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Ants biting amphibians: a review and new observations

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ABSTRACT

Antagonistic interactions between insects and amphibians are the subject of many scientific articles, mostly concerning amphibian predation on insect, but many fewer examples exist of the opposite situation. In this article we review available information from the literature and add our own observations collected during amphibian pitfall trap monitoring in 2012–2016 in Western Poland, as well as discuss potential conservation implications of observed behavior. We identified a total of 29 cases involving 94 individual ants attacking four species of Anura, *Rana temporaria, Pelophylax esculentus* complex, *Bufo bufo*, and *Pelobates fuscus*, and biting their back, cloaca, armpits, or hind legs. Bites were inflicted by three ant species: *Myrmica rubra, Lasius fuliginosus*, and *Formica polyctena*. The number of ants found on an amphibian was positively and significantly correlated with its body length. To date, direct damage by ants on amphibians was reported mainly from the tropics in general predation accident. However, as we document here, it is probably a more common phenomenon, especially in some ecological traps or during pitfall trapping, which is a common method to mitigate road mortality of frogs and toads.

KEYWORDS

Anura; drift fences; Formicidae; frogs; interaction; toads

INTRODUCTION

Direct damage caused by invertebrates on amphibians mainly concerns predation accident for all we know. Data on vertebrate predation by invertebrates in the literature is scarce, since it is difficult to observe such behavior in natural conditions (Toledo 2005). However, predation behavior toward vertebrates by invertebrates is not as common as the opposite situation, but it is also nothing extraordinary (McCormick & Polis 1982; Scholtz & Ralston 2017; Toledo 2005; Bernard & Samoląg 2014). The most common invertebrate predators are spiders and insects (e.g., Belostomatidae: Carabidae), and the most common habitats are water bodies (McCormick & Polis 1982; Toledo 2005). Although there is a noticeable amount of information about such predation in water bodies (McCormick & Polis 1982; Toledo 2005; Linares et al. 2016), cases in terrestrial ecosystems are scarce and mostly concern ground beetles (Coleoptera: Carabidae) (Wizen & Gasith 2011a; Wizen & Gasith 2011b; Bernard & Samoląg 2014). Some authors suggest that there are major knowledge gaps in this regard for terrestrial systems and incidental predation; such events are observed only opportunistically and described as anecdotal data. In the case of small lizards (arboreal gecko), predation rates by invertebrates are responsible for up to 23% of predation events during an experiment conducted in the wet season in Australia (Nordberg et al. 2018). Therefore, some invertebrates should be considered, at least seasonally, a significant component of food web dynamics, which requires further research. Against this background, other direct and indirect damage conduct by insects on amphibians was not well described yet in specialist literature in our opinion.

Ants can inflict some damage to amphibians most probably when the latter are trapped in some kind of hole or

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crevice and unable to escape. Consequently, it is difficult to conduct research on this topic in strictly natural conditions, but other man-made holes can act as a good substitute for investigating ant attacks on amphibians. One means of conducting such observations can be through the use of pitfall traps, a commonly used approach in both research and conservation projects (Puky 2006; Schmidt & Zumbach 2008).

Pitfall traps are one of the most commonly used passive traps in herpetological research (Jenkins et al. 2003; Sutherland 2006; McKnight et al. 2015). This method has many advantages including intensive sampling of animals in terms of time and effort and more standardized samples than in visual searches. For amphibians, the system usually consists of a fence and some empty containers (e.g., buckets), which are buried to be flush with soil level (Sutherland 2006). Amphibians (and other species) fall into pitfalls and become trapped (Willson & Gibbons, 2009). Use of this method to study vertebrates (in particular amphibians) requires regular and frequent checking in order to reduce the negative impact of prolonged capture (Sutherland 2006). Extending the scope of routinely collected data from pitfall traps during mitigation projects may be an opportunity to describe inter-species interactions occurring inside traps. It is worth mentioning that descriptions of amphibian predation in pitfall traps by mammals (Jenkins et al. 2003; Ferguson 2006; Ferguson et al. 2008), birds, or snakes (Enge 1997; Willson & Gibbons 2009) have been reported in the literature. Some authors proposed a technical modification to prevent predation (Sutherland 2006) but agile predators (e.g., snakes) can still enter pitfalls and consume animals (Ferguson 2006). On the other hand, information on insect direct damage of amphibians in pitfall traps is scarce; as far as we know only fire ants, *Solenopsis invicta* Buren, 1972, and some beetles have been thus recorded (Enge 1997; Enge 2001).

However, in this context, there are no solutions to protect amphibians from invertebrate attacks.

Following rare but repeated observations of ant attacks on amphibians in our pitfall trap system, we decided to investigate this phenomenon. We also try to explain the observed frog-ant interactions.

1. MATERIALS AND METHODS

All observations were made in a drift fence system on a road intersection in Poznań, Poland. This road crosses a valuable natural area and adjacent forest complex that is an ecological corridor (Dyderski et al. 2014). On both sides of the road temporary fences have been established for seasonal protection of the local amphibian population during migration. The fence is equipped with pitfall traps about every 15 m on average (totally 800 m of fence and 50 traps). In 2012–2017, during mitigation work, pitfalls were checked daily in the morning in two periods: (1) spring migration in March–May and (2) autumn dispersion of juveniles in August–October. A total of 6838 amphibians were captured, mostly Anura—6228 individuals (M. Kaczmarski, unpublished data). During hot and dry periods, to avoid desiccation of captured animals, checking was conducted twice a day. In the study area 11 species of amphibians (Kaczmarek et al., 2015) and 15 ant species (M. Michlewicz, unpublished data) occur. Trapped amphibians were carefully checked for ants and, when found, the amphibians were measured (snout-vent length, SVL, with calipers to an accuracy of 0.1 mm).

2. RESULTS

We recorded 29 cases of ants attacking amphibians by a total of 94 ants (Table 1), which represent only 0.47% of captured animals. Four amphibian taxa, *Rana temporaria* Linnaeus, 1758, *Pelophylax esculentus* complex, *Bufo bufo* Linnaeus, 1758, and *Pelobates fuscus* Laurenti, 1768, were observed with ants biting their back, cloaca, armpits, or hind legs (Fig. 1 & 2). No case on ant attacks on Caudata (smooth newt *Lissotriton vulgaris* Linnaeus, 1758) or on other Anura species occurring in this site was noted. Ants inflicted attack mostly on juvenile Anura of taxa dominant inside pitfall trap, but in the case of *B. bufo* only on adult individuals (Fig. 2C & D). Most cases (27 out of 29) were recorded in the autumn (Table 1).

The number of ants biting on amphibians was positively correlated with amphibian body length ($r = 0.407$, $n = 28$, $P < 0.05$).

Three ant species were recorded performing this behavior (Table 1). *Myrmica rubra* Linnaeus, 1758, was recorded biting the *P. esculentus* complex, *P. fuscus*, and *B. bufo* individuals and kept mostly to the hind legs or, rarely, forelegs and armpits. *Lasius fuliginosus* Latreille, 1798, was observed biting *R. temporaria* and the *P. esculentus* complex in the cloaca area, belly, and legs of the amphibians. *Formica polyctena* Förster, 1850, was observed biting *B. bufo* in the hind legs, bottom, and armpits. Detailed information is available in the Supplementary materials (SM)—Appendix 1.

In the case of two *P. fuscus*, individuals bitten by ants were weak, and had movement problems and swollen bodies. After the removal of the ants they returned to a good condition within 48 h and were released. Dead amphibians both with ants bitten on the body and without any ants, as well as some dead ants, were found in the pitfall traps, but reasons for death are unknown (SM—Appendix 1).

3. DISCUSSION

We report cases of ants biting adult frogs and toads, which is a novelty, because so far most researchers have focused only on direct damage by ants on amphibians. We did not notice any case of ant attacks on *L. vulgaris*, probably because of greater agility (Caudata can easily remove ants using the snout or eat them).

According to our knowledge, four ant species are known to be predators of amphibians. The first of these, *Paraponera clavata* Fabricius, 1775, is a giant, predatory species from South America, which hunts frogs from the genus *Eleutherodactylus* Duméril and Bibron, 1841, and strawberry

Table 1. Summary of all reported cases of ants biting amphibians recorded during our study.

Ant species	Amphibian species*	Number of cases	2012	2013	2014	2015	2016	Ant bites of amphibians			
			Autumn				Spring	Min	Max	Mean	Total
Myrmica rubra	PEC	4	4	-	-	-	-	2	9	5.0	20
	RT	5	1	-	-	4	-	1	2	1.6	8
	PF	2	-	1	1	-	-	3	14	8.5	17
	BB	1	-	1	-	-	-	5	5	5.0	5
		12	5	2	1	4	-	1	14	4.2	50
Lasius fuliginosus	PEC	11	-	9	2	-	-	1	7	2.2	24
	RT	3	-	3	-	-	-	2	4	3.0	9
		14	-	12	2	-	-	1	9	2.4	33
Formica polyctena	BB	2	-		-	-	2	2	4	3.0	6
Species indefinite	RT	1	-	1	-	-	-	5	5	5	5
Total		29	5	15	3	4	2	1	14	3.2	94

**PEC—Pelophylax esculentus complex; RT—Rana temporaria; PF—Pelobates fuscus; BB—Bufo bufo*

poison frogs *Oophaga pumilio* Schmidt, 1858 (Fritz et al. 1981). *Iridomyrmex purpureus* Smith, 1858, an ant from Australia, is known to hunt small individuals of the cane toad *Rhinella marina* Linnaeus, 1758, after its metamorphosis (Clerke & Williamson 1992). The red imported fire ant *S. invicta* hunts Houston toad *Anaxyrus houstonensis* Sanders, 1953 (Thomas & Allen 1997; Brown et al. 2012), and the mole salamander *Ambystomatal talpoideum* Holbrook, 1838 (Todd et al. 2008). Lastly, the red wood ant *Formica rufa* Linnaeus, 1761, is the only temperate species known to predate amphibians, and is known for hunting juvenile common toads *B. bufo* (Zuffi 2001).

However, the interaction between ants and amphibians found in pitfall traps is not necessarily direct predation, because:

1) The pitfall traps collect both ants and amphibians but the former can escape from them easily. When more and more ants fall into, or simply aggregate in, the pitfall traps, they react to the sudden movements of the amphibians and start to bite them. Similar results (i.e., toleration but biting after sudden movements) were found in amphibian and ant hiding places in the savanna (Rödel & Braun, 1999).

2) Ants use pitfall traps to prey on invertebrates; but when an amphibian was caught inside the trap, ants tried to attack it. However, the number of ants was probably too low to kill the amphibian.

3) Amphibians inside pitfall traps might be a little desiccated and generally weaker (Parris 1999), so they are probably an easier target for ants and other predators. In this case, the ants can play the role of scavengers.

Pitfall traps in our study were probably used by ants as a food reservoir rather than a nesting site because there was no evidence of eggs, larvae, pupae, or a nest in the buckets during observations. However, there is a possibility that the ant nest was located under the buckets, as they possess drainage holes in the bottom. No amphibians with ants on them were found outside the pitfall traps. This is probably because of the fact that in the restricted area of pitfall traps it is easier for an ant to bite an amphibian. Every ant that bit the anurans was alive and able to release itself when amphibians were released from the pitfall traps. In Europe, probably only red wood ant (and its relatives from the subgenus *Formica sensu stricto*) can be actual predators of amphibians, since it is a big, non-selective predatory species, which can forage within about 100 m from its nest (sometimes further) (Czechowski et al. 2012). This is in agreement with the results found by Zuffi (2001). However, in some cases (e.g., in pitfall traps as documented here),

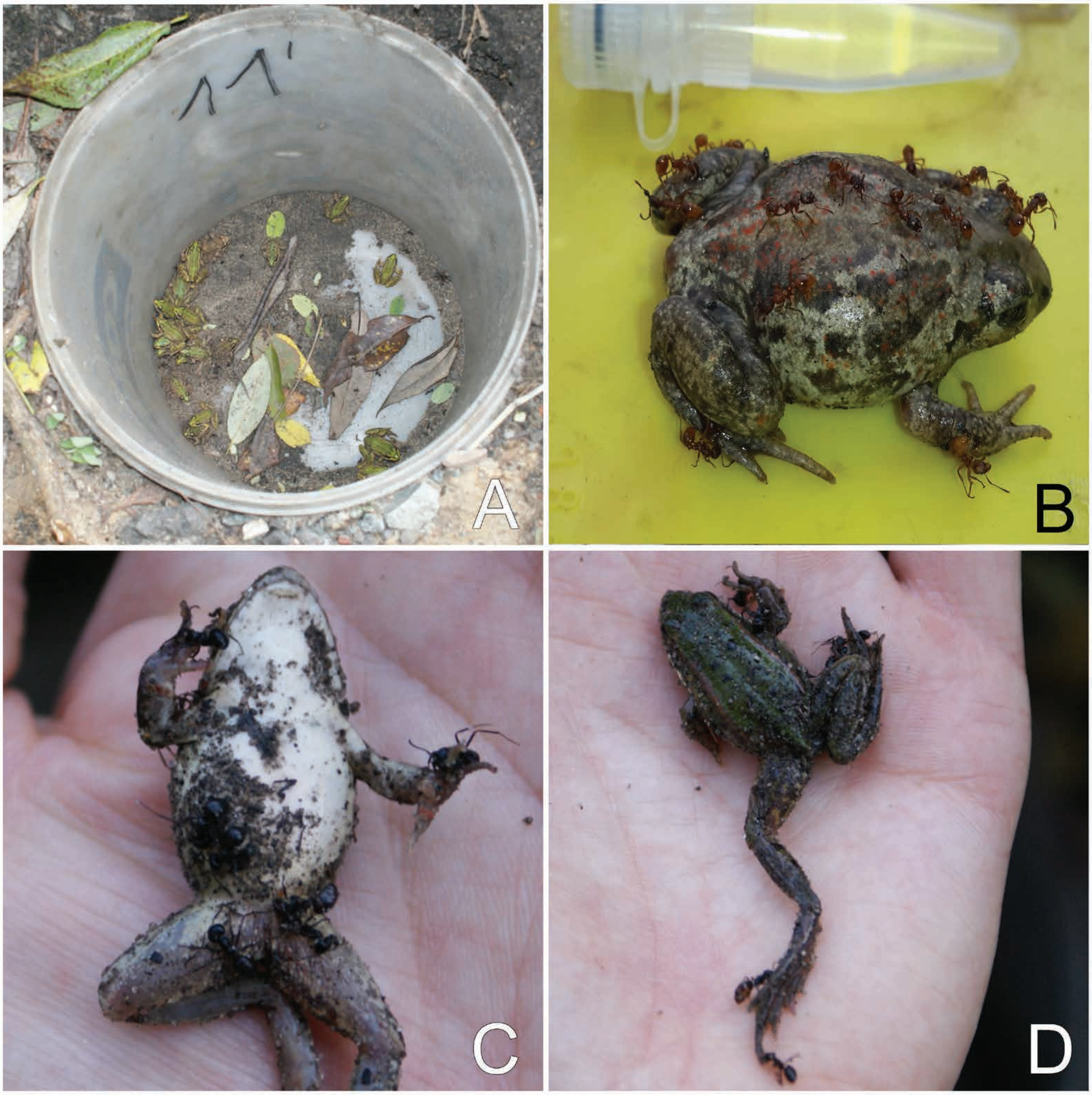

Figure 1. (A) Typical bucket used as a pitfall trap (without platform for insects/mammals). Inside are 18 individuals of the Pelophylax esculentus complex (September 24, 2013). (B) Swollen Pelobates fuscus with Myrmica rubra after removal from the pitfall trap (October 21, 2014). (C), (D) Pelophylax esculentus complex attacked by Lasius fuliginosus in the bucket, the abdominal and dorsal view with ants (October 22, 2013).

other ant species can be a threat to amphibians, even if checks are performed daily.

Due to the low frequency of the phenomenon, we do not have the opportunity to test differences in the occurrence of attacks for individual taxon or year. However, we documented a larger number of ants attacking bigger amphibians, which is in agreement with the results by Ward-Fear et al. (2010). This is probably because bigger individuals provide more sites for biting by ants. Different species of ants can also affect the various behaviors of amphibians and predator avoidance. Long et al. (2015) observed that, in experimental conditions, southern toad *Anaxyrus terrestris* Bonnaterre, 1802, increased movements in the presence of red imported fire ants compared to native pyramid ants *Dorymyrmex bureni* Trager, 1988.

Despite the fact that pitfall traps are widely used in amphibian conservation (Puky 2006, Schmidt & Zumbach, 2008), invertebrate biting is not a commonly reported issue. Pitfall traps may be a threat for many non-target groups of animals. Particularly little is known about active hunting of amphibians inside pitfall traps by predatory invertebrates. The phenomenon may have a similar negative effect as does the predation by vertebrates, such as snakes or mammals, in such structures (Ferguson 2006; Ferguson et al. 2008). On the other hand, the fact that this method is commonly used makes the

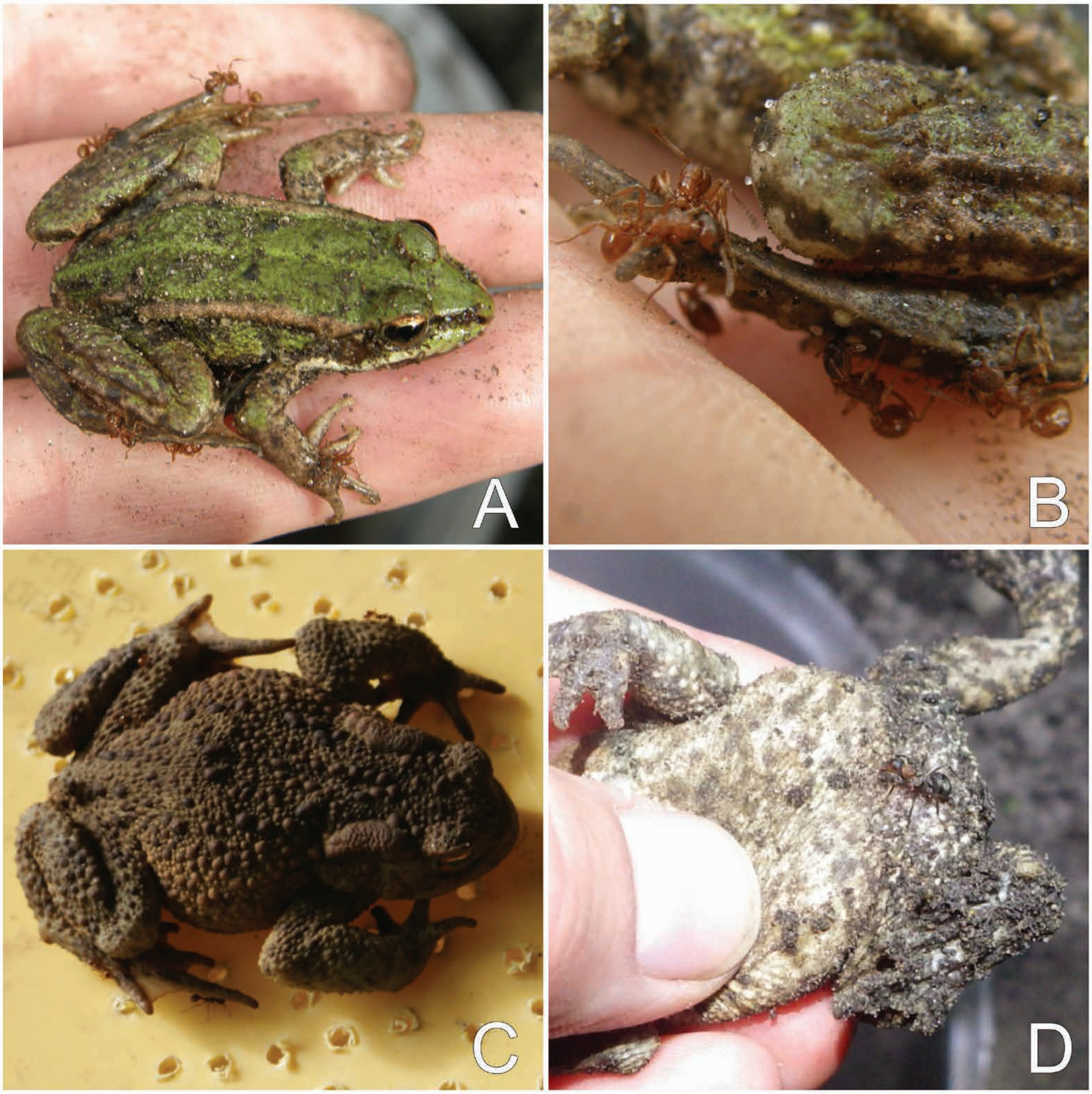

Figure 2. (A) Pelophylax esculentus complex attacked by Myrmica rubra; (B) the same individual—the hind limb with ants (October 5, 2012). (C) Bufo bufo with Myrmica rubra after removal from the pitfall trap (September 24, 2013). (D) Formica polyctena bite on the belly of Bufo bufo (March 31, 2016).

reporting of our results important so that other interactions can be observed.

In contrast to the majority of insects, ants do not show a clear diurnal pattern (Hölldobler & Wilson 1990) and it is unlikely to prevent the attacks on amphibians by changing the timing of pitfall checks. The only possible way to prevent the negative effect of this interaction is more frequent checks, which would prevent amphibians drying out, and would not expose them to aggressive ants for a long period of time.

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APPENDIX 1

Table 1S. All reported cases of ants biting amphibians recorded during our study.

	Date	Pitfall traps number	Species	Anura size range (mm)	Anuran health condition	The number of ants "biting" the frog	Ant species	Comments (number of ants biting each body part given in parentheses)
1	10.05.2012	8	PEC	45/50	live	9	Myrmica rubra	hind leg (8), hind leg digit (1)
2	10.05.2012	9	RT	35/40	live	2	Myrmica rubra	forearm (1), hind leg digit (1)
3	10.05.2012	8	PEC	35/40	live	6	Myrmica rubra	hind leg (3), abdomen (3)
4	10.05.2012	8	PEC	55/60	live	3	Myrmica rubra	hind leg (3)
5	10.05.2012	9	PEC	35/40	live	2	Myrmica rubra	forearm (1), thigh (1)
6	08.21.2013	8	RT	40/45	dead	5	no data	no data
7	08.22.2013	9	PF	35/40	weak, movement problems	3	Myrmica rubra	no data
8	09.18.2013	8	PEC	25/30	dead	2	Lasius fuliginosus	no data
9	09.21.2013	11'	RT	35/40	live	2	Lasius fuliginosus	foreleg digit (1), hind leg digit (1)
10	09.21.2013	11'	PEC	30/35	live	1	Lasius fuliginosus	thigh (1)
11	09.24.2013	11'	PEC	30/35	live	1	Lasius fuliginosus	hind leg digit (1); total number of 11 PEC in bucket that day
12	09.24.2013	11'	PEC	35/40	live	1	Lasius fuliginosus	hind leg digit (1)
13	09.24.2013	11'	PEC	35/40	live	1	Lasius fuliginosus	hind leg digit (1)
14	09.24.2013	9	BB	65/70	live	5	Myrmica rubra	foreleg and hind leg, armpit, interdigital webbing (5)

	Date	Pitfall traps number	Species	Anura size range (mm)	Anuran health condition	The number of ants “biting” the frog	Ant species	Comments (number of ants biting each body part given in parentheses)
15	10.04.2013	11’	PEC	25/30	dead	1	Lasius fuliginosus	no data
16	10.07.2013	11’	PEC	40/45	live	3	Lasius fuliginosus	foreleg (1), cloaca (3)
17	10.07.2013	11’	PEC	40/45	live	4	Lasius fuliginosus	foreleg (1), cloaca (4)
18	10.22.2013	11’	PEC	30/35	weak, movement problems	7	Lasius fuliginosus	foreleg (3), hind leg (3), abdomen (1)
19	10.23.2013	11’	RT	30/35	live	3	Lasius fuliginosus	no data
20	10.25.2013	11’	RT	35/40	dead	4	Lasius fuliginosus	thigh (1), abdomen (3)
21	09.09.2014	11’	PEC	35/40	live	1	Lasius fuliginosus	hind leg (1)
22	10.12.2014	11’	PEC	30/35	live	2	Lasius fuliginosus	hind leg (2)
23	10.21.2014	9	PF	30/35	live	14	Myrmica rubra	hind leg (4), foreleg (3), head (2), trunk (5)
24	09.02.2015	9	RT	25/30	live	1	Myrmica rubra	no data
25	09.02.2015	9	RT	20/25	live	2	Myrmica rubra	no data
26	09.02.2015	9	RT	20/25	live	2	Myrmica rubra	no data
27	09.18.2015	9	RT	20/25	live	1	Myrmica rubra	interdigital webbing of hind leg (1)
28	03.31.2016	X	BB	55/60	live	1	Formica polyctena	abdomen (1)
29	03.31.2016	X	BB	85/90	live	5	Formica polyctena	pair in ampleksus; thigh (1), digit (2), interdigital webbing (2)

Anura species: PEC—Pelophylax esculentus complex; RT—Rana temporaria; PF—Pelobates fuscus; BB—Bufo bufo