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Herpetofauna recorded by a fauna rescue program in a Caatinga area of João Câmara, Rio Grande do Norte, Brazil

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Abstract
We present an annotated list of herpetofauna for the municipality of João Câmara, Rio Grande do Norte State (RN), Brazil, in Caatinga domain. The data were obtained through fauna rescue program activities performed during the installation of two wind energy parks. We recorded 10 species of lizards, eight snakes, four amphisbaenids and three anurans. The results obtained present extensions to known geographic distribution for four species (*Amphisbaena littoralis*, *Enyalius bibronii*, *Epictia borapeliotes* and *Corythomantis greeningi*) and add information to the natural history of the first two species. This constitutes the second list of herpetofauna for RN. Our results show that such studies may contribute useful data on herpetofauna, especially in poorly studied areas.

Key words
Semi-arid; diversity; reptiles; amphibians; conservation.

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Introduction

The Caatinga, an exclusively Brazilian biome (Tabarelli and Silva 2005), is 1 of the 3 semi-arid spaces of South America (Ab'Sáber 2003). It is located in northeastern Brazil and covers about 850,000 km² (Andrade-Lima 1981, MMA 2016). Due to some environmental restrictions and its xerophytic condition, it was believed that the biome had a low species richness and endemism for several animal groups (Cordeiro and Hoge 1973, Vanzolini 1974, 1976, Vanzolini et al. 1980, Mares et al. 1985, Willig and Mare 1989). This conclusion, based on surveys performed several decades ago, proved to be incorrect after recent research and inventories (Rodrigues 2003, Arzabe et al. 2005, Borges-Nojosa and Arzabe 2005, Borges-Nojosa and Cascon. 2005, Santos et al. 2008, Loebmann and Haddad 2010, Albuquerque et al. 2012, Guedes et al. 2014a, 2014b, Magalhães et al. 2015, Caldas et al. 2016, Freitas et al. 2016, Abbeg et al. 2017a, 2017b). This lead to an increase in the amount of protected areas from less than 2% of Caatinga territory to about 7.5% (Leal et al. 2005, MMA 2016).

Among the studies on the herpetofauna in Caatinga, Rodrigues (2003) reported 167 taxa, of which 116 were reptiles (4 testudines, 3 crocodilians, 52 snakes, 47 lizards, and 10 amphisbaenids) and 51 amphibians (3 caecilians and 48 anurans). Although this list can be representative of the groups and the biome, it is out of date. In the last decade, many surveys were performed and new species were described, while taxonomic revisions revealed endemic taxa (Heyer and Juncá 2003, Borges-

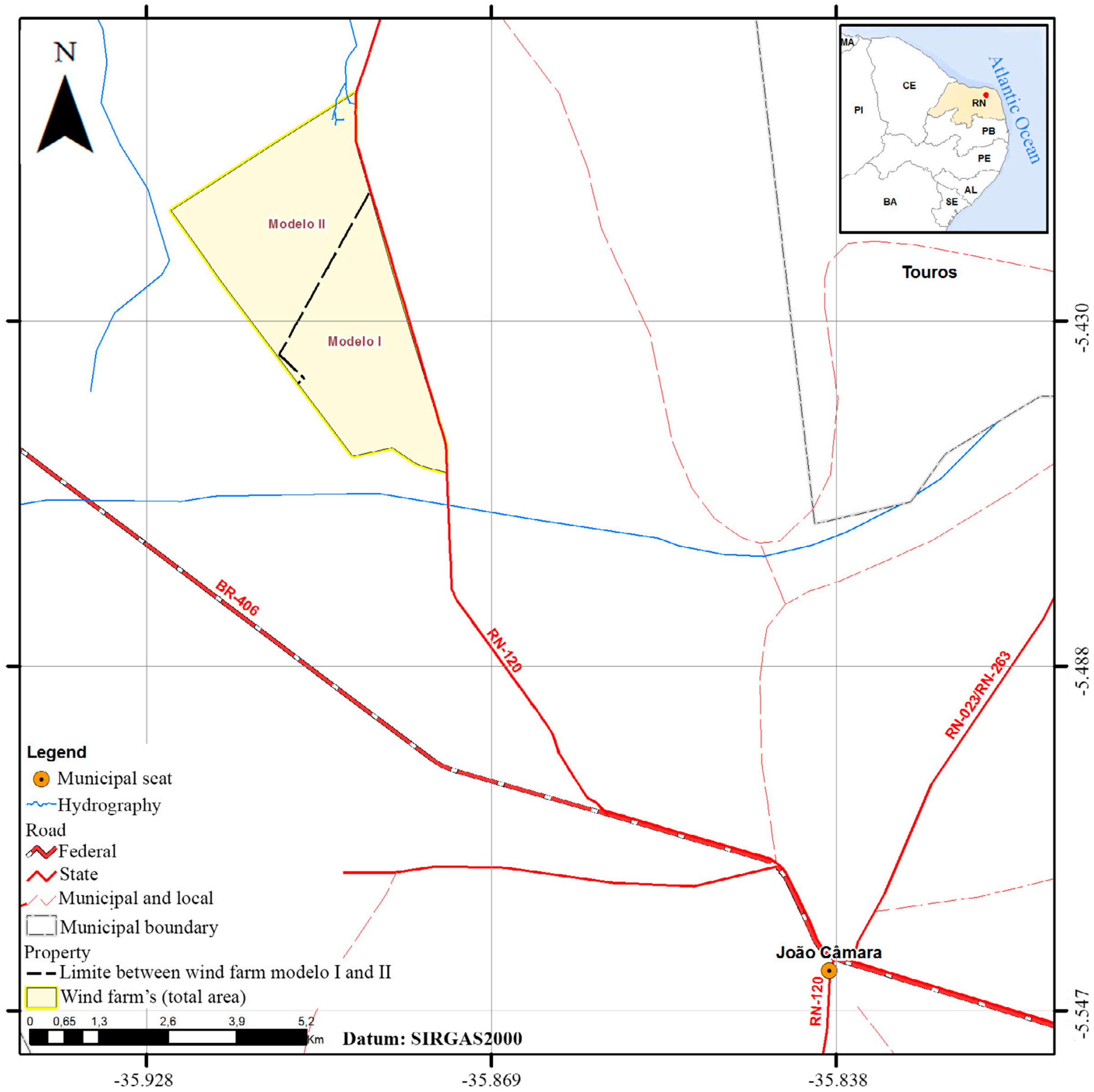

Figure 1. Map showing the location of the wind energy parks Modelo I and Modelo II in João Câmara, Rio Grande do Norte, Brazil.

Nojosa and Santos 2005, Rodrigues et al. 2006, Arias et al. 2011, 2014, Ribeiro et al. 2012, Garda et al. 2013, Cavalcanti et al. 2014, Guedes et al. 2014a, Pires et al. 2014, Recorder et al. 2014, Roberto et al. 2014, Andrade et al. 2016).

Despite advances in the knowledge of the Caatinga biota, the fragmentation of the biome by human activities continues and many localities remain unsampled (Castelleti et al. 2003, Rodrigues 2003). In RN there are 5 lists for reptiles and amphibians, 1 for amphibians, 1 for squamates reptiles, 2 for lizards and 1 for general herpetofauna (Freire 1996, Delfim and Freire 2007, Freire et al. 2009, Magalhães et al. 2013, Caldas et al. 2016).

According to National Biodiversity Policy knowledge of biological diversity in areas for occupancy and management is the responsibility of both public and private institutions. Thus, the aim herein is to present a list of herpetofauna recorded during a fauna rescue program performed during the installation of 2 wind energy parks at João Câmara, RN, Brazil. This list aims to fill gaps in the knowledge of the herpetofauna in a poorly known region of the Caatinga domain and intends to assist proposals of conservation of local biodiversity.

Methods

Study site. Data collection was part of the fauna rescue program conducted prior to the construction of wind energy parks Model I and Model II (05.427° S, 035.911° W, 194 m elev., datum SIRGAS2000). The project's area is 1729.7 ha, located in the rural area of João Câmara, RN (Fig. 1). Installation of the wind energy parks required removal of about 52 ha of vegetation, or 2.99% of the total area.

The study site is located in the "Depressão Sertaneja Setentrional", 1 of 8 ecoregions of Caatinga, which has a hot and semi-arid climate with annual average precipitation of 500 to 800 mm (Velloso et al. 2002). The vegetation is characterized as Steppical-Savanna Wooded (IBGE 2012). Its topography is flat or slightly undulating with rocky soil and rocky outcrops. Prior to removal of vegetation, we found 2 distinct vegetation types in the area, characterized by the predominance of arboreal-shrubby and arboreal species. Vegetation of the arboreal-shrubby type was composed of smaller trees and shrubs with bole diameters <8 cm. The height of the canopy did not surpass 2 m. The most common species were *Croton sonderianus* Müll. Arg (Marmeleiro), *C. campestris* St. Hil. (Velame), and *Jatropha* cf. *poliana* Müll. Arg. (Pinhão-bravo). The arboreal vegetation was composed of larger trees; the most common species were *Bursera leptophloeos* Mart. (Imburana-cambão), *Myracrodruon urundeuva* Allemão (Aroeira), *Mimosa tenuiflora* (Willd.) Poir (Jurema), *Aspidosperma pyrifolium* Mart. (Pereiro), and *Sapium* sp. (Burra-leiteira). There was herbaceous vegetation with abundant bromeliads *Bromelia laciniosa* Mart. ex Schult. (Macambira), which occurred in sparse groups or formed mantles under arboreal vegetation.

Data collection. During the removal of vegetation, we conducted active searches to locate amphibians and reptiles. The active search consisted of monitoring during and after vegetation removal (using bulldozers and chainsaws). It was conducted 8 hours per day (7:00h to 17:00h) by 2 collectors, between 22 March 2013 and 17 May 2013, totalling 152 hours per collector. Most of the fauna rescue program occurred during the dry season in the Caatinga (March to July). During the period when the fieldwork was conducted (March to May) the average local precipitation was only 22.61 mm (Empresa de Pesquisa Agropecuária do Rio Grande do Norte, pers. comm.). Specimens were captured by hand, identified, photographed, and transported out of the immediate area. Captured animals whose welfare was in doubt or that could not be identified in the field were euthanized in accordance with resolution no. 301 of December 8/2012 (CFBIO 2012). Subsequently, these specimens were fixed in 10% formol, preserved in 70% alcohol and sent to the Federal University of Rio Grande do Norte, Biosciences Center, Department of Botany, Ecology and Zoology. Specimens that were observed but not captured were not included in the study because of the possibility of incorrect identification. Activities were performed in accordance with permits issued by the Instituto de Desenvolvimento Sustentável e Meio Ambiente do Rio Grande do Norte (IDEMA) numbers 2012-056408/TEC/Sveg-0167 and 2012-056409/TEC/Sveg-0168. The nomenclature for reptiles and amphibians followed Uetz et al. (2016) and Frost (2017), respectively.

Data analysis. The abundance and species richness data were plotted in a rarefaction curve in order to determine the sampling efficiency, using Chao2P species estimator (Gotelli and Colwell 2001). The rarefaction curve was generated using the statistical program EstimateS 9.1.0 (Colwell 2013).

Results

The rescue activities resulted in 115 recorded individuals belonging to 25 species (Table 1; Figs 2–23), of which 3 are Anura (3 individuals) and 22 are Squamata (112 individuals). The anurans were *Rhinella jimi* (Stevaux, 2002), *Corythomantis greeningi* Boulenger, 1896, and *Physalaemus cicada* Bokermann, 1966. The Squamata, consisted of 68 lizards in 10 species from 8 families and 17 snakes in 8 species from 4 families. We recorded 27 amphisbaenids in 4 species from 1 family. The list of species is shown in Table 1. The rarefaction curve (Fig. 24) did not reach the asymptote, indicating that other species are expected for the area. Species accounts with natural history, diagnosis and notes on distribution are provided below.

Amphibians

Family Bufonidae Gray, 1825

Rhinella jimi Stevaux, 2002: Figure 2

Bufo jimi Stevaux 2002: 19—Kwet et al. 2006: 96; Freire et al. 2009; Caldas et al. 2016: 1929.

Chaunnus jimi—Frost et al., 2006: 364.

Before the description of *R. jimi*, the populations of the Brazilian northeast were identified as *Bufo paracnemis* (= *R. schneideri*). Stevaux (2002) described and differentiated *R. jimi* from other species of the *marinus* group using the following characteristics: presence of glands on forearm, on the external side of the foot and both sides of cloaca; median snout-vent length (SVL) is 147.48 mm in males and 133.8 mm in females (Stevaux, 2002). No individuals of this common species were collected.

Family Hylidae Rafinesque, 1815

Corythomantis greeningi Boulenger, 1896: Figure 3

Corythomantis greeningi Boulenger 1896: 405—Carvalho, 1941: 107; Jared et al. 2005: 265; Freire et al. 2009; Pombal et al. 2012: 3; Caldas et al. 2016: 1929.

Corythomantis schubarti Miranda-Ribeiro 1937: 56—Miranda-Ribeiro 1955: 42.

The following characters distinguish *C. greeningi* from its congener *C. galeata* Pombal Jr, Menezes, Fontes, Rocha & Van Sluys, 2012: head with ridge on the posterior border; skin of dorsum granulate and relatively large discs on fingers and toes, which present keratinized spicules. Snout-vent length varies between 34–82 mm (Carvalho 1941). *Corythomantis greeningi* was recorded 4 times in the RN and never in sympatry with *C. galeata* in this state (Jared et al. 2005, Pombal et al. 2012, Magalhães et al. 2013, Caldas et al. 2016). This species can be found in the entrance of tree cavities and among rocks. When found in tree cavities, the cavities contain humid organic material (Jared et al. 1999). Our individual was collect in such a cavity. The voucher of the individual is UFRN 4123.

Figures 2–9. Herpetofauna recorded in João Câmara, Rio Grande do Norte, Brazil. **2.** *Rhinella jimi*. **3.** *Corythomantis greeningi*. **4.** *Amphisbaena alba*. **5.** *Amphisbaena littoralis*. **6.** *Amphisbaena pretrei*. **7.** *Leposternon polystegum*. **8.** *Diploglossus lessonae*. **9.** *Hemidactylus agrius*.

Table 1. List of the herpetofauna species recorded during the fauna rescue program in João Câmara, Rio Grande do Norte, with their respective vouchers. Abbreviations: *N*: numbers of individuals per species.

Family	Species	Source	*N*	Vouchers	Photo
Anura					
Bufonidae	*Rhinella jimi* (Stevaux, 2002)	Present study, Caldas et al. (2016)	1	—	2
Hylidae	*Corythomantis greeningi* Boulenger, 1896	Present study, Caldas et al. (2016)	1	UFRN 4123	3
Leptodactylidae	*Physalaemus cicada* Bokermann, 1966	Present study, Caldas et al. (2016)	1	UFRN 4128	—
Squamata					
Amphisbaenidae	*Amphisbaena alba* Linnaeus, 1758	Present study	2	—	4
	Amphisbaena littoralis Roberto, Brito & Ávila, 2014	Present study	6	UFRN 4108–4112	5
	Amphisbaena pretrei Duméril & Bibron, 1839	Present study	13	UFRN 4091, 4100–4102, 4117	6
	Leposternon polystegum (Duméril, 1851)	Present study	6	UFRN 4113–4116	7
Anguidae	*Diploglossus lessonae* Peracca, 1890	Present study	6	UFRN 4106	8
Gekkonidae	*Hemidactylus agrius* (Vanzolini, 1978)	Present study, Caldas et al. (2016)	7	UFRN 4119	9
Gymnophthalmidae	*Micrablepharus maximiliani* (Reinhardt & Luetken, 1862)	Present study	20	UFRN 4103, 4104	10
	Vanzosaura multiscutata (Amaral, 1933)	Present study, Caldas et al. (2016)	7	UFRN 4097, 4098	11
Leiosauridae	*Enyalius bibronii* Boulenger, 1885	Present study	1	UFRN 4089	—
Phyllodactylidae	*Gymnodactylus geckoides* Spix, 1825	Present study, Caldas et al. (2016)	14	UFRN 4094, 4095	12
Scincidae	*Brasiliscincus heathi* (Schmidt & Inger, 1951)	Present study, Caldas et al. (2016)	5	UFRN 4096, 4105	13
Teiidae	*Ameiva ameiva* (Linnaeus, 1758)	Present study, Caldas et al. (2016)	3	UFRN 4090, 4124, 4125	14
	Ameivula ocellifera (Spix, 1825)	Present study, Caldas et al. (2016)	2	—	15
Tropiduridae	*Tropidurus hispidus* (Spix, 1825)	Present study, Caldas et al. (2016)	3	UFRN 4121, 4122	16
Leptotyphlopidae	*Epictia borapeliotes* (Vanzolini, 1996)	Present study, Caldas et al. (2016)	3	UFRN 4129	17
Boidae	*Boa constrictor* Linnaeus, 1758	Present study, Caldas et al. (2016)	2	—	18
Colubridae	*Apostolepis cearensis* Gomes, 1915	Present study	3	UFRN 4126, 4127	19
	Boiruna sertaneja Zaher, 1996	Present study	1	UFRN 4099	20
	Oxyrhopus trigeminus Duméril, Bibron & Duméril, 1854	Present study, Caldas et al. (2016)	1	—	21
	Philodryas nattereri Steindachner, 1870	Present study, Caldas et al. (2016)	3	UFRN 4132	22
	Tantilla melanocephala (Linnaeus, 1758)	Present study	2	UFRN 4091, 4093	—
Viperidae	*Bothrops erythromelas* Amaral, 1923	Present study, Caldas et al. (2016)	2	UFRN 4130, 4131	23

Reptiles

Family Amphisbaenidae Gray, 1825

Amphisbaena littoralis Roberto, Brito & Ávila, 2014: Figure 5

Amphisbaena littoralis resembles 5 other congeners (*A. alba, A. fuliginosa, A. ignatiana, A. lumbricalis* and *A. pretrei*) in the Brazilian northeast. However, *A. littoralis* is distinguished from *A. ignatiana* and *A. lumbricalis* by greater SVL, and from *A. fuliginosa* by the higher number of body annuli and ventral and dorsal segments. Also, *A. littoralis* may be distinguished from *A. alba* by a greater number of body annuli, smaller SVL and possessing an autotomic site, and from *A. pretrei* by higher number of body and tail annuli. The vouchers of individuals are UFRN 4108–4112.

Family Leiosauridae Frost, Etheridge, Janies & Titus, 2001

Enyalius bibronii Boulenger, 1885

Enyalius bibronii Boulenger 1885: 199—Frost et al. 2001: 3343; Freire 1996: 13; Rodrigues 2003; Gogliath et al. 2010: 6; Lima et al. 2016: 47.

Enyalius bibronii may be distinguished from its congeners by the following characters: infradigital lamellae smooth; paravertebral scales fewer than 170 and vertebral scales 62–67; males creamy whitish or spotted dorsally, never uniformly green; venter with 3 faint longitudinal stripes (Rodrigues et al. 2006). Very little is known about the natural history and ecology of this species. We found this individual in tree-shrub type vegetation. The specimen is voucher UFRN 4089.

Figures 10–17. Herpetofauna recorded in João Câmara, Rio Grande do Norte, Brazil. **10.** *Micrablepharus maximiliani*. **11.** *Vanzosaura multiscutata*. **12.** *Gymnodactylus geckoides*. **13.** *Brasiliscincus heathi*. **14.** *Ameica ameiva*. **15.** *Ameivula ocellifera*. **16.** *Tropidurus hispidus*. **17.** *Epictia borapeliotes*.

Figures 18–23. Herpetofauna recorded in João Câmara, Rio Grande do Norte, Brazil. **18.** *Boa constrictor*. **19.** *Apostolepis cearensis*. **20.** *Boiruna sertaneja*. **21.** *Oxyrhopus trigeminus*. **22.** *Philodryas nattereri*. **23.** *Bothrops erythromelas*.

Family Leptotyphlopidae Stejneger, 1892

Epictia borapeliotes (Vanzolini, 1996): Figure 17

Leptotyphlophs borapeliotes Vanzolini 1996: 15—Adalsteinsson et al. 2009: 2244; Freire et al. 2009; Guedes et al. 2014b: 3863; Caldas et al. 2016: 1929.

Epictia borapeliotes is widespread in the northeast of Brazil (Vanzolini 1996, Guedes et al. 2014a) and distinguished from other congeners by middorsal scales 256–276, subcaudal scales 14–18, presence of light rostral and white caudal spots (Vanzolini 1996). This species is diurnal and nocturnal and has fossorial habits (Guedes et al. 2014a). The use of the tip of the tail for defense was observed during handling (POC pers. obs.). The voucher of individual is UFRN 4129.

Family Colubridae Oppel, 1811

Apostolepis cearensis Gomes, 1915: Figure 19

Apostolepis cearensis Gomes 1915: 122—Ferrarezzi 1993: 234; Ferrarezzi et al. 1996: 55; Lema 2002; Ferrarezi et al. 2005: 45; Wallach et al. 2014: 50; Guedes et al. 2014b: 3863.

Apostolepis flavotorquata—Amaral 1930: 109; Peters and Orejas-Miranda 1970: 22.

This species may be distinguished from other *assimilis* group species (*A. assimilis* and *A. ammodites*) by snout-rostral shape which is strongly prominent and pointed, white nuchal collar absent, ventral and subcaudal scales 215–248 and 23–32, respectively (Ferrarezi et al. 2005). This snake is fossorial and species of the Amphisbaenidae family are one of its food items (Amorim et al. 2015). Individuals of this species also exhibit the behaviour of using the tip of the tail as defense when handled (POC pers. obs.). This behaviour has been observed for congeners (Martins and Oliveira, 1993). The vouchers of individuals are UFRN 4126 and 4127.

Boiruna sertaneja Zaher, 1996: Figure 20

Boiruna sertaneja Zaher 1996: 14—Freire et al. 2009; Guedes et al. 2014b: 3863; Caldas et al. 2016: 1929.

This species may be distinguished from *B. maculata* by a higher number of subcaudal scales (68–79 in males and 60–75 in females) and hemipenis completely spineless and bicapitate (Zaher 1996). This snake does not exhibit aggressive behaviour and when handled seeks to escape through vigorous movements and constriction. It has been observed to forage at night (Mesquita et al. 2013). The voucher of the individual is UFRN 4099.

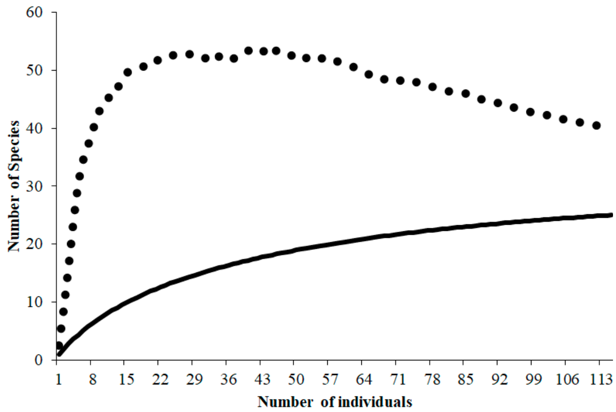

Figure 24. Species accumulation and rarefaction curves for herpetofauna based on number of individual specimens recorded in João Câmara, Rio Grande do Norte, Brazil. Solid line represents collected individuals and dots are total species estimates based on Chao2P.

Discussion

The low diversity and abundance of anurans be associated with 2 factors. First, the activity search was performed during the daylight hours and anurans are more active at night. The second factor may be the sampling method. Studies conducted in the same season and in nearby areas recorded high anuran richness (*N* = 34 and 19; Magalhães et al. 2013, Caldas et al. 2016, respectively). However, those studies used other sampling methods such active search in temporary and semi-permanent ponds, pitfall trapping and glue traps (Heyer et al. 1994). Furthermore, the study of Magalhães et al. (2013) was conducted in an ecotonal region of Caatinga and Atlantic Forest, where rainfall and humidity levels are higher than in Caatinga stricto sensu. We highlight the record of *Corythomantis greeningi*, which is the fifth record for RN and extends this species' geographic distribution more than 80 km to the northeast from the record of Jared et al. (2005) in Angicos, RN (Pombal et al. 2012, Magalhães et al. 2013, Caldas et al. 2016).

For reptiles, we recorded diversity similar to that in Caldas et al. (2016), who recorded 22 species (13 lizards, 8 snakes, and 1 chelonian), the same number as this study. However, less than half (*N* = 12) of their species were found in this study (Table 1).

In our study, lizards were more abundant, possibly because most lizard species recorded were heliophilic, which favors their presence during dry season (Abe 1994) and also because of daylight sampling. The record of *Enyalius bibronii* is the third record from RN and represents an extension of 130 km northeast from the closest record at Tenente Laurentino Cruz, RN (Freire 1996, Gogliath et al. 2010). *Enyalius bibronii* exhibits relictual distribution, which may include incursions in certain areas of Caatinga. Our record confirms this possibility (Rodrigues 2003, Gogliath et al. 2010, Silva and Moura 2013). However, *E. bibronii* may be a species complex, and more detailed taxonomic studies are required (Rodrigues 2003).

For snakes, our records represent 32% of the species known for RN (*N* = 25; Guedes et al. 2014b). Possibly a greater richness of snakes could be recorded with medium to long-term studies along with a variety of sampling methods. The record of the *Epictia borapeliotes* is the third from RN and it represents an extension of 90 km northeast from the nearest published locality (Angicos, RN; Guedes et al. 2014a).

For Amphisbaenia, 4 species were found in the study area. At least 7 species are known in the state (Perez and Ribeiro 2008, Freire et al. 2009, Roberto et al. 2014, Caldas et al. 2016). Our record of *Amphisbaena littoralis* is the second record from RN and represents a range extension and a new habitat. The study area is 65 km southeast from the type locality (Guamaré, RN) and is in Caatinga *stricto sensu* habitat very different from the marine influenced environments where the species was found previously (Roberto et al. 2014).

We estimate that the species sampled in this study should be representative of the local herpetofauna, since the rescue activities relied on active searching. However, the absence of the stabilization of rarefaction curve (Fig. 24) indicates the possible occurrence of other species in the study area. Alternatively, this could be because of the low numbers of individuals collected of most species (*N* = 11 species; 44% of total richness). Furthermore, the low incidence of anurans influenced the rarefaction curve. We associate this with the fact that sampling occurred during daylight hours in the dry period and because we used only a single search method. During the study, most anuran species were probably in estivation in burrows in soil, termite mounds, or in lower areas where there is a higher moisture concentration (Navas et al. 2004, Borges-Nojosa and Santos 2005, Loebmann and Haddad 2010). Therefore, it is likely that the herpetofauna, particularly amphibians, concentrates in lower areas during the dry season. In any case, we recommend studies of population dynamics of the herpetofauna in different environments of the Caatinga.

In conclusion, the results indicate that, in order to reduce impacts on biodiversity of the Caatinga, development projects that require the removal of vegetation should perform studies on the dynamics of species in all seasons, to determine the best times and places for carrying out activities. Our data indicate that dry periods are more suitable for vegetation removal activities. Finally, the results demonstrate that programs related to environmental licensing of projects provide meaningful data on communities and species. Therefore, we recommend that studies required by the licensing, in particular fauna rescue and monitoring programs, be published, because they contribute important records in poorly sampled regions.

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Authors' Contributions

POC collected and identified the individuals. POC and SAAM analyzed the data and wrote the paper.

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