The effect of pitfall trapping on lizard diets

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Pitfall trapping is a widely used sampling method in amphibian and reptile studies. Despite their broad use and numerous advantages, the question of whether diets of trapped animals differ from those under natural conditions remains uninvestigated. We use data on eight lizard species to test the hypotheses that lizards captured in pitfall traps differ in diet composition and/or have higher stomach content volumes when compared to lizards collected using other methods. The basis for these hypotheses is that many common lizard prey items fall into the traps and are thus available to trapped lizards. Testing these hypotheses is critical to validate the results of diet studies that use animals taken from pitfall traps. Our results showed that lizards collected from pitfall traps did not differ significantly from lizards collected outside the traps in diet composition or volume of prey consumed. However, two species (among eight) had different stomach content volumes inside the traps; one (*Anolis chrysolepis*) had a higher volume and the other (*Tropidurus oreadicus*) had a lower volume. For the species we studied, we found that lizards collected with pitfall traps can be used in diet studies. Nevertheless, we recommend checking traps at least once a day to avoid prolonged exposure to different prey items, collecting large sample sizes, and also collecting animals outside the traps.

Key words: food selection, foraging behavior, iguanids, niche overlap, teiids

INTRODUCTION

Pitfall traps are a widely used sampling method in the study of amphibians and reptiles (Mengak & Guynn, 1987; Heyer, 1994; Doan, 2003). Pitfall trapping consists of buckets that are buried in the ground and are often connected to each other by drift-fences, which direct animals into the buckets (Gibbons & Semlitsch, 1981; Scrocchi & Kretzschmar, 1996). Pitfall traps have proved to be effective in herpetofaunal surveys in a variety of habitats (Corn & Bury, 1990; Raxworthy & Nussbaum, 1994; Cechin & Martins, 2000; Bragg et al., 2005). One important advantage of this method is that it eliminates sampling bias resulting from collector experience, so that data are comparable among different sites, provided the design and trapping effort are the same (Cechin & Martins, 2000). In addition, pitfall traps are especially effective in capturing fossorial and semi-fossorial species (Enge, 2001), which may be missed using other survey methods. Pitfall traps are also effective for capturing other vertebrate or invertebrate groups, adding important comparable data to species inventories.

Many studies that focus on monitoring populations, seasonal patterns of reproduction and abundance, and demography (Gibbons & Bennett, 1974; Allmon, 1991; Duellman, 1995; Hanlin et al., 2000) are possible or effective only because they use pitfall traps. Animals collected with pitfall traps have also been used in dietary studies (e.g. Gainsbury and Colli, 2003; Mesquita et al., 2006a). Despite the broad use and numerous advantages of pitfall traps, the question of whether the diet data collected from trapped animals are truly representative of the diet under natural conditions has not been evaluated.

Diets of individuals captured in pitfalls could differ from free-ranging individuals because they consume prey also trapped in buckets. Consequently, diet composition of trapped lizards (including prey type and/or prey number) may not reflect the diet under natural conditions. Therefore, conclusions generated using individuals collected in pitfalls may not be reliable. An alternative hypothesis is that under stressful conditions, such as being trapped in the bucket, lizards will not feed at all, or their diet in pitfall traps would be a subset of that in natural environments. In both cases, conclusions of studies using animals collected in pitfall traps would be compromised.

Regardless of the pros and cons of pitfall trapping, no empirical evidence has been produced to support or refute the above arguments. In this paper, we investigate the diet composition of lizards sampled in the same habitats, using pitfall traps and haphazard collection methods simultaneously. Specifically, we address the following questions: 1) does diet composition of lizards captured in pitfall traps differ from that of lizards collected haphazardly, and 2) do lizards captured in pitfall traps have a higher stomach content volume than lizards collected haphazardly?

MATERIALS AND METHODS

Lizard sampling

Lizards were collected during different years at various localities, as part of several biological survey projects in the Cerrado region of central Brazil. Field expeditions were performed between 1998 and 2005. In all fieldwork, we used 25 arrays of pitfall traps. Each array consisted of four

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Table 1. Results of EcoSim using the niche overlap module. Comparison among lizards collected in pitfall traps and haphazardly, based on 10,000 permutations of the original data matrix. *n* = sample size for lizards collected in the traps and haphazardly; *P* = probability that the observed niche overlap is lower or equal to that expected by chance.

Species	*n*	Observed niche overlap	Simulated mean niche overlap	*P*
Ameiva ameiva	45/24	0.78	0.25	0.98
Anolis chrysolepis	80/21	0.84	0.2	0.98
Cnemidophorus mumbuca	161/27	0.91	0.21	>0.99
Cnemidophorus cryptus	45/25	0.67	0.25	0.93
Cnemidophorus parecis	28/73	0.9	0.19	0.98
Gymnodactylus carvalhoi	21/67	0.49	0.18	0.92
Kentropyx vanzoi	38/25	0.55	0.15	0.98
Tropidurus oreadicus	126/25	0.45	0.29	0.83

20-litre buckets arranged in a Y-shape (one at the centre and three at the ends); buckets were 5 m from each other and 40-cm high plastic fences (bottom edge buried) spanned the distance between buckets. Arrays were spaced 20 m apart. Traps were checked at least once a day for approximately 30 days at each locality. Lizards were taken back to the field laboratory, usually within 1–2 hrs of capture, where live animals were euthanazed with an injection of Tiopental®, given uniquely numbered tags, measured and preserved with 10% formalin. All specimens were deposited at the Coleção Herpetológica da Universidade de Brasília (CHUNB).

In addition to pitfall trapping, we collected lizards haphazardly by hand, noose or shotgun. Live animals were euthanazed as above within 1–2 hrs of capture. For diet comparisons between lizards collected in pitfall traps versus lizards collected haphazardly, we used only species with large sample sizes for each collecting method (i.e. at least 20 adult individuals for each category; we avoided using juveniles to minimize variation within species). The species used were: *Cnemidophorus mumbuca*, *Gymnodactylus carvalhoi* and *Tropidurus oreadicus* from Mateiros, Tocantins (10°32'S, 46°25'W); *Ameiva ameiva* and *Cnemidophorus cryptus* from Monte Alegre, Pará (2º00'S, 44º20'W); *Anolis chrysolepis* from São Domingos, Goiás (13°24'S, 46°19'W); and *Cnemidophorus parecis* and *Kentropyx vanzoi* from Vilhena, Rondônia (12°43'S, 60°07'W).

Diet analysis

We removed lizard stomachs by dissection and examined the contents under a stereomicroscope. We identified prey items to order, recorded body length and width (0.01 mm) of intact items with digital callipers, and estimated prey volume (*V*) as an ellipsoid (Mesquita et al., 2006b). We calculated numeric and volumetric percentages of each prey category for pooled stomachs for lizards of each species collected by pitfall traps and haphazardly.

We acknowledge that identifying prey items to order might mask some variation in diets (e.g. at family level). Nevertheless, most studies involving lizard diets report diet items at the order level, including studies performing major ecological comparisons among several lizard species (Pianka, 1986; Vitt et al., 2003; Vitt & Pianka, 2005). Therefore, if variation in prey consumption below the level of order exists between lizards collected in pitfall traps versus those collected haphazardly, it is not a problem in relation to the objectives of this study.

Diet composition differences

To test the hypothesis that lizards collected in pitfall traps have a different diet composition compared to lizards collected haphazardly, we used the niche overlap module of the software program EcoSim (Gotelli & Entsminger, 2006). The data in this analysis consist of a matrix with lizard species in rows and prey categories as columns. In our case, instead of using different species in the rows we used the same species divided into haphazardly collected and pitfall collected. Entries in the matrix represent the volumetric importance of prey categories for the pooled stomachs. The matrix is reshuffled a number of times to produce random patterns of niche overlap that would be expected by chance. We used the following settings in EcoSim: Pianka's niche overlap index (Pianka, 1973), randomization algorithm two (RA2) and 10,000 permutations of the original matrix. Niche overlap varies from 0 (no overlap) to 1 (complete overlap). Randomization algorithm two (RA2) substitutes the importance in the original matrix with a random uniform number between 0 and 1, while retaining the zero structure in the matrix (Winemiller & Pianka, 1990). This algorithm assumes that certain dietary items are unavailable for each species.

In these tests, the null hypothesis was that the observed niche overlap is higher than or equal to the mean simulated niche overlap (expected by chance). If lizards collected in pitfall traps have a significantly different diet composition relative to lizards collected haphazardly, then the null hypothesis should be rejected.

Prey intake differences

To test the hypothesis that lizards collected in pitfalls have a higher stomach content volume than lizards collected haphazardly, we conducted a nonparametric analysis of variance (Kruskal–Wallis test) comparing the stomach content volume of lizards collected in pitfall traps with that of lizards collected haphazardly. If lizards were feeding more inside the traps, then this analysis should point to a significantly higher volumetric content in stomachs of lizards collected in the traps. For this analysis, we used the software SAS (version 9.1).

Table 2. Results of the nonparametric analysis of variance (Kruskal–Wallis test) on the volumetric contents of stomachs of lizards collected by pitfall traps and haphazardly. Sample sizes for each species are the same as in Table 1.

	Mean scores			
Species	Pitfall	Haphazardly	χ^2	*P*
Ameiva ameiva	35.6	33.9	0.11	0.73
Anolis chrysolepis	55.3	34.6	8.50	<0.01*
Cnemidophorus mumbuca	93.7	99.2	0.23	0.62
Cnemidophorus cryptus	35.1	36.3	0.06	0.81
Cnemidophorus parecis	47.1	52.5	0.71	0.40
Gymnodactylus carvalhoi	46.5	43.9	0.16	0.68
Kentropyx vanzoi	33.0	30.5	0.27	0.60
Tropidurus oreadicus	69.9	106.6	14.7	<0.01*

* Means are statistically different.

RESULTS

The results of the null-model analysis in EcoSim showed that for no species was the null hypothesis rejected, demonstrating that the diet composition of lizards collected in pitfall traps does not differ significantly from that of lizards collected haphazardly (Table 1). In fact, for most species the niche overlap was extremely high. The highest niche overlap occurred in *Cnemidophorus mumbuca* (0.91, *P*>0.99) and the smallest in *Tropidurus oreadicus* (0.45, *P*=0.83).

Only two species, *Anolis chrysolepis* and *T. oreadicus*, exhibited significant differences in stomach content volume between lizards collected in pitfall traps and lizards collected haphazardly (Table 2).

DISCUSSION

Results for all species support the null hypothesis that lizards collected in pitfall traps do not change their diet composition significantly when compared to those collected haphazardly. In addition, none of the species, with the exception of *Anolis chrysolepis* and *Tropidurus oreadicus*, differed in stomach content volume inside the pitfalls. Various hypotheses might explain this pattern: 1) trapped lizards tend not to eat while inside the traps; 2) prey items fall into the traps reflecting their natural proportion in the environment and trapped lizards feed inside the traps in the same manner they do outside; and/or 3) prey items fall in the traps in a different proportion than they are available in the environment (e.g. bias toward terrestrial moving arthropods), but lizard diet is constrained and if they do feed, they do so on the same kind of prey and in the same amounts as they would outside the traps. Although our results do not favour one hypothesis over another, it seems more parsimonious to assume that lizards tend not to feed inside the traps, than that in the limited amount of time lizards are confined in the trap they prey on the same items and in the same proportions as they do outside the traps. However, feeding experiments with trapped lizards would efficiently test this hypothesis.

The pattern described above was most evident for teiid lizards; these species had high niche overlap and did not differ in stomach content volume. Teiids are active foragers and chemically discriminate prey (Vitt et al., 2003; Vitt & Pianka, 2005). Active foragers usually pursue prey in the environment by chasing them, spending a large amount of time moving (Cooper & Whiting, 1999; Cooper et al., 2001). While trapped inside buckets, active foraging lizards may be stressed by the constraints on movement and not feed on any item even if their naturally common prey are available inside the bucket.

The diet composition in *A. chrysolepis* did not differ significantly; however, lizards collected in pitfalls had a greater stomach content volume than lizards collected haphazardly, indicating that they might have consumed prey inside the traps. This species is a member of the clade Iguania, which employ sit-and-wait ambush strategies to overcome their prey (Vitt et al., 2003; Vitt & Pianka, 2005). Therefore, inside the traps they will not experience the same movement constraints because their natural feeding behaviour does not require much movement, and thus they can keep eating while trapped.

Tropidurus oreadicus did not differ in diet composition either, but had smaller stomach content volumes inside than outside the pitfalls. This result is curious considering the fact that animals were preserved within a few hours of collection, thus leaving little time for stomach contents to be digested. A more likely explanation for this pattern is that *T. oreadicus* were falling in the pitfalls earlier in the day before they had full stomachs, whereas haphazardly collected individuals were collected at different times throughout the day. Therefore, more individuals with full stomachs would be expected using haphazard collection methods. This is particularly likely in *Tropidurus* due to its bimodal pattern of activity, with one peak in the early morning and another in the late afternoon (Vitt, 1993; Van Sluys, 2000; Faria & Araújo, 2004).

Many herpetologists commonly use pitfall traps in survey projects, so our results have important implications. Fieldwork is expensive and time consuming. In addition, areas being surveyed might be poorly known and/or endangered by human activities. Being able to extract as much information as possible from animals collected in pitfall traps is important to maximize the return on investments.

Our results suggest that animals collected with pitfall traps can be used in diet analyses without any major effects. Nevertheless, if the goal of the project involves diet analysis, then it is necessary to take a few precautions during field work: check traps at least once a day to avoid long exposure to different prey items; collect adequate sample sizes; and collect animals outside the traps as well to validate results based on pitfall trapping. We believe these measures are sufficient to safeguard against any confounding influence of using pitfall-trapped lizards in dietary studies.

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