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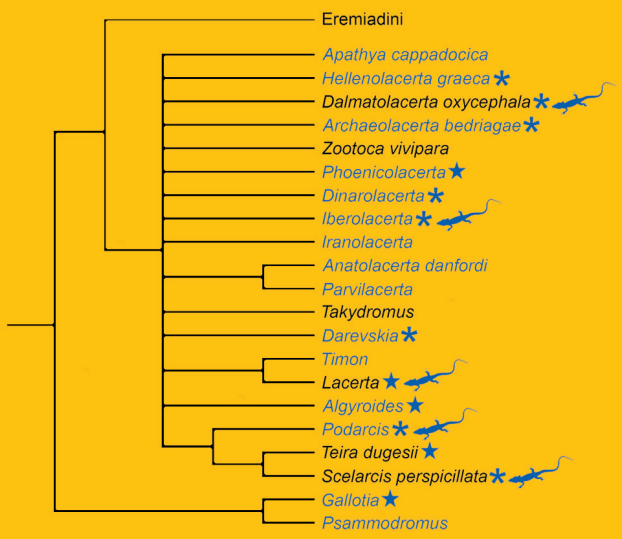

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Diet and fecundity of *Sphaenorhynchus planicola* (Anura, Hylidae) from a coastal lagoon in southeastern Brazil

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Abstract: The diet and fecundity of *Sphaenorhynchus planicola* inhabiting a coastal lagoon in southeastern Brazil were analyzed. Diet was examined in 85 exemplars of both males and females, and fecundity was analyzed in seven females. The studied population was male-biased with females much larger than males. Large proportions of the diet consisted of small arthropods. Prey size changed with growth suggesting ontogenetic trophic shift. Colonial arthropods, such as ants, were mainly ingested. Coleoptera larvae were also found in the stomach contents suggesting that the home range of *S. planicola* includes adjacent areas that have a supply of leaf litter and deadwood. The variety of ingested preys and high consumption of ants indicate *S. planicola* uses both active and sit-and-wait foraging behavior. The mean fecundity of *S. planicola* is 192.7, which is considered typical for hylids of this size. The population at the studied site seems to be small, suggesting that habitat degradation is affecting population size.
Key words: Brazil, fecundity, feeding, foraging, Hylidae.

Resumen: Dieta y fecundidad de *Sphaenorhynchus planicola* (Anura, Hylidae) en una laguna costera en el sudeste de Brasil. – Se analizó la dieta de 85 ejemplares de *Sphaenorhynchus planicola* habitantes de una laguna costera en el sureste de Brasil y la fecundidad de siete hembras. La población estudiada estaba formada mayoritariamente por machos, siendo las hembras de tamaño mucho mayor. Una gran proporción de la dieta consistió en pequeños artrópodos y cambió con el crecimiento, sugiriendo variación trófica asociada a la ontogenia. Artrópodos coloniales, tales como hormigas, fueron las presas mayoritariamente ingeridas. También fueron encontradas en los contenidos estomacales larvas de coleópteros, sugiriendo que el rango de forrajeo de *S. planicola* comprende áreas adyacentes a la laguna que incluyen hojarasca y madera muerta. La variedad de presas ingeridas y alto consumo de hormigas indican que *S. planicola* utiliza tanto forrajeo activo como forrajeo al acecho. La fecundidad promedio de *S. planicola* es 192.7, que puede considerarse típica para hílidos de tamaño similar. La población estudiada fue sorprendentemente pequeña, sugiriendo que la degradación del hábitat está afectando a su tamaño.
Palabras clave: alimentación, Brasil, fecundidad, forrajeo, Hylidae.

INTRODUCTION

Proper management of wildlife populations requires an in-depth knowledge of the natural history of each species. Diet composition and habitat use have been investigated in amphibians (TOFT, 1980, 1981; TEIXEIRA & VRCIBRADIC, 2004; FERREIRA *et al.*, 2007). Many species, however, require ecological information such as hylids. Without knowing how species utilize their environment, species numbers

could easily decline for seemingly unknown reasons.

Anurans are generally considered to be opportunists in relation to their feeding habits, and most of them act as ambush predators of small arthropods (Toft, 1980; Teixeira & Vrcibradic, 2004). Their diet reflects the microhabitat where they live, their ability to prey, and the abundance of potential prey (Duellman & Trueb, 1994; Giaretta *et al*., 1998).

Sphaenorhynchus planicola (Lutz & Lutz, 1938) is a small, greenish hylid frog distributed along the coast from the south of Bahia State to Rio de Janeiro State in southeastern Brazil. It spawns green eggs around floating vegetation, and is limited to permanent water bodies that contain a lot of floating vegetation (Izecksohn & Carvalho-e-Silva, 2001). *Sphaenorhynchus planicola* is also known to adapt well to disturbed habitats (Cruz & Telles, 2004). This species is considered to be of Least Concern by the IUCN (2009) due to its wide distribution. Even so data on its range, biology and ecology are scarce (Cruz & Telles, 2004), and no research has addressed the diet of *S. planicola*. The aim of this study was to determine (1) diet, and (2) fecundity of a *S. planicola* population inhabiting one coastal lagoon of southeastern Brazil.

Material and Methods

Study site

The study site was situated in the coastal Maimbá lagoon (20° 45’ S, 40° 57’ W, 8 m a.s.l.), located in the municipality of Anchieta, state of Espiríto Santo, southeastern Brazil. In the border of this coastal lagoon we established one 100 m long transect.

The studied area belongs to type Aw Tropical according to Köppen’s Climate Classification (Köppen, 1936), with high temperatures, a rainy summer (December-March) and a dry winter (June-September). The average monthly rainfall in the Anchieta region is 1200 mm, and the mean annual temperature is 25°C (Incaper, 2008).

Before a road linking the municipalities of Anchieta and Guarapari was built ca 40 years ago, the Maimbá lagoon was an estuarine system. Today, this lagoon is a freshwater system and its vegetation is dominated by *Typha dominguensis* (Typhaceae). The largest area of the study site was characterized by floating vegetation, represented mainly by *Salvinia* sp. (Salviniaceae). The site is linked to the ocean by a narrow channel covered with *T. dominguensis*. The environment around the lagoon has been, for the most part, greatly modified by humans and is characterized by herbaceous vegetation. The soil is very disturbed due to cattle using this site to drink, and the water has evidence of bovine and human feces.

Originally, the terrestrial environment of the study area was comprised mainly of “restinga” vegetation (Rizzini, 1979), included in the Tropical Atlantic Rain Forest morphoclimatic domain, which covered 90% of Espírito Santo state. Presently, vegetation has been reduced by 8.9% (SOS Mata Atlântica, 2004) due to economic exploitation including sand removal, heavy logging, and urban development (CCREMAD, 1992).

Samples

Research was conducted bimonthly from November 1994 through September 1995, and monthly from November 1996 through March 1997. The studied area was searched by one researcher, who manually collected the samples randomly along the transect. When a frog was collected the use of the microhabitat when first observed was

recorded. Collected frogs were measured alive (snout-vent length [SVL], to the nearest 0.1 mm with Vernier calipers) and weighed using a digital balance (0.1 g precision). After collection the frogs without apparent oocytes inside their body had the stomach contents removed using the stomach-flushing method (LEGLER & SULLIVAN, 1979). Frogs were released at the capture site during the same night. The stomach contents were placed in 70% ethanol until further examination. Seven females with mature oocytes were immediately euthanized with ether and transferred to 10% formalin for 24 h. They were then washed and preserved in 70% alcohol. These females were later dissected for fecundity determination and stomach content analysis. For fecundity analysis the number of oocytes was counted in each ovary.

Stomach contents obtained from both the males and females were identified to the lowest taxonomic category possible using a stereomicroscope. The relative importance of each food type was assessed based on the frequency of occurrence (F), number of prey (N), and wet weight (W); the latter was measured with a digital balance (± 0.0001 g). The frequency of occurrence was defined as the number of individuals that had item *i* in the stomachs, divided by the total number of sampled exemplars. Weights of the contents were taken after removing excess water with an absorbent paper. Intact prey items were measured to their total length using veneer calipers (to the nearest 0.1 mm). The vegetation found in the stomachs could not be properly quantified and therefore was not considered in the analyses, with exception of seeds.

Statistical Procedures

Sex ratio was assessed using the chi-square test (χ^2), and the difference in the mean SVL between males and females was tested using one-way analysis of variance (ANOVA). Before applying ANOVA, data were tested for normality (Kolmogorov-Smirnov test) and homoscedasticitity (Levene's test). When necessary, data were $\log_{10}$ transformed. Cluster analysis based on the Euclidian distances was performed in order to identify possible trophic ontogenetic variation in different SVL groups. For this, only log transformed data of prey size was used.

RESULTS

Eighty eight individuals of *Sphaenorhynchus planicola* were collected on floating vegetation, basically on *Salvinia* sp. Seventy seven of the individuals were males that ranged in SVL from 11.4 to 25.2 mm (mean = 22.2 mm , SD = 2.1 mm). Only eight females totalized our samples, and they varied in SVL from 24.2 to 27.9 mm (mean = 25.9 mm SVL, SD = 1.5 mm). The mean SVL was significant different between sexes (ANOVA: $F_{1.81} = 42.9$, $p < 0.01$), females being much larger than males. The sex ratio was 9.6:1, which was significantly different from the expected 1:1 ratio ($\chi^2 = 56.0$, $p < 0.01$). The other three individuals collected were considered juveniles since they were smaller and we were not able to identify the sex.

Seventy-four (87.0%) individuals had some prey in their stomachs (Table 1). Formicidae were the dominating food item, representing 46.3% of frequency, 58.7% of the number of prey, and 59.15% of the wet weight. Coleoptera larvae were the second largest prey group in the diet of *Sphaenorhynchus planicola*. Both groups represented 86.2% of the total food items, and 78.5% of the total prey weight. Our results suggest that individuals smaller than 26.0 mm SVL fed mostly on ants, while the largest fed on a greater prey variety (Fig. 1).

TABLE 1. Prey types found in the stomach of *Sphaenorhynchus planicola*. F: frequency, N: number, W: weight (in mg), TA: terrestrial prey, active on ground, TC: terrestrial and colonial prey, TH: terrestrial prey, hidden on surface, and GF: flying prey

TABLA 1. Tipo de presas encontradas en el contenido estomacal de *Sphaenorhynchus planicola*. F: frecuencia, N: número, W: peso (em mg), TA: presas terrestres, activas sobre el suelo, TC: presas terrestres y coloniales, TH: presas terrestres ocultas en la superfície del suelo y GF: presas voladoras.

Food items	Guilds	F	F (%)	N	N (%)	W	W (%)
Insecta							
Coleoptera (adult)	TA	3	3.8	3	2.8	7.5	3.6
Coleoptera (larvae)	TH	28	35.0	30	27.5	40.4	19.4
Diptera	GF	2	2.5	2	1.8	0.4	0.2
Homoptera	GF	1	1.3	1	0.9	0.7	0.3
Hymenoptera (Formicidae)	TC	37	46.3	64	58.7	123.2	59.1
Lepidoptera (larvae)	TH	2	2.5	2	1.8	6.3	3.0
Orthoptera	TA	2	2.5	2	1.8	5.5	2.6
Arachnida							
Araneae	TH	3	3.8	3	2.8	20.6	9.9
Mollusca							
Gastropoda	TA	1	1.3	1	0.9	1.9	0.9
Other							
Seed	-	1	1.3	1	0.9	1.8	0.9
Total	-	-	-	109	100.0	208.3	100.0

Seven females collected during the rainy season had mature oocytes. The number of oocytes was positively related to SVL ($y = 13.2x - 151.9$, $R^2 = 0.81$, $p < 0.05$, $n = 7$) (Fig. 2).

DISCUSSION

Interactions with plants play an important role for the success of *Sphaenorhynchus planicola* at the Maimbá lagoon, since all individuals were collected on floating vegetation. This vegetation probably determines the distribution of *S. planicola* in the Maimbá lagoon, which is restricted to the studied area. In addition the green coloration of the frog offers a good camouflage when sitting on *Salvinia* sp., becoming difficult to detect by day-active predators. Its cryptic coloration probably contributes to its survivorship in this area.

The sex ratio is an important characteristic when assessing aspects of population structure. In most animals, a sex-ratio of 1:1 is expected (LEIGH, 1970), but in our studied population the ratio was male biased. This may be because our sampling method was biased in favor of calling individuals. Perhaps this difference is only a characteristic of this specific population. Even so females are considered for some authors as a scarce resource at breeding sites, which consequently determines sexual selection (WELLS, 1977; RYAN, 1985; ROBERTSON, 1986). Facultative sex ratio variation will only be favored when its fitness benefits are greater than its cost (WEST *et al.*, 2002). Male-male competition during the reproductive period may give some advantage for the future generation; for example, producing a better singer, since most females have a preference for more

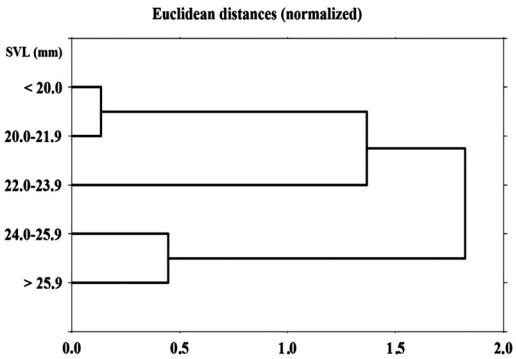

FIGURE 1. Cluster analysis supporting the hypothesis that diet shifts occur in *Sphaenorhynchus planicola* during ontogeny.
FIGURA 1. Análisis cluster que soporta la hipótesis del cambio de dieta de *Sphaenorhynchus planicola* durante su ontogenia.

complex calls (frequency and rates), which generally are produced by more fit males (GREERS & WELLS, 1980).

Males were significantly smaller than the females, which is a typical finding in most species of frogs (HAYEK & HEYER, 2005). Current evidence suggests that sexual dimorphism in size reflects the adaptation of males and females in their different reproductive roles (FAIRBAIRN, 1997).

The population of *Sphaenorhynchus planicola* analyzed here is characterized by a fecundity which is typical for hylids of this size. Prior to our study, only data for a single female *S. surdus* (Cochran, 1953) of 28.4 mm with 149 eggs were available (see POMBAL & HADDAD, 2005). *S. planicola* has a quite similar fecundity in relation to others hylids with similar SVL, such as *Dendropsophus microps* PETERS, 1873 of 31.4 mm with 336 eggs, *D. minutus* (Peters, 1872) of 24.9 mm with 255 eggs, and *S. fuscomarginatus* (Lutz, 1925) of 20 mm with 226 eggs (see POMBAL & HADDAD, 2005). Thus as our study and others have pointed out, fecundity in hylids is directly related to a frog's SVL.

Our research is the first study addressing ecological aspects of *Sphaenorhynchus* frogs. Although further investigation is necessary, we suspect that the *Sphaenorhynchus planicola* population at our study site is small. It is probably related to the water eutrophication of the Maimba lagoon, and by heavy predation by fish and belostomatids found at the study site (R.L. Teixeira & R.B. Ferreira, unpublished data). Smaller individuals of *S. planicola* were found feeding primarily on small ants, which is in line with previous research that suggests frogs prey mainly on small arthropods (e.g. TOFT, 1981; VAN SLUYS *et al.*, 2001; SANTOS *et al.*, 2004; FERREIRA *et al.,* 2007). Prey size is strongly related to a frogs' mouth width (EMERSON, 1985). The trophic ontogenetic shift found by cluster analyses suggests that the *S. planicola* avoids intraspecific competition, which is a strategy that has been reported for many anuran species (GIARETTA *et al.*, 1998; FERREIRA *et al.*, 2007). Although all individuals were collected on floating vegetation, the home range may also include leaf litter and dead wood on land. This

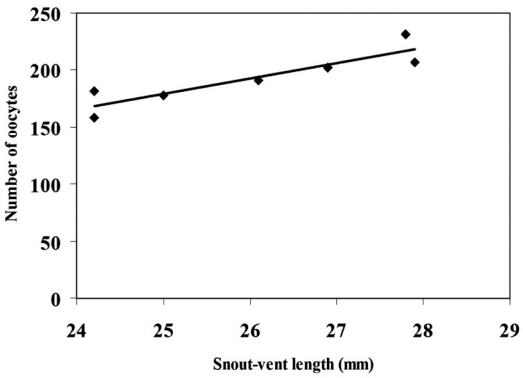

FIGURE 2. Relationship between the number of oocytes and snout-vent length (SVL) in *Sphaenorhynchus planicola* ($y = 13.2x - 151.9$, $R^2 = 0.81$, $P < 0.05$; $n = 7$).
FIGURA 2. Relación entre el número de oocitos y la longitud hocico-cloaca (SVL) en *Sphaenorhynchus planicola* ($y = 13.2x - 151.9$, $R^2 = 0.81$, $P < 0.05$; $n = 7$).

assumption is based on the relatively large amount of Coleoptera larvae that was ingested.

TOFT (1981) stated that foraging behavior and the number of prey in the stomach is correlated with the degree of specialization on ants; the sit-and-wait foragers rarely caught ants, and instead, they ate one or two large prey. Conversely, the more active forager has a higher proportion of ants in their diet. However, for some species along the continuum, inclusion in a particular guild may be arbitrary. Thus we suggest that *Sphaenorhynchus planicola* has a combination of the two foraging strategies. This frog may behave as an active forager until it finds an ant nest or trial, like small leaf frogs such as *Oophaga pumilio* (see DONNELY, 1991) and *Hypsiboas pulchellus* (see MANEYRO & ROSA, 2004), where they become in that situation a sit-and-wait predator. Besides the sit-and-wait behavior response for the wide variety of prey, which indicates a generalist feeder, *S. planicola* has a slight preference for ants. Feeding on colonial arthropods is a great advantage for anurans because these invertebrates comprise approximately 70% of the animal biomass in the tropical forest (HÖLLDOBLER & WILSON, 1990).

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