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DIET COMPOSITION OF THE SUBDESERT TOAD, *AMIETOPHRYNUS XEROS* (ANURA: BUFONIDAE) IN SUDAN, NORTH AFRICA

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Abstract. —**We analyzed the dietary composition of 153 specimens of the subdesert toad, *Amietophrynus xeros*, collected in the rainy and dry seasons in Shendi, Sudan. The dietary items in the toads included a wide variety of arthropod prey belonging to 10 orders: Hymenoptera, Coleoptera, Heteroptera, Diptera, Isoptera, Lepidoptera, Orthoptera, Acari, Araneae, and Lithobiomorpha. The most frequent prey items were insects of the order Hymenoptera and Coleoptera, during both the rainy and dry seasons. We found significant positive correlations between the snout-vent length of the toads and both the number and length of prey consumed, based on analyses of all toads and several prey orders. We did not find significant differences between male and female toads in the mean number or mean length of prey consumed during either the rainy or dry seasons. Likewise, we did not find significant differences between juveniles and adults in the mean number or mean length of prey consumed during the two seasons, even though adults averaged approximately twice as long as juveniles.**

Key Words. —amphibian; consumption; prey item; prey size

INTRODUCTION

Information on the dietary composition of an animal could reflect its habitat conditions as well as the distribution of prey species. Bufonids are usually considered generalists in their feeding habits (Evans and Lampo 1996; Vences et al. 1998; Sabagh and Carvalho-e-Silva 2008), and some of them have been considered ant-specialists (Rosa et al. 2002; Ferreira and Teixeira 2009). However, in general, the terrestrial toads predominantly feed on ants, beetles, and other terrestrial invertebrates (Parmelee 1999; Hirai and Matsui 2002). Moreover, larger anurans often consume more and larger prey than smaller individuals (Hirai 2002; Biavati et al. 2004; Wells 2007), and males and females often differ in body size and /or foraging circumstances and hence feed on different items (Biavati et al. 2004).

The toad, *Amietophrynus xeros* (Tandy et al. 1976) is a medium-sized terrestrial anuran that lives in arid regions of Africa close to permanent water bodies and dry riverbeds, and around oases (Rödel 2000; Harper et al. 2010). Within Sudan, *A. xeros* is found in the northern parts where it inhabits local moist farms and gardens and it is mainly nocturnal. Because of the limited knowledge concerning the ecology and biology of *A. xeros*, the objectives of our study were (1) to describe the dietary composition of this toad in the rainy and dry seasons in Shendi city, which is located in the northern part of Sudan; (2) to evaluate the relationship between snout-vent length (SVL) of the toad and the number and body length of prey consumed; and (3) to evaluate the influence of sex on the number and body length of prey consumed.

MATERIALS AND METHODS

We collected 153 *A. xeros* toads by hand during two sampling periods, the rainy season (August to mid September 2014) and the dry season (October 2014 to January 2015) from around ponds in the agricultural lands in Shendi (16°40'N, 33°25'E), River Nile State, Sudan, North Africa. We immediately transferred the specimens to a laboratory and sacrificed them using chloroform. We then measured their snout-vent length (SVL) with calipers to the nearest 0.1 mm. In the necropsy, we recorded the sex of each toad by direct observation of the gonads, then we removed the stomach and its contents, placed this in a Petri-dish, and examined the contents under a stereomicroscope. We identified the prey items in each stomach to order, and determined the number of each prey type along with its frequency of occurrence (i.e., the fraction of toads that contained the prey type). We also measured the body length of the prey items to the nearest 0.1 mm using calipers.

For analysis, we grouped the toads into two age classes (juvenile SVL < 40 mm; and adult SVL ≥ 40 mm) based on our observation that individuals with a SVL below 40 mm did not have differentiated gonads. We evaluated the relationship between SVL of the toad and the body length and number of prey consumed using the Pearson correlation coefficient (*r*). We analyzed the

TABLE 1. Snout-vent length (SVL) of 153 *Amietophrynus xeros* toads during the rainy season (18 juveniles, 30 males, and 30 females) and dry season (30 juveniles, 28 males, and 17 females) in 2014–2015 in Shendi, Sudan, North Africa.

Season	SVL (mm)	Juvenile	Male	Female
Rainy	Mean ± SD	22.67 ± 6.40	56.66 ± 9.32	52.95 ± 9.53
	Range	12.43–34.55	41.32–77.00	41.24–69.36
Dry	Mean ± SD	24.29 ± 5.55	59.89 ± 11.55	55.41 ± 8.08
	Range	16.30–36.30	41.43–79.21	44.21–70.23

full data set and the data by order. We also made comparisons among male, female, and juvenile toads with respect to the number and body length of prey items within each season and between seasons using both independent and paired sample *t*-tests. We used the statistical software, SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois, USA) to conduct the data analysis, and we considered values significant when $P \leq 0.05$.

RESULTS

Of the 153 toads we collected, we caught 78 in the rainy season and 75 in the dry season. We did not find significant differences in SVL of toads between seasons for juveniles, males, or females (Table 1). However, there were significant differences in SVL in the dry season between juveniles and males ($t = 15.13$, df = 56, $P < 0.001$) and females ($t = 15.62$, df = 45, $P < 0.001$). Likewise, in the rainy season there were significant differences in SVL between juveniles and males ($t = 13.33$, df = 46, $P < 0.001$) and females ($t = 11.99$, df = 46, $P < 0.001$).

We found all the toads had one or more prey items in their stomachs. We identified 10 orders of prey belonging to the phylum Arthropoda: Hymenoptera, Coleoptera, Isoptera, Orthoptera, Diptera, Heteroptera, Lepidoptera, Acari, Araneae, and Lithobiomorpha (Table 2). Hymenoptera were the predominant prey item in terms of number and frequency, followed by Coleoptera, for both juvenile and adult toads during both the rainy and dry seasons (Table 2). Most (97.5%) of the prey items were insects. The length of prey items ranged from 3.2 mm to 16.9 mm (Table 3). We found sand in the stomach content of some toads. However, we assume this material was ingested accidentally during foraging and we did not consider it as a dietary item.

We found a positive correlation between the SVL of toads and the number of prey consumed in the rainy season ($r = 0.23$, $P = 0.012$, n = 78) as well in the dry season ($r = 0.52$, $P = 0.005$, n = 75). When analyzed by prey order for the two seasons, we found a positive correlation between toad SVL and the number of the prey items consumed during at least one season for the following orders: Coleoptera, Hymenoptera, Isoptera, Lithobiomorpha, and Orthoptera, ($r = 0.20$–0.47, $P = 0.001$–0.044). We did not find a significant correlation during either season for Acari, Araneae, Diptera, and Heteroptera ($r = 0.02$–0.19, $P = 0.088$–0.838).

Likewise, we found a positive correlation between the SVL of toads and the length of all prey consumed in the rainy season ($r = 0.22$, $P = 0.012$, n = 78) as well in the dry season ($r = 0.60$, $P = 0.031$, n = 75). When analyzed by prey order for the two seasons, we found a positive correlation between toad SVL and the length of the prey items consumed during at least one season in the following orders: Heteroptera, Orthoptera, Acari, Araneae, and Lithobiomorpha, ($r = 0.86$–0.94, $P = 0.001$–0.005). We did not find a significant correlation during either season for the remaining orders: Hymenoptera, Coleoptera, Diptera, and Isoptera ($r = -0.02$–0.48, $P = 0.083$–0.273).

We did not find significant differences between male and female toads in the mean number of the all prey types combined ($t = 1.84$, df = 58, $P = 0.073$), as well in the mean length of the all prey types combined ($t = -0.13$, df = 58, $P = 0.910$) in the rainy season. Likewise, for the dry season, we did not find significant differences between male and female toads in the mean number of the all prey types combined ($t = 1.94$, df = 43, $P = 0.050$), as well in the mean length of the all prey types combined ($t = 0.02$, df = 43, $P = 0.923$).

Moreover, we did not find significant differences between the toad sexes either in the mean number of prey consumed ($t = 0.77$–2.69, df = 58, $P = 0.055$–0.946), or in the mean length of prey consumed ($t = -0.24$–3.71, df = 58, $P = 0.073$– 0.331), for any order in the rainy season. Similarly, for the dry season, we did not find significant differences between the toad sexes either in the mean number of prey consumed ($t = -0.66$–1.91, df = 43, $P = 0.146$–0.607), or in the mean length of prey consumed ($t = -0.22$–0.44, df = 43, $P = 0.181$–0.791), for any order. Further, a comparison between the toad sexes collected during the rainy and dry season collectively yielded no significant difference between them either in the mean number of prey consumed ($t = -2.04$, df = 103, $P = 0.073$) or in the mean length of prey items consumed ($t = 0.64$, df = 103, $P = 0.654$). We did not find a significant difference between juvenile and adult male toads in the mean number of prey consumed ($t = 0.88$, df = 46, $P = 0.331$) nor between juvenile and

TABLE 2. Number (sample size under heading) and frequency (%) of the prey items consumed by *Amietophrynus xeros* toads during the rainy and dry seasons of 2014–2015 in Shendi, Sudan, North Africa. Abbreviations are Juv. = juvenile; Freq. = frequency; number of toads with designated prey type (percentage of toads with designated prey type); ND = no data.

	Prey number consumed by toads during rainy season					Prey number consumed by toads during dry season					Overall	
Prey item	Juv. (18)	Male (30)	Female (30)	Total (%)	Freq. (%)	Juv. (30)	Male (28)	Female (17)	Total (%)	Freq. (%)	Total (%)	Freq. (%)
Insecta												
Hymenoptera	143	337	244	724 (52.1)	61 (78.2)	171	202	83	456 (59.4)	61 (81.3)	1180 (54.7)	122 (79.7)
Coleoptera	84	186	162	432 (31.1)	38 (48.7)	66	129	18	213 (27.6)	38 (50.7)	645 (29.7)	76 (49.7)
Isoptera	13	34	35	82 (5.6)	25 (32.1)	12	19	17	48 (6.3)	15 (20.0)	130 (6.0)	40 (26.1)
Orthoptera	1	17	18	36 (2.3)	31 (39.7)	ND	10	3	13 (1.7)	9 (12.0)	49 (2.3)	40 (26.1)
Diptera	4	18	9	31 (2.2)	21 (26.9)	6	3	ND	9 (1.2)	7 (9.3)	40 (1.9)	28 (18.3)
Heteroptera	7	17	6	30 (2.2)	23 (29.5)	2	10	ND	12 (1.6)	6 (8.0)	42 (1.9)	29 (19.0)
Lepidoptera	ND	10	6	16 (1.2)	14 (17.9)	ND	2	2	4 (0.5)	4 (5.3)	20 (0.9)	18 (11.8)
Arachnida												
Acari	8	12	ND	20 (1.4)	13 (16.7)	6	5	1	12 (1.6)	10 (13.3)	32 (1.5)	23 (15.0)
Araneae	ND	1	1	2 (0.1)	2 (2.6)	ND	ND	ND	ND	ND	2 (0.1)	2 (1.3)
Chilopoda												
Lithobiomorpha	ND	6	12	18 (1.3)	15 (19.2)	ND	1	ND	1 (0.1)	1 (1.3)	19 (0.9)	17 (11.1)
Overall	260	638	493	1391 (100.0)		263	381	124	768 (100.0)		2159 (100.0)	

adult female toads (t = 0.83, df = 46, P = 0.514) during the rainy season. Similarly, during the dry season no significant difference was found between juvenile and adult male toads in the mean number of prey consumed (t = 0.42, df = 56, P = 0.713) nor between juvenile and adult female toads (t = -0.71, df = 45, P = 0.543).

Discussion

The prey items recovered from the stomachs of the subdesert toad, *A. xeros*, during the rainy and dry seasons were terrestrial arthropods, mainly several orders of insects. This finding is consistent with several previous studies of anurans (Clarke 1974; Moseley et al. 2005; Batista et al. 2011). The high frequency of insects in the stomach contents of this toad presumably largely reflects the abundance and availability of this prey type. Previously, it has been reported that higher frequency of prey and presence of different prey sizes in the stomachs of some *Bufo* species were due to the availability of prey in the habitat of the predator (Clarke 1974; Jones 1982; Guix 1993).

The SVL of the toads was positively correlated with both the body length and number of prey consumed. Large toads tended to consume more and larger prey items such as grasshoppers and moths whereas smaller toads tended to consume relatively smaller prey such as ants, ticks, and small beetles. These findings can be explained as a mechanical consequence of larger toads having larger heads; hence, a wider mouth opening enables larger toads to feed on larger and more prey (Hirai 2002; Maneyro et al. 2004; Wells 2007). Surprisingly, though, we did not find any significant differences between juvenile and adult toads for the mean number and mean body length of prey consumed during the rainy and dry seasons even though adults averaged nearly twice as long as juveniles. Previously, it has been reported in anurans that larger individuals consume much larger sized prey than do smaller ones (Low et al. 1990; Hirai 2002; Biavati et al. 2004), particularly in generalist species (Wells 2007).

TABLE 3. Mean ± SD body length (mm) of the prey consumed by *Amietophrynus xeros* toads during the rainy and dry seasons of 2014–2015 in Shendi, Sudan, North Africa. ND = no data.

Prey item	Body length of prey consumed during rainy season			Body length of prey consumed during dry season		
	Juvenile (n = 18)	Male (n = 30)	Female (n = 30)	Juvenile (n = 30)	Male (n = 28)	Female (n = 17)
Insecta						
Hymenoptera	3.4 ± 0.5	3.6 ± 0.4	3.6 ± 0.4	3.6 ± 0.5	3.6 ± 0.5	3.6 ± 0.5
Coleoptera	9.3 ± 2.5	10.1 ± 0.4	9.5 ± 2.1	8.9 ± 2.5	8.5 ± 2.9	10.1 ± 0.5
Isoptera	3.2 ± 0.3	3.5 ± 0.4	3.2 ± 0.1	4.5 ± 0.1	3.3 ± 0.1	3.4 ± 0.1
Orthoptera	15.0 ± 0.4	16.1 ± 0.7	15.4 ± 0.6	ND	15.0 ± 0.5	16.7 ± 0.3
Diptera	4.9 ± 0.4	5.3 ± 0.3	5.0 ± 0.4	5.0 ± 0.4	5.4 ± 0.1	ND
Heteroptera	9.9 ± 0.4	11.1 ± 0.8	11.6 ± 0.7	9.9 ± 0.5	10.4 ± 0.6	ND
Lepidoptera	ND	16.5 ± 0.7	14.0 ± 0.4	ND	12.0 ± 0.6	13.1 ± 0.6
Arachnida						
Acari	4.3 ± 0.2	4.8 ± 0.4	ND	4.1 ± 0.1	4.6 ± 0.2	4.8
Araneae	ND	4.8	5.3	ND	3.0	ND
Chilopoda						
Lithobiomorpha	ND	ND	10.5 ± 0.3	ND	16.9 ± 0.5	ND

However, in a previous study on the toad *Bufo bufo*, there was no correlation between body size of the toad and the number of prey consumed (Crnobrnja-Isailovic et al. 2012). In addition, in the case of the toad, *Rhinella arenarum*, prey size was not related to body size of the toad, even though the relationship between the prey number and the body size of this toad was positive (Quiroga et al. 2009). In our study, we did not find significant differences between male and female toads in terms of the number or body length of prey consumed when compared within each season or between the rainy and dry seasons. This finding is similar to other studies carried out on bufonids (Clarke 1974; Hirai and Matsui 2002; Maragno and Souza 2011), and suggests that males and females (which did not differ significantly in body size in the present study) use the same microhabitat for foraging, and hence consume the same dietary materials.

In conclusion, our study showed that the subdesert toad, *A. xeros*, preys upon a wide variety of arthropods, mainly insects. The correlation between the SVL of toads and the number and length of prey consumed indicates that larger toads take more and larger prey than smaller toads. Male and female toads did not differ in body size, number of prey, and size of prey, suggesting that they forage in the same microhabitat. We also found no differences between the toad sexes or between juvenile and adult toad in number and length of prey consumed in the rainy and dry seasons.

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