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Subterranean ants (Hymenoptera, Formicidae) as prey of fossorial reptiles (Reptilia, Squamata: Amphisbaenidae) in Central Brazil

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ABSTRACT

The ant diversity observed in stomach contents of fossorial reptiles was compared to the subterranean ant richness collected using traditional and modern techniques of ant collections. We analyzed the alimentary tract of 64 specimens of amphisbaenians (4 Amphisbaena alba, *10* A. fuliginosa, *25* A. vermicularis, *and 25* Leposternon infraorbitale*) collected during the fauna rescue for the construction of Serra da Mesa hydroelectric dam in the Tocantins River (from 1992 to 1997), in Minaçu County, Goiás, Brazil. We found only five ant species present in the stomach contents, all belonging to the army ants subfamily Ecitoninae. In contrast, the traditional techniques for subterranean ants' collection are far more efficient than the exam of fossorial reptile's stomach contents, collecting a much richer and diverse ant fauna. The exclusive occurrence of army ants in the alimentary tract of these fossorial reptiles suggests that they trace the chemical trails laid by the ants while moving inside and over the soil. Further, the occurrence of the epigaeic army ants* Eciton *and* Labidus *in the stomach contents suggests that amphisbaenians may forage on the soil surface as well.*

Keywords: Amphisbaenians; Ecitoninae; Subterranean ants; Stomach contents.

INTRODUCTION

Formicidae is one of the most important insect taxa in regard to biomass, abundance and ecological impact in tropical and subtropical terrestrial habitats (Hölldobler & Wilson, 1990; Floren *et al.,* 2002; Wilson & Hölldobler, 2005a, b). A recent study (Brandão; Silva & Delabie, in press) on the community structure of local tropical ant faunas have revealed that these faunas are not random assemblages of species, but are rather structured in 16 well defined guilds, of which nine live mostly in the leaf litter, three are arboricolous, two are subterraneous (one nomadic hypogaeic), one is nomadic epigaeic and one repre-

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sented by social parasites, which are rarely collected in tropical environments.

The species that spend most of their life cycles inside the soil, called here subterraneous, seldom visit the surface and represent one of the new frontiers in myrmecology, as this is the relatively less known segment of the fauna and so has the potential to reveal relevant new taxa (Silva & Silvestre, 2004). For instance, an exclusively underground ant, *Dolopomyrmex pilatus,* was recently discovered in Southwestern United States (Cover & Deyrup, 2007). In the Neotropical region, subterraneous ant guilds are composed mostly by the Cerapachyinae, most Ecitoninae and Leptanilloidinae, certain species of Myrmicinae that either live and forage exclusively in the deeper layers of soil (*Tranopelta,* for instance), and the relatively very small hypogaeic *Carebara* and some *Solenopsis,* which are also very frequent in the upper layers of soil (Silva & Silvestre, 2004).

The techniques currently in use for the collection of hypogaeic ants are subterranean baited pitfall traps (Brandão *et al.,* in press), subterranean baits (Silvestre, 2000; Morini *et al.,* 2004), cylindrical probes (Ryder Wilkie *et al.,* 2007), baited sieve buckets (using palm oil, tuna and cookies) (Berghoff *et al.,* 2003), and soil submitted to Winkler extractor (Silva & Silvestre, 2004). However, these techniques reach relatively small depths, except for the cylindrical probes which can sample ants up to one meter below the surface soil. So, techniques to access the ant diversity that apparently abounds in the middle and lower soil horizons and that remains to be discovered are to be improved (Cover & Deyrup, 2007). We investigated the diet of fossorial reptiles in Central Brazil, based on the analysis of the stomach contents of amphisbaenian reptiles from Minaçu County, Goiás, giving special attention to the ants found in these contents. In so doing, we compare the efficiency of the traditional techniques with the results obtained here. We assume that these reptiles have relatively high mobility and are able to forage at a depth greater than that achieved by the above mentioned techniques.

Several behavioral associations have been reported between ants and different reptiles, such as predation (Riley *et al.,* 1986; Cruz-Neto & Abe, 1993; Barros Filho & Valverde, 1996; Colli & Zamboni, 1999; Kearney, 2003; Wetterer & Moore, 2005; Staller *et al.,* 2005; Bernardo-Silva *et al.,* 2006; Whitfield & Donnelly, 2006; Goldsbrough *et al.,* 2006), and inquilinism (Brandão & Vanzolini, 1985; Riley *et al.,* 1986; Oliveira & Della Lucia, 1993).

The amphisbaenian genus group is represented by *circa* 160 species of fossorial reptiles with world-wide distribution (Uetz, 2002). In Brazil, this group is represented by six genera *(Amphisbaena, Anops, Aulura, Bronia, Cercolophia* and *Leposternon),* comprising 44 species (Barros Filho & Valverde, 1996). These reptiles develop their life cycles almost entirely restricted to the interior of loose or sandy soil of tropical and temperate environments (Kearney, 2003). Due to their habits, they are seldom collected and/or observed, and little is known on their biology and distribution (Gans, 1978; Barros Filho & Valverde, 1996). The use of chemical clues for prey detection and identification was described for *Blanus cireneus* (López & Salvador, 1992, 1994; López & Martin, 1994). However, the prey choice mechanism remains uncertain for most species in this group (López *et al.,* 1991). According to some studies (Riley *et al.,* 1986; Cruz-Neto & Abe, 1993; Barros Filho & Valverde, 1996; Colli & Zamboni, 1999; Kearney, 2003; Bernardo-Silva *et al.,* 2006), the diet of these reptiles consists mainly of small arthropods, mostly isopterans, hymenopterans (especially ants), coleopterans and arachnids. Ants have relatively great importance (volumetric and numeric) in the amphisbaenian diet (Colli & Zamboni, 1999); there are records of both colonial and nomadic species in the stomach contents of these reptiles (Riley *et al.,* 1986; Bernardo-Silva *et al.,* 2006).

MATERIAL AND METHODS

We took advantage of the exceptional opportunity of the filling of the Serra da Mesa hydroelectric dam in Rio Tocantins, and the fauna rescue (from 1992 to 1997) in Minaçu county, state of Goiás, Central Brazil (13°43'S 48°15'W), which resulted in the collection of approximately 400 specimens of fossorial reptiles. From this total, we obtained permission to dissect 64 specimens (25 of *Amphisbaena vermicularis,* 10 of *A. fuliginosa,* 4 of *A. alba,* and 25 of *Leposternum infraorbitale*), which had their digestive tract dissected.

The ants found in the amphisbaenian stomach contents were sorted out into morph-species and, whenever possible, identified to species level by comparison with the material deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP) ant collection. Most of these ants were found fragmented, so the number of heads was used to estimate the number of individuals of each morph-species.

All amphisbaenians and the ants are deposited in the appropriate MZUSP collections.

RESULTS

Of the analyzed reptile specimens, only six presented ants in their stomachs, and all ants found belong to the Ecitoninae: *Neivamyrmex punctaticeps* (17 heads), one unidentified *Neivamyrmex* (10 heads), fragments of *Labidus coecus* (52 heads) and *Labidus praedator* (23 heads), and *Eciton mexicanum* (10 heads). Ant immatures were not found in any of the examined contents (see Table 1).

Besides the ants, other insect remains (beetles and termites) were found in some of the stomach contents (Table 1).

DISCUSSION

We identified 5 ant species in 64 dissected amphisbaenians of Minaçu, of which, only 6 presented ants in their stomachs. In the same locality and at the same time, Silvestre (2000) collected 15 ant species using 40 subterranean baits. On the other hand, in different localities, Berghoff *et al.* (2003) found 85 ant species in 182 baited sieve buckets; Silva & Silvestre (2004) collected 71 ant species in 90 soil samples submitted to Winkler extractors; Morini *et al.* (2004) collected 42 ant species in 40 subterranean baits and Ryder Wilkie *et al.* (2007) collected 47 ant species in 50 cylindrical probes.

TABLE 1: Ant species found in the stomach contents of studied amphisbaenians from the MZUSP collection from in Minaçu, GO, Brazil.

Species	MZUSP code	Content	Number of individuals
Amphisbaena alba	83444	Formicidae *(Labidus coecus)*	15
A. alba	83445	empty	0
A. alba	83446	Formicidae *(Eciton mexicanum)*	9
A. alba	83447	Coleoptera	1
Amphisbaena fuliginosa	10705	Coleoptera	2
A. fuliginosa	19219	Formicidae *(Labidus coecus)*	27
A. fuliginosa	19603	Isoptera	31
A. fuliginosa	20026	empty	0
A. fuliginosa	20885	Formicidae *(Labidus praedator)*	17
A. fuliginosa	20885	Formicidae *(Labidus coecus)*	1
A. fuliginosa	20885	Formicidae *(Neivamyrmex* sp. 1*)*	10
A. fuliginosa	20885	Isoptera	14
A. fuliginosa	22173	Formicidae *(Neivamyrmex punctaticeps)*	17
A. fuliginosa	22173	Formicidae *(Labidus coecus)*	2
A. fuliginosa	22173	Formicidae *(Labidus praedator)*	6
A. fuliginosa	22173	Isoptera	45
A. fuliginosa	24198	Isoptera	15
A. fuliginosa	24569	Isoptera	125
A. fuliginosa	24795	empty	0
A. fuliginosa	83404	Formicidae *(Eciton mexicanum)*	1
A. fuliginosa	83404	Isoptera	33
Amphisbaena vermicularis	83303	Formicidae *(Labidus coecus)*	7
A. vermicularis	83325	empty	0
A. vermicularis	83352	empty	0
A. vermicularis	83304-17	empty	0
A. vermicularis	83319-23	empty	0
A. vermicularis	83328-30	empty	0
Leposternon infraorbitale	85231	Isoptera	4
L. infraorbitale	85232	Coleoptera	1
L. infraorbitale	85235	Coleoptera	1
L. infraorbitale	85249	Isoptera	1
L. infraorbitale	85291	empty	0
L. infraorbitale	85225-30	empty	0
L. infraorbitale	85236-42	empty	0
L. infraorbitale	85244-47	empty	0
L. infraorbitale	85296-98	empty	0

Our results suggest that traditional techniques of hypogaeic ants collection portray with much greater fidelity the underground ant fauna than the analysis of fossorial reptiles' stomach contents, due to the relatively low ant diversity found in this kind of samples, and also to the low observed frequencies in relation to the average size of ant colonies.

Despite the record of *Amphisbaena alba* as a facultative inquiline in nests of *Atta cephalotes* (Riley *et al.,* 1986), we found no *Atta* ants in the stomach contents examined in any of examined reptiles, including *A. alba.*

Notwithstanding the opinion of Webb *et al.* (2000) that the reptiles may evade raiding ant nests, avoiding being onslaught by the great number of workers in most colonies, we believe that the ants' soft bodied larvae and pupae would be quickly digested and thus seldom would be preserved in reptiles' stomach contents, even in ant species which pupae are covered by cocoons. This may explain why we have found no immature in the studied material. However, there is a record of an ant larva in the stomach content of *Bipes biporus* (Kearney, 2003). One of the reviewers of the manuscript, was kind enough to suggest that this may also depend on the time elapsed between capture and fixation of the reptile.

Interestingly we recorded workers of the epigaeic *Eciton* and *Labidus praedator* (Ecitoninae) in the stomach contents of amphisbaenian reptiles, which indicate that amphisbaenians forage also on the soil surface, as suggested by Bernardo-Silva *et al.* (2006) and observed by Gorzula *et al.* (1975). Also, one of the ant individuals found in the stomach contents of an *Amphisbaena alba* is a large soldier of *Eciton mexicanum,* suggesting also that these reptiles are not reluctant to invest against potentially aggressive ants.

Ecitoninae army ants include genera *(Eciton, Labidus, Neivamyrmex, Nomamyrmex* and *Cheliomyrmex)* which show a primarily Neotropical distribution, encompassing predatory, nomadic species, with life cycles that alternate migratory and stationary phases (Palácio, 2003). Ecitoninae includes species that forage both on the soil surface *(Eciton* and *Labidus praedator)* as in the underground (other species of *Labidus,* all species of *Neivamyrmex, Nomamyrmex* and *Cheliomyrmex;* Nascimento *et al.* 2004; Quiroz-Robledo *et al.,* 2002). *Eciton, Labidus* and some *Neivamyrmex* can be easily spotted in the field by their dense columns composed of sometimes thousands of workers, which move in compact rows. The biology of *Nomamyrmex* remains unknown, but it is believed that it presents hypogaeic habits (Palácio, 2003). We know very little on the biology of *Cheliomyrmex* species; O'Donnell *et al.* (2005) reported that *C. andicola* prey on large-bodied ground dwelling invertebrates and, probably, vertebrates, using (possibly) their unusual mandibles and stings to pierce and grip the integument of non-arthropod prey animals, and for rapidly subduing large-bodied prey, respectively. Despite the abundance of Ecitoninae in Neotropical forests (Kaspari & O'Donnell, 2003), data on the structure of their communities and ecological impacts are limited (O'Donnell *et al.,* 2007, but see Berghoff *et al.,* 2008, and included references for Panama's Canal Zone). Most of what is known about the biology of Ecitoninae is derived from observations on the behavior of *Eciton burchelli* (see Gotwald, 1995; O'Donnell *et al.,* 2007).

The exclusive occurrence of Ecitoninae ants in stomach contents of fossorial reptiles studied by us could be explained by the ability of amphisbaenians to trace chemical trails, even underground. The experiments made by Riley *et al.* (1986) suggest that *Amphisbaena alba* can follow the chemical trails left by *Atta cephalotes* and that the orientation cue used by these reptiles is predominantly olfactory.

The biology of ant species other than Ecitoninae that also live in the deeper layers of soil is unknown as well. So, new information on this group is expected from the improvement of collection techniques adapted to this habitat, which may result in more intense assessments in this relatively poorly known substrate.

RESUMO

A diversidade de formigas no conteúdo estomacal de répteis fossoriais foi comparada à riqueza de formigas subterrâneas coletadas com o uso de técnicas tradicionais e modernas para sua coleta. Analisamos o trato alimentar de 64 espécimes de anfisbenídeos (4 Amphisbaena alba, *10* A. fuliginosa, *25* A. vermicularis *e 25* Leposternon infraorbitale*) coletados durante o resgate da fauna para a construção da represa da Hidroelétrica da Serra da Mesa no Rio Tocantins (de 1992 a 1997), na cidade de Minaçu, Goiás, Brasil. Encontramos apenas cinco espécies de formigas presentes nos conteúdos estomacais aqui examinados, todas pertencentes à subfamília das formigas-de-correição, Ecitoninae. Ao contrário, as técnicas tradicionais de coleta de formigas subterrâneas são muito mais eficientes que o exame dos conteúdos estomacais de répteis fossoriais, coletando uma fauna muito mais rica e diversa de formigas. A ocorrência exclusiva de formigas-de-correição no trato alimentar destes répteis fossoriais sugere que eles seguem trilhas químicas deixadas pelas formigas à medida que se elas movimentam no*

interior e sobre o solo. Ainda, a ocorrência das formigas-de-correição epigéicas Eciton *e* Labidus *nos conteúdos estomacais analisados sugere que os anfisbenídeos podem também forragear na superfície do solo.*

Palavras-chave: Anfisbenídeos; Ecitoninae; Formigas subterrâneas; Conteúdo estomacal.

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