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Anuran composition in a Brazilian semi-arid environment with notes on reproductive activity

Composição da Anurofauna em ambiente semiárido do Brasil com observações sobre atividade reprodutiva

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Abstract

There are few studies on the composition and diversity of species in the Brazilian semi-arid region, especially regarding the Anura biodiversity. Within this context, we aimed to characterize the composition of the anuran community of Cajueiro Farm, Paraíba semi-arid. The field samplings were conducted monthly between November 2013 and June 2014 for two consecutive days. The species were localized through visual and auditory active search limited by time. Using the Pearson regression analysis, the relation between the number of species and vocalization vs. rainfall was tested. The sample-based species accumulation curve indicated the adequacy of the anuran capture methodology. A total of 324 individuals, distributed in 17 species, 11 genera and four families, namely Leptodactylidae (n = 9), Hylidae (n = 5), Bufonidae (n = 2), Odontophrynidae (n = 1), were recorded. Among the recorded species, 13 presented reproductive activity (vocalization) during the study period. The number of species recorded, as well as the number of species in vocalization, was not related to rainfall.

Keywords: biodiversity, caatinga, conservation.

Resumo

A região do sertão do Nordeste brasileiro apresenta poucos estudos sobre a composição e diversidade de espécies, em especial referentes à biodiversidade de Anura da Caatinga. Dentro desse contexto, nosso objetivo foi caracterizar a composição da comunidade de anuros da Fazenda Cajueiro, Sertão paraibano. Realizamos as amostragens de campo mensalmente entre novembro de 2013 a junho de 2014 durante dois dias seguidos. Localizamos as espécies por meio de busca ativa visual e auditiva limitada por tempo. Utilizando-se a análise de regressão de Pearson, foi testada a relação entre o número de espécies vs. a pluviosidade e a vocalização. A curva de acumulação de espécies, baseada em amostras, indicou adequação da metodologia na captura dos anuros. Registramos 324 indivíduos, distribuídos em 17 espécies, 11 gêneros e quatro famílias: Leptodactylidae (n = 9), Hylidae (n = 5), Bufonidae (n = 2), Odontophrynidae (n = 1). Dentre as espécies registradas, 13 apresentaram atividade reprodutiva (vocalização) durante o período de estudo. O número de espécies, bem como o número de espécies em vocalização, não teve relação com a pluviosidade.

Palavras-chave: biodiversidade, caatinga, conservação.

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Introduction

Studies on the biology and distribution of amphibians can generate important information about the quality of the environment itself, mainly in natural areas, working as a basis for the elaboration of effective management and conservation measures (Pereira *et al*., 2015). The Neotropical region comprises the largest diversity of anuran amphibians, with approximately one-third of the species known in the world (Duellman, 1999). However, mostly of the Caatinga amphibian inventories published to date have been conducted within protected areas and/or in humid areas of high altitude, being in fact areas that are better characterized as Rain Forest and/or Cerrado enclaves (Santana *et al*., 2015).

The Brazilian territory comprises 1080 known species of amphibians (Segalla *et al*., 2016), and this high diversity may be explained by the extensive domain of the landscape, formed by very heterogeneous ecosystems. Nevertheless, the knowledge about amphibian diversity in Brazilian biomes is scarce (Vieira, 2007), and this animal group has one of the highest rates of decline in several places in the world (Stuart *et al*., 2004). The main reasons for these declines are the increasing climate change, the intense destruction of their natural habitats, infectious diseases from the high degrees of pollution, invasive species, ultraviolet radiation and illegal trade (Young *et al*., 2004).

Among the Brazilian morphoclimatic domains, the Caatinga biome is represented by a mosaic of xerophilous, thorny and shrub vegetation, inserted in a semi-arid region, covering an area of 844,453 square kilometers, corresponding to 11% of the Brazilian territory, but little protected and studied (Leal *et al*., 2003). Despite being neglected with a small parcel protected by conservation units, the Caatinga has a diverse biological heritage, in which recent studies (Arias *et al*., 2001, 2011; Passos *et al*., 2011; Magalhães *et al*., 2014; Santana *et al*., 2015) have described new species in the semi-arid regions, demonstrating that, contrary to that many stated previously, this domain is not poor in species or endemism, although still poorly sampled (Pessoa *et al*., 2012).

The Caatinga has regional characteristics, such as backwoods areas, a term used in the northeastern states to designate the driest part of the biome where vegetation reflects these environmental conditions. The Brazilian semi-arid region has shallow soils, irregular pluviometrical precipitations, contrasting with prolonged droughts and ephemeral torrential rains (Araújo *et al*., 2016). The species of anurans that present reproductive modes dependent on accumulated water gather in these aquatic habitats suitable for oviposition and larval development, forming aggregations with high inter and intraspecific potential (Bertoluci and Rodrigues, 2002). The use of different microhabitats as reproductive sites facilitates spatial partitioning by anurans, and the reproductive activity of these individuals is strongly influenced by the availability of water bodies and mild temperatures (Ferreira-Silva *et al*., 2016).

There are large gaps in relation to the distribution of species of anurans amphibians in the northeastern semi-arid region and few studies are developed in this environment, avoiding better directions in conservation and management actions for the amphibian fauna of this region. About the knowledge of the anurans of the semi-arid region of the state of Paraíba, few studies were held, highlighting Vieira *et al*. (2007), Protázio *et al*. (2015) and Costa *et al*. (2016). Within this context, our aim in this work was to analyses the community composition of anuran amphibians in an area inserted in the Caatinga biome, in Northeast Brazil, evaluating also whether there is a relationship between number of species and vocal activity vs. precipitation. Observations on reproductive activity and use of microhabitats are also reported.

Material and methods

Study area

The Cajueiro Farm (6°20'38"S, 37°44'48" W) belongs to the Human and Agrarian Sciences Center of the State University of Paraíba (UEPB), Campus IV, located in the municipality of Catolé do Rocha, Paraíba, located in the semi-arid region of the Brazilian Northeast, with an average altitude of 270 m above the sea level. It has a hot semi-arid climate, with summer rains, and a dry weather predominating in an average of five to seven months. According to the Köppen-Geiger classification, it is a tropical savanna climate with dry winter (Aw) (Kottek *et al*., 2006). The average annual rainfall is approximately 850 mm and its average temperature ranges from 26 to 27ºC. The vegetation is of the Caatinga-Backwood type (Beltrão *et al*., 2005).

The study site has an area of 112 hectares, is covered by Caatinga physiognomy of the type tree and shrub rich in thorny plants, cactaceous and several fruit species, with the presence of streams, reservoirs, wetlands and hillside areas. We collected the specimens in the farm pond, which presented water throughout the study period. The vegetation in its surroundings is represented by arboreal-shrub Caatinga besides the presence of grasses and sandy soil with the presence of rocks. We obtained the values of rainfall (Table 1) through the Executive Agency of Water Management of the State of Paraíba (AESA, n.d.).

We conducted the field samplings monthly, from November 2013 to June 2014, for two consecutive days. Species were recorded through active visual and auditory search limited by time (Heyer *et al*., 1990), starting at 6h p.m. until 9h p.m., totaling 96 hours/man of sample effort. Data on reproductive activity of individuals were

Table 1. Accumulated rainfall values at Cajueiro Farm, Catolé do Rocha, Paraíba semi-arid region, Northeast Brazil, in the period from November 2013 to June 2014.

	Months	Rainfall (mm)
2013	November	109.20
	December	126.10
2014	January	7.00
	February	148.20
	March	191.80
	April	331.90
	May	139.30
	June	13.80

also recorded, including vocalization and/or amplexus, calling season, as well as types and use of microhabitat (shrub, water, sand, stone, aquatic vegetation). Voucher specimens were killed following the resolution 714 of the Federal Council of Veterinary Medicine (2002), by means of hyper doses of anesthetic lidocaine 5%, fixed with 10% formaldehyde and preserved in alcohol 70%. All voucher specimens are housed in the didactic collection of the Laboratory of Zoology of the Federal University of Campina Grande (UFCG/Cuité, PB) (Collection License Nº. 82872297, Chico Mendes Institute for Biodiversity Conservation).

Data analysis

To evaluate the efficacy of the capture methodology, a sample-based rarefaction (species accumulation curve) was generated, based on a presence-absence data matrix. We performed a Pearson regression analysis between number of recorded species and vocal activity and rainfall.

Results

We recorded a total of 324 individuals, distributed in 17 species, 11 genera and four families: Leptodactylidae (n = 9), Hylidae (n = 5), Bufonidae (n = 2), Odontophrynidae (n = 1) (Chart 1; Figures 1-3). Analyzing the rarefaction curve (species accumulation) we observed that it reached its asymptote from the sixth collection (Figure 4), demonstrating that the sampling effort was adequate and enough for the study area.

Regarding reproductive activities, we recorded 13 species by vocalizing. This behavior was observed in all months of research, with high variation in the number of vocalizing species (Table 2). The lowest number was recorded in November 2013, with the vocalizing of only *Pseudopaludicola pocoto.* The maximum registered number of vocalizing species occurred in February 2014 (Table 2). Individuals of *P. pocoto* showed the higher activity of vocalization, presenting the behavior in seven of the eight months of collection, followed by *B. raniceps* and

Chart 1. List of anuran species recorded at the Cajueiro Farm, Paraíba semi-arid region, Northastern Brazil, from November 2013 to June 2014.

Family	Species
Bufonidae	*Rhinella granulosa* (Spix 1824)
	Rhinella jimi (Stevaux 2002)
Hylidae	*Corythomantis greeningi* Boulenger 1896
	Dendropsophus nanus (Boulenger 1889)
	Boana raniceps (Cope 1862)
	Pithecopus nordestinus (Caramaschi 2006)
	Scinax x-signatus (Spix 1824)
Leptodactylidae	*Leptodactylus fuscus* (Schneider 1799)
	Leptodactylus macrosternum Miranda-Ribeiro 1926
	Leptodactylus troglodytes Lutz 1926
	Leptodactylus vastus Lutz 1930
	Physalaemus albifrons (Spix 1824)
	Physalaemus cicada Bokermann 1966
	Physalaemus kroyeri (Reinhardt, Lütken 1862)
	Pleurodema diplolister (Peters 1870)
	Pseudopaludicola pocoto Magalhães Loebmann, Kokubum, Haddad, Garda 2014
Odontophrynidae	*Proceratophrys cristiceps* (Muller 1883)

Figure 1. Anurans recorded in Cajueiro Farm, Paraíba semi-arid region, Northastern Brazil: A= *Corythomantis greeningi*; B= *Dendropsophus nanus*; C= *Boana raniceps*; D= *Leptodactylus macrosternum*; E= *Leptodactylus fuscus*; F= *Leptodactylus troglodytes*.

D. nanus who vocalized in six of the eight months (Table 2). In relation to the use of microhabitats, two species (*L. macrosternum* and *R. jimi*) were the ones with the highest distribution, with records on three types of microhabitats (sand, water and stone). Seven species used two microhabitats (Table 2). The microhabitats used by these species were: (i) shrubs and aquatic vegetation, for *D. nanus* and *B. raniceps*; (ii) sand and stone by S. *x-signatus* and *P. pocoto* and (iii) sand and water by *P. albifrons, P. kroyeri* and *P. diplolister*. We also recorded eight species in only one microhabitat. The substrates used by these species were: (i) sand (*R. granulosa, L. fuscus, L. troglodytes* and

Figure 2. Anurans registered in Cajueiro Farm, Paraíba semi-arid region, northastern Brazil: A= *Leptodactylus vastus*; B= *Pithecopus nordestinus*; C= *Physalaemus kroyeri*; D= *Physalaemus cicada*; E= *Physalaemus albifrons*; F= *Pleurodema diplolister.*

P. cristiceps) and (ii) shrub (*P. nortestina*) and water (*L. vastus* and *P. cicada*) (Table 2).

Even with rain during all the months of collection, the highest number of species, with higher intensity of vocalization activity among the anurans was observed in the period with the highest rainfall values, mainly in the months of February and March. However, there is no relationship between vocalization and rainfall (r = 0.23; p = 0.56) (Figure 5a). In this period, we also recorded a high number of species, with 14 of the 17 anurans recorded. However, there is no relationship between the number of species recorded and rainfall (r = 0.18; 0.67) (Figure 5b).

Figure 3. Anurans registered in Cajueiro Farm, Paraíba semi-arid region, Northastern Brazil: A= *Proceratophrys cristiceps*; B= *Pseudopaludicola pocoto*; C= *Rhinella jimi*; D= *Rhinella granulosa*; E= *Scinax x-signatus.*

Discussion

A total of 19 species registered at the Cajueiro Farm are considered typical of occurrence in the Caatinga (Rodrigues, 2003), including a species recently described (*Pseudopaludicola pocoto*) (Magalhães *et al*., 2014). In the semi-arid region of Paraíba Cariri, 16 species are known (Vieira *et al.*, 2007), of which 13 were recorded in the present study. A similar richness (17 species) was recorded in another area of Caatinga (Abrantes *et al.*, 2011), of which 11 occur in Cajueiro Farm. Comparisons with the anurans recorded in a remnant of Caatinga in the Pernambuco semi-arid region, with 23 recorded species (Pereira *et al.*, 2015), and another work in an ecotone of Atlantic-

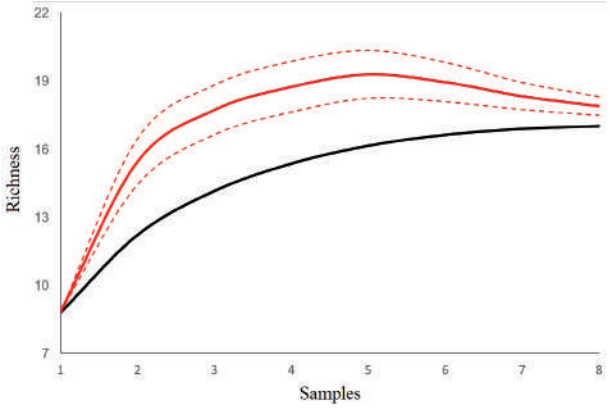

Figure 4. Anuran accumulation curve at Cajueiro Farm, Paraíba semi-arid region, Northastern Brazil. The black line represents the accumulation curves, the red line represents estimates of species based on Jacknife1 and the red dashed lines represent their confidence interval (95%).

Caatinga Forest in the state of Rio Grande do Norte, with a total of 34 species of anurans (Magalhães *et al.*, 2013), 16 species of our study are shared. However, the species *P. kroyeri* recorded here was not found in any of the studies cited previously. This sharing of species in these areas demonstrates a similar fauna in regions under the Caatinga domain, while the greatest richness found by Magalhães *et al.* (2013) is probably related to the location of the area studied by them in a transition region with the Atlantic Forest domain. Despite the fact that all these inventories have different sampling effort (e.g. area, time), such comparison is imperative to better understanding geographic patters of anurans in this poorly sampled domain.

The prevalence of the Leptodactylidae and Hylidae families regarding the other anuran families is recurrent in studies in the semi-arid region (e.g. Vieira *et al*., 2007; Cunha *et al*., 2010; Pereira Jr *et al*., 2003; Magalhães *et al*., 2014; Pereira *et al.*, 2015), demonstrating that these

Table 2. Reproductive patterns of the 17 anurans species recorded in the sampling period from November 2013 to June 2014 at the Cajueiro Farm, Paraíba semi-arid region, Northastern Brazil.

Family/Species	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	ME
Bufonidae									
Rhinella granulosa		S				S			As
Rhinella jimi	S	S	S	S	S	S	S	S	St; Wa As
Hylidae									
Corythomantis greeningi									Wa
Dendropsophus nanus									Sh; Av
Boana raniceps									Sh; Av
Pithecopus nordestinus									Sh
Scinax x-signatus		S					S	S	Sa; St
Leptodactylidae									
Leptodactylus fuscus	S		S		S				As
Leptodactylus macrosternum	S	S	S	S	S	S	S	S	Sa; Wa; St
Leptodactylus troglodytes		S				S	S		As
Leptodactylus vastus					S				Wa
Physalaemus albifrons								S	Wa; As
Physalaemus cicada									Wa
Physalaemus kroyeri								S	Wa; As
Pleurodema diplolister	S	S	S		Em			S	Sa; Wa
Pseudopaludicola pocoto									Sa; St
Odontophrynidae									
Proceratophrys cristiceps									Sa
Number of species vocalizing	**1**	**2**	**2**	**12**	**10**	**3**	**2**	**3**	
Number of species registered	**5**	**8**	**6**	**14**	**14**	**7**	**7**	**9**	

Notes: Abundance classes of males in vocalization activity: = 1-2; = 3-10; = 11-20. Av: on Aquatic Vegetation; Em: couple embrace; ME: Vocalization Microenvironment; S: silent individuals, which were not vocalizing; Sa - Sand; Sh - Shrub; St - on Stone; Wa - Water.

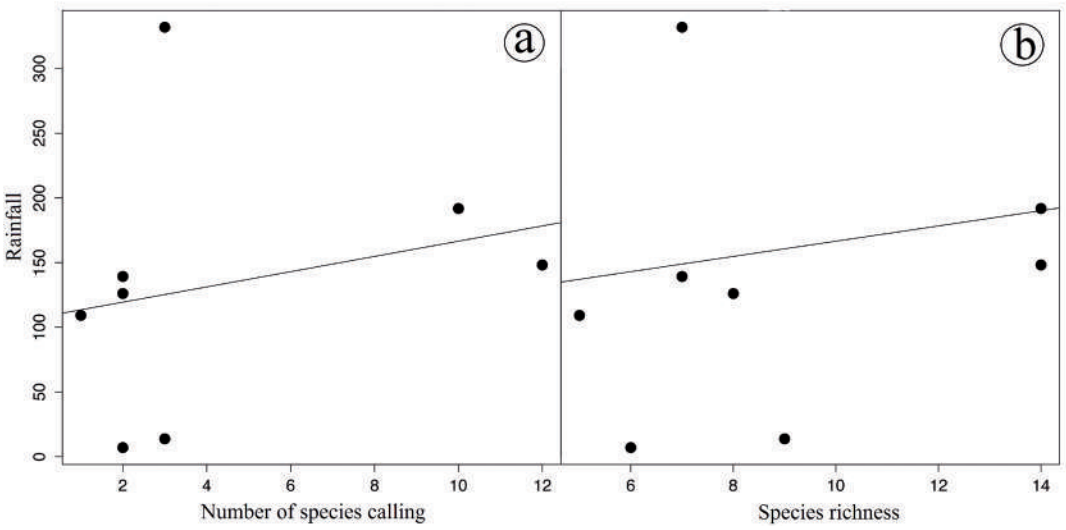

Figure 5. Pearson correlation between (a) the number of vocalizing species vs. rainfall and (b) species richness vs. rainfall from November 2013 to June 2014 at Cajueiro Farm, Paraíba semi-arid region, northeastern Brazil.

families are more abundant and diversified in this area. The abundance of *L. macrosternum* and *P. pocoto* recorded in most of the samplings also occurred in other studies performed in the region (Magalhães *et al*., 2013; Pereira *et al*., 2015), explaining their dominance in relation to the others.

The concentration of rainfall in season of semi-arid regions, causes oscillations in water volumes of water bodies used by anurans, thus affecting, the number of species that breed in these environments (Abrantes *et al*., 2011) and, consequently, the dynamics of seasonal distribution of the anurans present in these areas. In this context, the non-relation between reproductive/vocalization activity and species richness with rainfall may be related to the constant presence of water in the study area, due to the reservoir that presented water throughout the sample period, which facilitates the permanence of the species in the environment.

The range of the Hylidae family in the use of the different microhabitats may be related to the fact that the hylids present a greater vertical segregation in relation to the families with representatives of terrestrial habits (e.g. Bufonidae, Leptodactylidae and Microhylidae) (Pereira Jr *et al*., 2013). Usually, the choice of diverse microhabitats allows species coexistence (Melo *et al*., 2003, 2007; Conte and Rossa-Feres, 2007). The overlap in the use of microhabitats is possibly associated with the reproductive mode of the anuran species from the Caatinga biome, which present behavioral specializations to avoid excessive loss of water. These factors may explain not only the overlap of microenvironments, but also the greater species diversity for periods with higher rainfall concentrations.

Studies of this nature, developed outside a protected area, are of extreme importance. Besides, the studied region is poorly sampled, and with strong anthropogenic pressures, in many cases due to the lack of knowledge of the composition and richness of the species that inhabit these localities. Thus, the enhancement of the basic knowledge is essential to draw up plans for the conservation of the biota.

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