Papéis Avulsos de Zoologia
Museu de Zoologia da Universidade de São Paulo

ARTICLE

Diet of bromeliad-frog *Phyllodytes luteolus* (Anura, Hylidae) in Atlantic Forest environments: what have the frogs been eating outside sandy coastal plains?

Marcio Marques Mageski[1,4], Elaine Costa Campinhos[1,5], Charles Duca[2], Maria Carolina Stein[1,6], Melissa Peron de Oliveira[1,7] & Rute Beatriz Garcia Clemente-Carvalho[3]

[1] Universidade Vila Velha (UVV). Vila Velha, ES, Brasil.
[2] Universidade Vila Velha (UVV), Laboratório de Ecologia de Populações e Conservação (LEPC). Vila Velha, ES, Brasil.
ORCID: http://orcid.org/0000-0003-3903-8260. E-mail: cduca@uvv.br (corresponding author).
[3] Queen's University, Department of Biology. Kingston, Ontario, Canada.
ORCID: http://orcid.org/0000-0001-6922-9418. E-mail: rute_beatriz@hotmail.com
[4] Programa de Pós-Graduação em Ecologia de Ecossistemas (PPGEE).
ORCID: http://orcid.org/0000-0001-7528-072X. E-mail: marcioherpetologia@gmail.com
[5] ORCID: http://orcid.org/0000-0002-0205-4091. E-mail: elainecostacampinhos@gmail.com
[6] ORCID: http://orcid.org/0000-0003-0360-8786. E-mail: carolstein1@hotmail.com
[7] ORCID: http://orcid.org/0000-0002-9814-6723. E-mail: melissaperon@hotmail.com

Abstract. Knowledge about the diet of anurans in different environments is essential to understanding important aspects of their trophic ecology. The bromeliad-frog *Phyllodytes luteolus* inhabits tank bromeliads in sandy coastal plains and lowland forests on the mainland, as well as a continental island in southeastern Brazil. In this work, we describe and analyze the diet of *P. luteolus* in three environments. We obtained the consumed prey items of 92 frogs (32 from sandy coastal plain, 32 from lowland forest and 28 from the island) via a stomach-flushing procedure. We found some variations in consumed prey composition and prey volume across populations, but ants represented the most important consumed prey in all environments. Only ants had a relative importance greater than 50%, which may suggest a specialized diet that transcends the sandy coastal plain environment.

Key-Words. Amphibians; Lowland forest; Prey; Restinga; Trophic ecology.

INTRODUCTION

Amphibians generally prey on a wide variety of invertebrates (Lima *et al.*, 2010; Cicort-Lucaciu *et al.*, 2011; Solé & Rödder, 2010), vertebrates (Duellman & Lizana, 1994), and, less frequently, fruits (Silva & Britto-Pereira, 2006). They are therefore considered to be generalists in their diet. However, prey consumption by amphibians may vary in composition and size, especially when populations live in different environments (Berazategui *et al.*, 2007; Sabagh *et al.*, 2012; Maia-Carneiro *et al.*, 2013).

The bromeliad frog *Phyllodytes luteolus* (Wied-Newied, 1824) is an endemic species from the Atlantic Forest on the eastern coast of Brazil (Frost, 2016). This frog evolved to use the water stored in tank bromeliads, which are required for reproduction (Peixoto, 1995; Haddad & Prado, 2005). This ecological relationship with bromeliads allows the frog occurrence in environments where fresh water is a limiting resource, namely, in sandy coastal plains (Peixoto, 1995; Ferreira *et al.*, 2012; Mageski *et al.*, 2016; Frost, 2016). However, some populations of *P. luteolus* were recently found in other environments, including lowland forests and a continental island (Peixoto, 1995; Mageski *et al.*, 2014; Mageski *et al.*, 2015).

Phyllodytes luteolus was reported to be the most abundant anuran in sandy coastal plains, preying mainly on ants and termites (Eterovick, 1999; Ferreira *et al.*, 2012; Mageski *et al.*, 2015; Motta-Tavares *et al.*, 2016). However, nothing is known about the diet of *P. luteolus* outside the sandy coastal plains. This knowledge is crucial to describing the spectrum of its diet and to understanding the patterns and variations of its prey consumption, positioning in trophic webs and

Pap. Avulsos Zool., 2019; v.59: e20195929
http://doi.org/10.11606/1807-0205/2019.59.29
http://www.revistas.usp.br/paz
http://www.scielo.br/paz
Edited by: Carlos José Einicker Lamas
Received: 20/07/2018
Accepted: 12/06/2019
Published: 03/07/2019

ISSN On-Line: 1807-0205
ISSN Printed: 0031-1049
ISNI: 0000-0004-0384-1825

foraging strategies (Toft, 1980, 1981; Wells, 2007; Motta-Tavares *et al.,* 2016).

We described and analyzed the diet of three *P. luteolus* populations that inhabit different environments (sandy coastal plains, lowland forest and island) in order to reveal the most important consumed prey item outside sandy coastal plains. Our goal was to assess the variety of consumed prey items (kind, number and volume) at each environment in order to estimate trophic niche overlapping among the populations and to determine the foraging strategy of *P. luteolus.*

MATERIALS AND METHODS

We sampled three populations of *P. luteolus* in different environments in 2015 (9 and 10 May in the sandy coastal plain, 23 August in the island and 13 and 14 September in the lowland forest), all within Espírito Santo State (Fig. 1). The sandy coastal plain (-20.614780° lat, -40.418049° long, datum WGS84 – Fig. 1), which is greatly influenced by the ocean, is a largely open environment with sandy soil and low vegetation cover (Franco *et al.,* 1984; Mageski *et al.,* 2016). The lowland forest (-19.137466° lat, -40.062733° long, datum WGS84 – Fig. 1) has a mixture of sandy and clay soil, with a high proportion under cover of vegetation (Jacomine, 1996; Paula, 2006). The island (-20.613186° lat, -40.382230° long, datum WGS84 – Fig. 1) is mainly composed of rocky outcrops with ground vegetation and is close to the sandy coastal plain (~3 km).

We searched for frogs randomly in clusters of tank bromeliads during the night (18-23 h). Following capture, we applied a stomach-flushing procedure (Solé *et al.,* 2005) to obtain the stomach contents, which were preserved in 70% ethanol. To prevent recapture, all captured individuals were kept in moist plastic bags until the end of sampling and were then released.

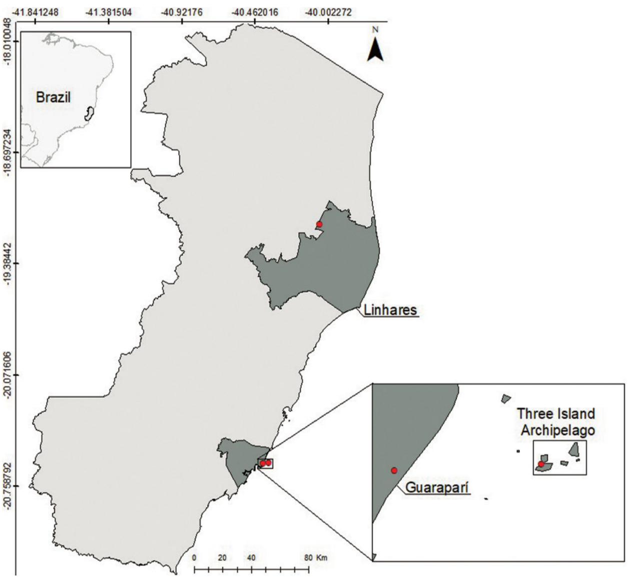

Figure 1. Study sites in Espírito Santo State, southeastern Brazil. Dark gray points represent the sampled *Phyllodytes luteolus* populations.

We analyzed the stomach contents under a stereomicroscope. All prey items were identified to Order level, and ants were identified to Family level. The number and frequency of occurrence for each prey item were quantified, and the width and length were measured with digital caliper (0.01 precision). These measurements were required for calculating the ellipsoidal volume ($V = 4/3\pi * (L/2) * (W/2)^2$), where L = prey length and W = prey width (Colli & Zamboni, 1999; Biavati *et al.,* 2004), and the index of relative importance (I = (N% + F% + V%)/3), where N% = the number of each prey category relative to the total number of prey ingested, F% = the number of stomachs containing each prey relative to number of stomachs analyzed, and V% = the volume of each prey category relative to the total volume of prey ingested (Biavati *et al.,* 2004). We used the prey volume to calculate Pianka's similarity index (Pianka, 1973) to test the trophic niche overlap between populations:

$$Ojk = \frac{\sum_{i=1}^{n} pij\, pik}{\sqrt{\sum_{i=1}^{n} pij^2 \sum_{i=1}^{n} pik^2}}$$

j and *k* are the pairs of populations being compared, and *pi* is the proportion of prey *i* consumed (number or volume).

Additionally, we performed an analysis of similarity with non-metric multidimensional scaling (NMDS, Motta-Tavares *et al.,* 2016) using Euclidean distance to compare the presence of consumed prey across populations. We used analysis of variance (ANOVA) to test whether the number and volume of ingested prey were different across populations (Motta-Tavares *et al.,* 2016). All statistical analyses were performed in R 3.1.2 (R Development Core Team, 2016), using $P < 0.05$ as the significance level.

RESULTS

In all environments, *P. luteolus* were found inhabiting tanks of soil bromeliads in open areas (without vegetation cover). We evaluated the stomach contents of 92 individuals: 32 from sandy coastal plains, 32 from lowland forest and 28 from the island. Three of the individuals collected in the lowland forest did not have any stomach contents. We identified a total of 397 consumed prey items belonging to 12 taxa (Table 1). Ants were the most important prey category in the diet of *P. luteolus* in populations sampled, representing the highest number, frequency and volume relative to the other prey categories (Table 1). However, some consumed prey items were exclusive to a single environment (Table 1 and Fig. 2).

The number of prey items consumed by *P. luteolus* in the lowland forest (mean = 7.65 ± 2.18 SE), sandy coastal plains (mean = 4.69 ± 1.56), and on the island (mean = 2.59 ± 0.57 SE) did not differ (ANOVA, $F_{2,71} = 2.22$, $P = 0.11$), which was confirmed by the high niche overlap between populations (Table 2). However, the volume of consumed prey in the lowland forest (mean = 21.51 ± 5.28 SE) differed from that of the san-

Table 1. Prey ingested by *P. luteolus* in three environments in Espírito Santo State, southeastern Brazil. Number of ingested prey items in all stomachs (N), frequency of prey items in all stomachs (F), volume of prey ingested per category (V) and relative importance index (I).

Taxon	N (%)	F (%)	V (%)	I (%)
Sandy coastal plains				
Chilopoda	2 (1.85)	2 (7.14)	6.6 (3.86)	3.5 (3.4)
Coleoptera	2 (1.85)	2 (7.14)	9.8 (5.67)	4.6 (4.4)
Hymenoptera Formicidae	92(85.18)	20 (71.43)	141.8 (82.14)	84.6 (82.4)
Ixodidae	3 (2.78)	1 (3.57)	1.9 (1.13)	1.9 (1.8)
Isoptera	7 (6.48)	1 (3.57)	7.8 (4.54)	5.2 (5)
Larvae	2 (1.85)	2 (7.14)	4.5 (2.65)	2.8 (2.7)
Lowland forest				
Araneae	3 (1)	3 (9)	17.3 (3)	7.7 (2.58)
Coleoptera	6 (3)	5 (16)	25 (4)	12 (4)
Diptera	4 (2)	2 (6)	10 (2)	5.3 (1.7)
Hymenoptera Formicidae	196 (87)	27 (84)	357.5(58)	193.5 (64.9)
Hymenoptera non-Formicidae	11 (5)	7 (22)	73.7 (12)	30.5 (10.2)
Hemiptera	4 (2)	3 (9)	20.9 (3)	9.3 (3.1)
Odonata	1 (0)	1 (3)	117 (19)	39.6 (13.2)
Island				
Coleoptera	2 (3.08)	2 (6.67)	2.6 (0.95)	2.2 (1.8)
Diptera	4 (6.15)	4 (13.33)	8.6 (3.11)	5.53 (4.5)
Homoptera	1 (1.54)	1 (3.33)	9.4 (3.39)	3.8 (3.1)
Hymenoptera Formicidae	56 (86.15)	21 (70.00)	253 (90.49)	110 (90.5)

Table 2. Diet overlap index between populations of *P. luteolus* on the island and in mainland ecosystems in Espírito Santo State, southeastern Brazil.

Environments relations	Prey number	Prey volume
Sandy Coastal Plains x Island	0.73	0.74
Lowland Forest x Island	0.75	0.52
Sandy Coastal Plains x Lowland Forest	0.74	0.47

dy coastal plains (mean = 7.75 ± 2.91 SE) and the island (mean = 14.08 ± 1.99 SE), presenting smaller niche overlap in relation to those two areas (ANOVA: $F_{2,71} = 3.03$, $P = 0.05$, Tukey HSD: $P = 0.04$) (Table 2).

DISCUSSION

The diet of *P. luteolus* was composed exclusively of arthropods, and ants were the most consumed prey in number, frequency and volume in environments sampled. The high importance of ants in the diet of *P. luteolus* was also observed in other sandy coastal plains in Espírito Santo State (Ferreira *et al.,* 2012; Motta-Tavares *et al.,* 2016) and Bahia (Motta-Tavares *et al.,* 2016; Solé & Loebmann, 2017). Because of the high consumption of ants and termites, *P. luteolus* has been considered to be specialized with regards to its diet (colonial insects) and foraging strategies (Ferreira *et al.,* 2012). In addition, we found that the importance of ants in the diet of *P. luteolus* was independent of environment, which is further indicative of diet specialization, similar to other frog species. For example, ants also represented more than 50% of the diet of two other dendrobatid frogs (*Ameerega flavopicta* and *A. braccata*), which were thus classified as specialist predators with active foraging behavior (Biavatti *et al.,*

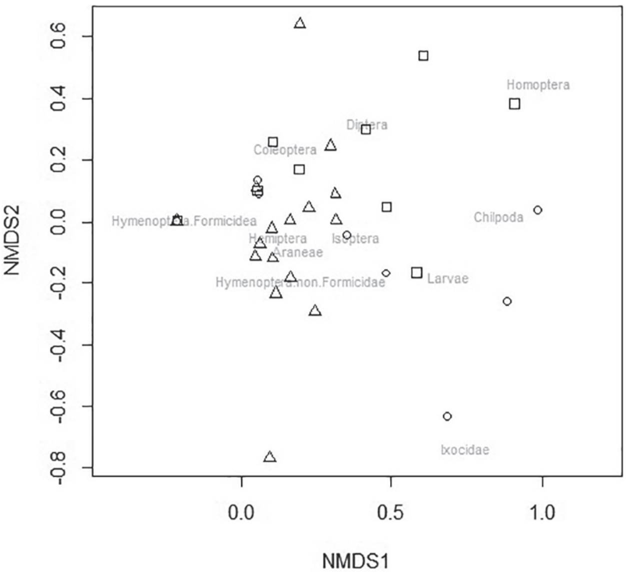

Figure 2. Non-metric multidimensional scaling (NMDS) plot for prey presence. The represented populations of *P. luteolus* in lowland forest (triangles), sandy coastal plains (circles) and island (squares) environments in Espírito Santo State, southeastern Brazil.

2004; Forti *et al.,* 2011). However, it is necessary to consider prey availability to determine whether the amount of ants consumed by *P. luteolus* was proportionate to the abundance of this prey in its environment.

Although ants were the most important prey in their stomachs, *P. luteolus* also fed on 13 other prey items that varied in either kind, or relative importance across populations. In addition to ants, *P. luteolus* ingested Isoptera and Coleoptera on sandy coastal plains, Odonata and Hymenoptera (Non Formicidae) in the lowland forest and Diptera and Homoptera on the island, as prey items with secondary importance. If we consider the same prey category division that was used in the present study, the number of prey items consumed by *P. luteolus* was the same as in the sandy coastal plain of northeastern Espírito Santo (Ferreira *et al.,* 2012) and was higher than that found in other sandy coastal plains in Espírito Santo, Bahia and Rio de Janeiro (Motta-Tavares *et al.,* 2016). Although the differences probably reflect the available prey in each environment, all consumed prey items were strongly associated with bromeliads (Lima & Moreira, 1993; Mestre *et al.,* 2001; Juncá & Borges, 2002; Sepka, 2008). These findings corroborate other studies that have suggested that *P. luteolus* rarely leaves the bromeliads to feed (Peixoto, 1995; Ferreira *et al.,* 2012; Motta-Tavares *et al.,* 2016).

We found that in the lowland forest, *P. luteolus* consumed a larger volume of prey and had a lower niche overlap compared to sandy coastal plains and the island. This variability is probably a consequence of the distance between locations and vegetation dissimilarities, differences that are reflected in prey composition (Maia-Carneiro *et al.,* 2013). The sandy coastal plain and lowland forest are very distant to each other (*ca.* 160 km) and have dissimilar vegetation, whereas the island is nearby the sandy coastal plain (*ca.* 3 km) and has similar vegetation (Rizzini, 1979; Mageski *et al.,* 2015). Similar patterns were found in a study comparing *P. luteolus* diet in three sandy coastal plains of southeastern Brazil (Guaraparí, Guriri and Prado), which showed that the major differences in consumed prey volume were found between the more distant populations (Motta-Tavares *et al.,* 2016). Another study that compared the diet of *Rhinella ornata* across environments showed no difference in consumed prey volume between similar environments (Maia-Carneiro *et al.,* 2013). Thus, both greater distance and vegetation dissimilarities may influence the variability of prey composition between environments, and that is reflected in the reported differences in consumed prey.

Our work contributes to the understanding of the patterns and variations underlying the diet of *P. luteolus* inhabiting environments outside of sandy coastal plains. We suggest that ants may be the most important component of the diet of *P. luteolus,* due to their high proportion in the frog's diet, as was observed in the environments studied here. Therefore, it is necessary to perform comparative studies between consumed and available prey items in bromeliads using the electivity index, as proposed by Jacobs (1974), to determine whether the observed dietary preferences of this bromeliad frog truly exist or are merely an artifact of prey availability.

ACKNOWLEDGMENTS

We are grateful to Dr. Mirco Solé for comments and suggestions on the final version of this manuscript and for English revision. The Instituto Estadual de Meio Ambiente e Recursos Hídricos (IEMA) and the Instituto Chico Mendes de Conservação da Biodiversisdade (ICMBio, SISBIO) provided the sampling permits (Proc. № 59666501/2013 and № 37762-2/2013, respectively). MMM received scholarships from Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

REFERENCES

Berazategui, M.; Camargo, A. & Maneyro, R. 2007. Environmental and seasonal variation in the diet of Elachistocleis bicolor (Guérin-Méneville 1838) (Anura: Microhylidae) from Northern Uruguay. *Zoological Science,* 24: 225-231. DOI

Biavati, G.M.; Wiederhecker, H.C. & Colli, G.R. 2004. Diet of *Epipedobates flavopictus* (Anura: Dendrobatidae) in a Neotropical Savanna. *Journal of Herpetology,* 38: 510-518. DOI

Cicort-Lucaciu, A.S.; Cupsa, D.; Ilies, D.; Ilies, A.; Baias, S. & Sas, I. 2011. Feeding of two amphibian species (*Bombina variegata* and *Pelophylax ridibundus*) from artificial habitats from Pădurea Craiului Mountains (Romania). *North-Western Journal of Zoology,* 7: 297-303.

Colli, G.R. & Zamboni, D.S. 1999. Ecology of the Worm-Lizard *Amphisbaena alba* in the Cerrado of Central Brazil. *Copeia,* 1999: 733-742. https://www.jstor.org/stable/1447606.

Duellman, W. & Lizana, M. 1994. Biology of a sit-and-wait predator, the Leptodactylid frog *Ceratophrys cornuta. Herpetologica,* 50: 51-64. https://www.jstor.org/stable/3892875.

Eterovick, P.C. 1999. Use and sharing of calling and retreat sites by *Phyllodytes luteolus* in modified environment. *Journal of Herpetology,* 33: 17-22.

Ferreira, R.B.; Schineider, J.A.P. & Teixeira, R.L. 2012. Diet, Fecundity, and Use of Bromeliads by *Phyllodytes luteolus* (Anura: Hylidae) in Southeastern Brazil. *Journal of Herpetology,* 46: 19-24. DOI

Forti, L.R.; Tissiani, A.S.O.; Mott, T. & Strüssmann, C. 2011. Diet of *Ameerega braccata* (Steindachner, 1864) (Anura: Dendrobatidae) from Chapada dos Guimarães and Cuiabá, Mato Grosso state, Brazil. *Brazilian Journal of Biology,* 71: 189-196. DOI

Franco, A.C.; Valeriano, D.M.; Santos, F.M.; Hay, J.D.; Henriques, R.P.B. & Medeiros, R.A. 1984. Os microclimas das zonas de vegetação da praia da sandy coastal plains de Barra de Maricá, Rio de Janeiro. *In:* Lacerda, L.D.; Araujo, D.S.D.; Cerqueira, R. & Turcq, B. (Eds.). *Restingas: origem, estrutura e processos.* Rio de Janeiro, CEUFF. p. 413-423.

Frost, D.R. 2016. *Amphibian Species of the World: an online reference.* Available at: http://research.amnh.org/herpetology/amphibia/index.html. Access in: 25/10/2017.

Haddad, C.F.B. & Prado, C.P.A. 2005. Reproductive modes in frogs and their unexpected diversity in the Atlantic Forest of Brazil. *Bioscience,* 55: 207-217. DOI

Jacobs, J. 1974. Quantitative measurement of food selection. *Oecologia,* 14: 413-417. https://link.springer.com/content/pdf/10.1007%2FBF00384581.pdf.

Jacomine, P.K.T. 1996. Distribuição geográfica, características e classificações dos solos coesos dos tabuleiros costeiros. *In:* Reunião Técnica Sobre Solos Coesos dos Tabuleiros, Cruz das Almas. *Anais.* Cruz das Almas, EMBRAPA/UFBA. p. 13-26.

Juncá, F.A. & Borges, C.L.S. 2002. Fauna associada a bromélias terrícolas da Serra da Jibóia, Bahia. *Sitientibus Série Ciências Biológicas,* 2: 73-81.

Lima, A.P. & Moreira, G. 1993. Effects of prey size and foraging mode on the ontogenetic change in feeding niche of *Colostethus stepheni* (Anura: Dendrobatidae). *Oecologia,* 95: 93-102. https://link.springer.com/content/pdf/10.1007%2FBF00649512.pdf.

Lima, E.P.L.; Rödder, D. & Solé, M. 2010. Diet of two sympatric *Phyllomedusa* (Anura: Hylidae) species from a cacao plantation in southern Bahia, Brazil. *North-Western Journal of Zoology,* 6: 13-24. http://www.biozoojournals.ro/nwjz/content/v6.1/nwjz.061102.Lima.pdf.

Mageski, M.M.; Coutinho, H. & Clemente-Carvalho, R.B. 2014. Distribuição espacial e seleção do hábitat por anfíbios anuros em Mata Atlântica sobre a formação Barreiras no sudeste do Brasil. *Natureza Online,* 12: 230-234. http://naturezaonline.com.br/natureza/conteudo/pdf/07_MageskiMetal_230-234.pdf.

Mageski, M.M.; Ferreira, R.B.; Beard, K.H.; Costa, L.C.; Jesus, P.R.; Medeiros, C.C. & Ferreira P.D. 2016. Bromeliad Selection by *Phyllodytes luteolus* (Anura, Hylidae): The Influence of plant structure and water quality factors. *Journal of Herpetology,* 50: 108-112. DOI

Mageski, M.M.; Ferreira, R.B.; Jesus, P.R.; Costa, L.C.; Roper, J.J. & Ferreira, P.D. 2015. The island rule in the Brazilian frog *Phyllodytes luteolus* (Anura: Hylidae): incipient gigantism? *Zoologia,* 32: 24-25. DOI

Maia-Carneiro, T.; Kiefer, M.C.; Van Sluys, M. & Rocha, C.F.D. 2013. Feeding habits, microhabitat use, and daily activity period of *Rhinella ornata* (Anura, Bufonidae) from three Atlantic rainforest remnants in southeastern Brazil. *North-Western Journal of Zoology,* 9: 157-165. http://biozoojournals.ro/nwjz/content/v9n1/nwjz.131506.Maia-Carneiro.pdf.

Mestre, L.A.M.; Aranha, J.M.R. & Esper, M.L. 2001. Macroinvertebrate fauna associated to the bromeliad *Vriesea inflata* of Atlantic Forest (Parana state, southern Brazil). *Brazilian Archives of Biology and Technology,* 44: 89-94. DOI

Motta-Tavares, T.; Maia-Carneiro, T.; Dantas, L.F.; Van Sluys, M.; Hatano, F.H.; Vrcibradic, D. & Rocha, C.F.D. 2016. Ecology of the bromeligenous frog

Phyllodytes luteolus (Anura, Hylidae) from three sandy coastal plains remnants across Brazil's coast. *Anais da Academia Brasileira de Ciências,* 88: 93-104. DOI

Paula, A. 2006. *Florística e fitossociologia de um trecho de floresta ombrófila densa de terras baixas na Reserva Biológica de Sooeretama, Linhares, ES.* Ph.D. Dissertation. Universidade Federal de São Carlos.

Peixoto, O.L. 1995. Associação de anuros e bromeliáceas na Mata Atlântica. *Revista Universidade Rural, Série Ciências da Vida,* 17: 75-83. http://ufrrj.br/SEER/index.php?journal=rcv&page=article&op=view&path%5B%5D=1568&path%5B%5D=1113.

Pianka, E.R. 1973. The structure of lizard communities. *Annual Review of Ecology and Systematics,* 4: 53-74. DOI

R Development Core Team. 2016. R: *A language and environment for statistical computing.* R Foundation for Statistical Computing.

Rizzini, C.T. 1979. *Tratado de Fitogeografia do Brasil.* São Paulo, HUCITEC/EDUSP.

Sabagh, L.T.; Carvalho-e-Silva, A.M.P.T. & Rocha, C.F.D. 2012. Diet of the toad *Rhinella icterica* (Anura: Bufonidae) from Atlantic Forest Highlands of southeastern Brazil. *Biota Neotropica,* 12: 258-262. http://www.biotaneotropica.org.br/v12n4/en/abstract?short-communication+bn01612042012.

Sepka, E.R. 2008. *Estudo de macroinvertebrados associados a Bromeliaceae em uma área de Mata Atlântica no estado do Paraná, Brasil, com ênfase na Família Syrphidae (Diptera).* Ph.D. Dissertation. Curitiba, Universidade Federal do Paraná.

Silva, H.R. & Britto-Pereira, M.C. 2006. How much fruit do fruit-eating frogs eat? An investigation on the diet of *Xenohyla truncata* (Lissamphibia: Anura: Hylidae). *Journal of Zoology,* 270: 692-698. DOI

Solé, M. & Loebmann, D. 2017. Disgusting or delicious? Predatory behavior of the hylid frog *Phyllodytes luteolus* on sympatric ants. *Iheringia, Série Zoologia,* 107: e2017030. DOI

Solé, M. & Rödder, D. 2010. Dietary assessments of adult amphibians. *In:* Dodd, C.K. *Amphibian ecology and conservation: a handbook of techniques.* Oxford, Oxford University Press. p. 167-184.

Solé, M.; Beckmann, O.; Pelz, B.; Kwet, A. & Engels, W. 2005. Stomach-flushing for diet analysis in anurans: an improved protocol evaluated in a case study in Araucaria forests, southern Brazil. *Studies on Neotropical Fauna and Environment,* 40: 23-28. DOI

Toft, C.A. 1980. Seasonal variation in populations of Panamanian litter frogs and their prey: a comparison of wetter and drier sites. *Oecologia,* 47: 34-38. DOI

Toft, C.A. 1981. Feeding ecology of Panamanian litter anurans: patterns in diet and foraging mode. *Journal of Herpetology,* 15: 139-144.

Wells, K.D. 2007. *The Ecology and Behavior of Amphibians.* Chicago, The University Chicago Press.