a potential food source. Leniowski et al. (2013) observed a slug (*A. vulgaris*) consuming Blackcap nestlings the day after they had removed a mollusc from the nest (it might had been the same individual). Some slugs can certainly detect odours, learn and change their feeding habits (Sahley et al. 1981). It remains to be discovered if nestlings are identified from a distance and approached.

The scale and range of slug predation

The available information about the frequency of *Arion* predation on passerines is shown in Table 2. The high values for the Whitethroat, the Wood Warbler *Phylloscopus sibilatrix* and the Reed Warbler *Acrocephalus scirpaceus* are probably overestimated because of the small sample of controlled nests. Diesselhorst (1953), Borowiec (personal communication) and Turzańska and Chachulska (unpublished) found no or single broods predated by slugs in their long-term studies on the Whitethroat.

All the described cases of nest predation by slugs concern ground- and shrub-nesting bird species. The recorded heights of the predated nests are: 25 cm (Whitethroat, Turzańska and Chachulska 2015), 50 cm (Chiffchaff *Phylloscopus collybita*, Bock 1961), 77 cm (Marsh warbler *Acrocephalus palustris*, Sklepowicz 2008) and 81 cm (Blackcap, Leniowski et al. 2013). The species that build their nests close to the ground, seem to be most vulnerable to the slug predation. During the last 45 years the large *Arion vulgaris* has become an invasive species in many European countries (Rabitsch 2006, Weidema 2006, Kozłowski 2007, Kappes et al. 2012). The records listed above show that the slug predation may be a long-standing but rare hazard for some birds (Floericke 1922, Diesselhorst 1953, Schmidt and Hantge 1954, Bock 1961). However, mass occurrence of invasive slug species – nowadays more and more frequent – may severely affect local bird populations by decreasing their breeding success.

Our intention is to sensitize biologists to slugs posing a real threat to birds' broods and to draw the field researchers' attention to any unusual circumstances of brood losses and nestling injuries that may be caused by slug activity.

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FIGURE LEGEND

Fig. 1

TABLE LEGENDS

Table 1. Circumstances of slug predation on broods of various bird species.

N – number of broods.

Conditions	Bird species	Slug species	Country
Nestlings dead or injured in the nest (N=19)			
	Acrocephalus palustris	*Arion sp.*	Poland[9]
	Acrocephalus scirpaceus/ Cuculus canorus	*a slug*	Germany[8]
	Embeliza citrinella	*Arion sp.*	Germany[3]
	Embeliza citrinella	a black slug	Germany[4]
	Embeliza citrinella	*Arion sp.*	Germany[4]
	Embeliza citrinella	*Arion sp.*	Germany[4]
	Emberiza schoeniclus	a red slug	Germany[3]
	Phylloscopus collybita	*Arion sp.*	Germany[3]
	Phylloscopus sibilatrix (N=2)	*Arion ater*	Netherlands[2]
	Phylloscopus sibilatrix (N=4)	*Arion sp.*	Netherlands[2]
	Saxicola rubetra	a red slug	Germany[7]
	*Saxicola rubicola (4 pull)**	*Arion rufus/ vulgaris*	Germany[5]
	Sylvia atricapilla	*Arion vulgaris*	Poland[6]
	Troglodytes troglodytes	*Arion ater*	Germany[4]
Nestlings outside the nest (N=4)			
	Embeliza citrinella	*Arion sp.*	Germany[3]
	Embeliza citrinella	*Arion sp.*	Germany[4]

	Embeliza citrinella	*Arion ater*	Germany[4]
	Setophaga caerulescens	*Arion sp.*	USA[1]
Male deserted (N=2)			
	Setophaga caerulescens	*Arion sp.*	USA[1]
	Sylvia communis	*Arion rufus/ vulgaris*	Poland[10]

* The number of broods from which the four nestlings originated was not reported in the paper

References: [1]Biasiolli 2009, [2]Bijlsma 2012, [3]Bock 1961, [4]Diesselhorst 1953, [5]Flinks 2008, [6]Leniowski et al. 2013, [7]Martin 1980, [8]Marbot 1959, [9]Sklepowicz 2008, [10]Turzańska and Chachulska 2015.

Table 2. Frequency of broods of various bird species predated by the slugs *Arion* sp.

Species	Number of controlled broods	Broods predated by *Arion* sp.	
		N	%
Phylloscopus sibilatrix (Bijlsma 2012)	12	6	50.0
Acrocephalus scirpaceus (parasited by *Cuculus canorus*, Marbot 1959)	10	3	30.0
Sylvia communis (Turzańska and Chachulska 2015)	14	1	7.1
Saxicola rubetra (Schmidt and Hantge 1954) *	129	2	2.7
Saxicola rubicola (Flinks 2008) *	209	1-4	0.5-1.9
Saxicola rubetra (Bezzel and Stiel 1977)	-	-	1.2
Acrocephalus palustris (Sklepowicz 2008)	282	1	0.3
Setophaga caerulescens (Biasiolli 2009)	2900	2	0.0

* predadion uncertain