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Inventory

The herpetofauna of priority highland areas for conservation of the Caatinga in the state of Rio Grande do Norte, northeastern Brazil

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Abstract: The Brazilian Caatinga has already lost extensive areas of original vegetation, thus it becomes imperative to perform fauna inventories within this region to fill geographical sampling gaps. Herein, we present a taxonomic list of the herpetofauna of a mountain chain located in the central zone of Rio Grande do Norte (RN) state whose region includes two priority areas for conservation of the Caatinga: "CA087 – Serra de Santana" in the west, and "CA078 – Nascente do Potengi" in the east. The sampling was carried out using methods of visual searching, pitfall traps with drift fences, specimens rescued during vegetation suppression activities in wind energy projects, occasional encounters, and third-party records. We recorded 19 amphibian species and 53 reptile species (23 lizards, 24 snakes, five amphisbaenians and one chelonian). About half of the recorded species have distributions entirely or mostly in the Caatinga. The mountain range sampled in this study harbors virtually all species found in nearby lowlands of the "sertaneja" depression of RN state, plus some relevant species with relictual distributions in the Caatinga, highlighting the importance of these highland areas for conservation of the Caatinga herpetofauna.
Keywords: *Amphibians; Nascente do Potengi; Reptiles; Serra de Santana; Wind farms.*

A herpetofauna de áreas serranas prioritárias para conservação da Caatinga no estado do Rio Grande do Norte, nordeste do Brasil

Resumo: A Caatinga brasileira já perdeu extensas áreas de vegetação original, por isso torna-se importante realizar inventários de fauna nesta região para preencher lacunas geográficas de amostragem. Aqui, apresentamos uma lista taxonômica da herpetofauna de uma cadeia serrana localizada na zona central do estado do Rio Grande do Norte (RN) e cuja região inclui duas áreas prioritárias para conservação da Caatinga: "CA087 – Serra de Santana" a oeste, e "CA078 – Nascente do Potengi" a leste. A amostragem foi realizada por meio de métodos de busca visual, armadilhas de interceptação e queda, espécimes resgatados durante atividades de supressão vegetal em projetos de energia eólica, encontros ocasionais e registros de terceiros. Registramos 19 espécies de anfíbios e 53 espécies de répteis (23 lagartos, 24 serpentes, cinco anfisbênias e um quelônio). Cerca de metade das espécies registradas tem distribuição inteiramente ou predominantemente na Caatinga. A cadeia serrana amostrada neste estudo abriga praticamente todas as espécies encontradas nas planícies próximas da depressão sertaneja do RN, além de algumas espécies relevantes com distribuição relictual na Caatinga, destacando a importância dessas áreas de altitude para a conservação da herpetofauna da Caatinga.
Palavras-chave: *Anfíbios; Nascente do Potengi; Parques Eólicos; Répteis; Serra de Santana.*

Introduction

The Caatinga is a well-recognized ecological region of about 900,000 km^2 and comprises a mosaic of deciduous and xerophytic thorny shrubs and seasonally dry forests that extend through most of semiarid northeastern Brazil (Leal et al. 2005), being the largest and most continuous expanse of seasonally dry tropical forest biome in the world (Queiroz et al. 2017). Most of the Caatinga covers lowlands up to 500 m above sea level, but isolated mountain ranges and high-altitude plateaus are scattered across the region, modifying the local climate, and acting as present-day refuges for species assemblages (Silva et al. 2017). This region constitutes a dynamic system whose characteristics are shaped by various ecological and evolutionary processes that interact at different spatial and temporal scales (Araújo et al. 2022).

Despite its importance, the Caatinga has already lost extensive areas of original vegetation (Antongiovanni et al. 2018), mostly due to the fast expansion of agriculture and livestock, and includes very large, disturbed areas, as well areas undergoing desertification processes, both of which have been given high priority for conservation (Albuquerque et al. 2012). In the last decade, the Caatinga has also harbored several renewable energy enterprises (Jong et al. 2017), mainly wind farms and photovoltaic solar plants, whose installation involves deforestation and soil removal for installation of wind turbines, solar modules, access roads and transmission lines.

With this continuous process of habitat loss in the Caatinga, it seems imperative to prioritize fauna inventories within this region to fill geographical sampling gaps, allowing more accurate decisions when licensing areas for construction by enterprises and defining priority areas for conservation (Dal Velchio et al. 2016, Pichorim et al. 2016). A recent evaluation conducted by the Brazilian Environment Ministry with large participation of federal agencies, environment state secretariats, universities, and other research bodies, as well as NGOs, has updated the priority areas for conservation of biodiversity in Brazil, originally established in 2004 (Fonseca et al. 2017, MMA 2018). Most of these defined priority areas still lack relevant information about biodiversity composition.

Rio Grande do Norte (RN) is the most northeastward state of Brazil, located between the latitudes 4.8317° S and 6.9828° S and longitudes 34.9686° W and 38.5822° W, and covering a total area of 52.811 km^2, which corresponds to 0.62% of Brazilian territory (IDEMA 2018). About 95% of the RN territory is within the Caatinga region, and its east coastal area comprises the north limit of the Atlantic Rainforest, with semi-deciduous forests, mangroves, and coastal vegetation (Tabarelli et al. 2005). The Caatinga of RN is in a relief composed by the lowland "sertaneja" depression and some mountain chains such as Serra de Martins, Serra de João do Vale, and Serra de Santana (Diniz et al. 2015).

Much of the biodiversity of RN is still unknown, but in recent years vertebrate lists for some sites were published regarding fish (Nascimento et al. 2014, Costa et al. 2017, Medeiros et al. 2019), amphibians (Magalhães et al. 2013, Caldas et al. 2016), reptiles (Freire et al. 2009, 2011, Sales et al. 2009, Caldas et al. 2016, Calixto & Morato 2017, Marques et al. 2021), birds (Silva et al. 2012, Pichorim et al. 2014, 2016, Sagot-Martin et al. 2020), terrestrial mammals (Marinho et al. 2018, Cherem et al. 2019), and bats (Vargas-Mena et al. 2018). With respect to the herpetofauna, only two sites in RN have published lists based on long-term standardized sampling effort: one in the Caatinga for amphibians and reptiles (Freire et al. 2009, Caldas et al. 2016), and the other in a transitional area between Caatinga and Atlantic Forest only for amphibians (Magalhães et al. 2013). Given the increase in threats to the biodiversity of the Caatinga in recent years, it is essential to expand the number of faunal inventories in RN, particularly within priority areas for conservation.

Considering that the main long-term study on the herpetofauna of the Caatinga of RN (Freire et al. 2009) was carried out in the Seridó sertaneja depression and that the species obtained were the most common that are widely distributed in the Caatinga, and additionally according to Rodrigues (2003), some species have relictual patterns of geographic distribution in the Caatinga, occurring only in areas with arboreal vegetation on sandy soils and/or in mountainous areas, increasing and expanding studies for these areas is essential. Herein, we combine data from two long-term studies with data from rescue and monitoring fauna programs of wind energy enterprises to present a taxonomic list of the herpetofauna of a mountain chain located in the central zone of RN whose area includes two priority areas for conservation of the Caatinga (MMA, 2018): "CA087 – Serra de Santana" in the west, and "CA078 – Nascente do Potengi" in the east.

Material and Methods

1. Study sites

The priority area for conservation of the Caatinga named "CA087 – Serra de Santana" (Figure 1) encompasses the western portion of a mountain range with an elongated shape in the east-west direction, featuring sedimentary geological formations which suffered weathering processes throughout geological history, and is characterized by plateau topography with ancient, eroded slopes covered by caatinga vegetation (RADAMBRASIL 1981). The Serra de Santana plateau fully or partially encompasses seven municipalities of RN (Lagoa Nova, Bodó, Santana

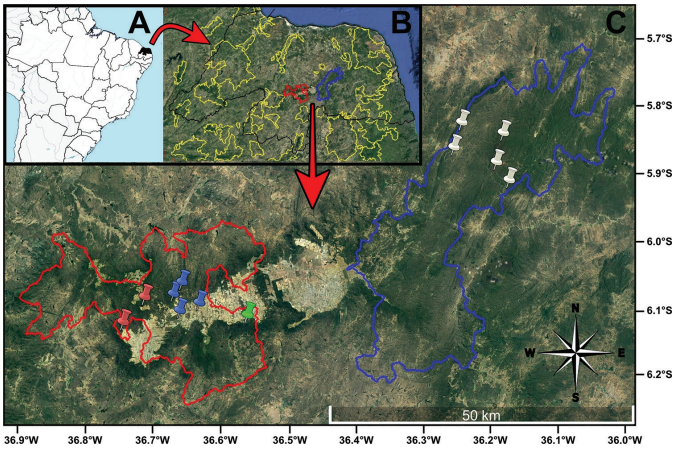

Figure 1. A = Location of Rio Grande do Norte state in northeastern Brazil. **B** = Location of CA087–Serra de Santana (red polygon) and CA078–Nascente do Potengi (blue polygon) priority areas for conservation of the Caatinga, in Rio Grande do Norte state (yellow polygons: other priority areas in the state). **C** = Sampled sites in each priority area; red pins correspond to Site 1 (municipality of Tenente Laurentino Cruz); green pin corresponds to Site 2 (municipality of Lagoa Nova); blue pins correspond to Site 3 (wind energy enterprise located in the rural zones of São Vicente, Santana do Matos, Tenente Laurentino Cruz and Lagoa Nova; and white pins correspond do Site 4 (wind energy enterprise located in the rural zones of Cerro Corá, Lajes and São Tomé municipalities).

do Matos, Florânia, Cerro Corá, São Vicente and Tenente Laurentino Cruz). Altitude in the plateau varies between 600 and 740 m, and the climate is semi-arid, with mean annual rainfall between 400 and 650 mm, and mean annual temperatures around 27 °C (Beltrão et al. 2005). Action conservation priority in CA087 – Serra de Santana is categorized as "very high", and the main proposed action is the creation of a protected area in the "integral protection" category of the National System of Conservation Units – SNUC (e.g., national park, biological reserve, ecological station; MMA 2018).

The second priority area for conservation of the Caatinga sampled in this study is "CA078 – Nascente do Potengi" (Figure 1), which partially includes the municipalities of Cerro Corá, São Tomé and Lajes. Action conservation priority in this area is also categorized as "very high", and the main proposed action is to create a protected area in the "integral protection" category (MMA 2018). This priority area encompasses the east portion of Serra de Santana plateau (Figure 1) and other mountain chains such as Serra do Feiticeiro in Lajes municipality. Altitude in the sampled area varies between 300 and 500 m, and climate conditions resemble the sampled areas of Serra de Santana.

The herpetofauna inventory of the two priority areas consisted of four distinct data sources (Figure 1). Two research projects coordinated by EMXF were conducted in Serra de Santana relatively well-preserved caatinga remnants in the municipalities of Tenente Laurentino Cruz (Site 1) and Lagoa Nova (Site 2). Plus, a third sampled site was a wind energy enterprise located in the rural zones of Santana do Matos, São Vicente, Tenente Laurentino Cruz and Lagoa Nova (Site 3). The sampled area in Nascente do Potengi was a wind energy enterprise located in the rural zones of Cerro Corá, Lajes and São Tomé municipalities (Site 4). Vegetation physiognomies are similar among study sites, characterized by arboreal-bushy stratum and abundance of rocky outcrops surrounded by vegetation (Figure 2A–D). Plus, habitat modification due to installation of wind farms and agriculture/livestock activities in the vicinities is present in all study sites (Figure 2E-F).

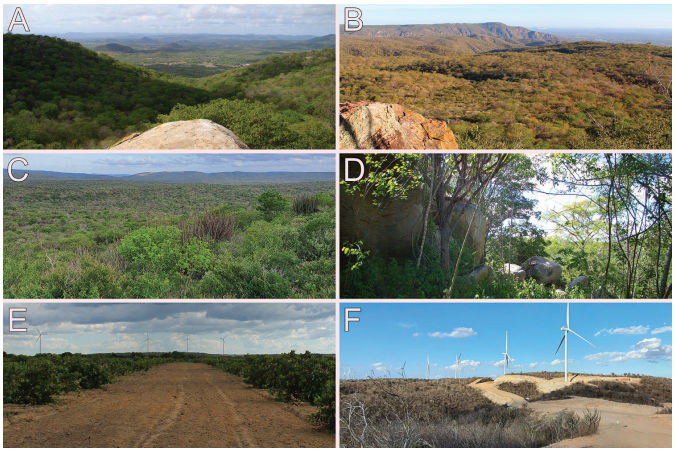

Figure 2. Panoramic view of the study sites and general aspect of the vegetation in Serra de Santana and Nascente do Potengi priority areas for conservation of the Caatinga in Rio Grande do Norte state, northeastern Brazil. **A -** Site 2; **B -** Site 3; **C -** Site 4; **D -** arboreal-bushy vegetation with rocky outcrops in Sites 2; **E -** land use for agriculture and wind farms in Site 3; **F -** wind farms installed in Site 4.

2. *Data collection*

The fieldwork in Site 1 (two sampling areas named Serra Nova – central coordinates: 06.0968° S, 36.7160° W, 704 m elev.; and Nascimento – central coordinates: 06.1337° S, 36.7481° W, 682 m elev.) consisted of 5-day monthly expeditions between September 2009 and August 2010 (except for February 2010), totaling 55 days of sampling effort. MG and MNCK collected the data in this site by two standardized methods: (1) time-constrained visual searches (Crump and Scott Jr 1994) at different times of the day (morning, afternoon, and night); and (2) pitfall traps with drift fences (Cechin and Martins 2000), installed in eight linear arrays, each one with 16 buckets of 38 L separated by 2.5 m. Additionally, occasional encounters outside the period dedicated to time-constrained visual search, and third-party records provided by local people were also considered for the list of species. Both amphibians and reptiles were sampled in Site 1, but the sampling of amphibians only occurred in September to November 2009, January and March 2010.

The fieldwork in Site 2 (one sampling area named Serro Alto – central coordinates: 06.1233° S, 36.5641° W, 682 m elev.) consisted of four 20-day expeditions in March and September 2014 (all reptiles), and March and September 2015 (only snakes and amphisbaenians), totaling 80 days of sampling effort. MFK, MMR, RFDS, MJMA and BPR collected the data from this site by two standardized methods: (1) time-constrained visual searches at different times of the day (morning, afternoon, and night); and (2) pitfall traps with drift fences, installed in six Y-shaped arrays, each one with 16 buckets of 38 L separated by 2.5 m. Additionally, occasional encounters outside the period dedicated to time-constrained visual search, and third-party records provided by local people were also considered for the list of species. Only reptiles were sampled at Site 2.

Data from Site 3 (four sampling areas; central coordinates: 06.0748° S, 36.6613° W, 627 m elev.; 06.0921° S, 36.6740° W, 648 m elev.; 06.1168° S, 36.6651° W, 711 m elev.; 06.1057° S, 36.6358° W, 704 m elev.) consisted of two sources: (a) the faunal monitoring environmental program and (b) the faunal rescue environmental program in the areas of influence of the wind energy enterprise (Acauã wind complex). Data from the faunal monitoring program was collected by RFDS along two 5-day expeditions in March and June 2021 by time-constrained visual searches in different times of the day (morning, afternoon, and night), totaling 10 days of sampling effort. Data from the faunal rescue program was collected by third parties (teams of biologists and veterinarians) during vegetation suppression activities for installing wind turbines and access roads of the enterprise, between March 2021 and February 2022, totaling 188 days of sampling effort. Data from the faunal rescue program was provided to us by the environmental consulting firm, together with voucher specimens. Both amphibians and reptiles were sampled at Site 3.

Similarly, data from Site 4 (five sampling areas; central coordinates: 05.8766° S, 36.2586° W, 347 m elev.; 05.8398° S, 36.2471° W, 420 m elev.; 05.8553° S, 36.1855° W, 511 m elev.; 05.8983° S, 36.1956° W, 261 m elev.; 05.9247° S, 36.1768° W, 249 m elev.) also consisted of two sources: (a) the faunal monitoring environmental program and (b) the faunal rescue environmental program in the areas of influence of the wind energy enterprise (Santa Rosa and Mundo Novo wind complex). Data from the faunal monitoring program was collected by VTCS along seven 4-day expeditions in August 2020, February, May, August and November 2021, and February and May 2022, totaling 28 days of

standardized sampling effort. Sampling methods were time-constrained visual searches at different times of the day (morning, afternoon, and night), and pitfall traps with drift fences, installed in 5 Y-shaped arrays, each one with 3 marginal buckets of 20 L and separated by 3 m from a central bucket of 60 L. Data from the faunal rescue program was collected by third parties during vegetation suppression activities for installation of wind turbines and access roads of the enterprise between February 2020 and January 2021, totaling 194 days of sampling effort. Data from the faunal rescue program was provided to us by the environmental consulting firm, together with voucher specimens. Both amphibians and reptiles were sampled at this site.

Voucher specimens are housed at the Herpetological Collection of Universidade Federal do Rio Grande do Norte (UFRN-CH), and the voucher numbers are provided in the Supplementary Material (Appendix S1). Material identification was carried out using the current available literature and eventually by consulting other specialist colleagues. The taxonomic nomenclature follows Frost (2021) and Uetz et al. (2022).

3. Data analysis

The sampling effort in each priority area was evaluated by rarefaction curves generated in the EstimateS 9.1.0 program obtained by 1000 randomizations without replacement (Colwell 2013), considering each day of fieldwork as a sample unit, pooling all sampling methods developed in that day. We built separate curves for (a) amphibians, (b) lizards, and (c) snakes and amphisbaenians, considering the different degrees of rarity in sampling these animals. The expected richness was evaluated by the Jackknife 1 estimator, whose calculation emphasizes the number of species that occurs in only one sample unit (Santos 2003).

Results

We recorded 19 amphibian species and 53 reptile species in the two sampled priority areas for conservation of the Caatinga in RN state (Tables 1-2, Figures 3–5). Among these, 18 amphibian species and 49 reptile species were recorded in CA087–Serra de Santana, and

Table 1. List of amphibian species recorded at Serra de Santana and Nascente do Potengi priority areas for conservation of Caatinga in Rio Grande do Norte state, northeastern Brazil. Sampling methods: **AS** = active search; **PT** = pitfall traps; **FR** = fauna rescue activities during vegetation suppression in wind energy enterprises. Distribution: **M-CA** = mostly distributed in the Caatinga and marginally in Atlantic Forest and/or eastern Cerrado; **CA/AF**: distributed in Caatinga and Atlantic Forest; **W** = widespread (common in ≥ 3 biomes). Voucher: **UFRN-CH** = Coleção Herpetológica da Universidade Federal do Rio Grande do Norte (voucher numbers are in the Appendix S1); there is a photographic record (Figure 3) for species that do not have a voucher specimen in UFRN-CH.

Amphibian species	Number of records		Sampling methods	Distribution	Voucher
	Serra de Santana	Nascente do Potengi			
ANURA					
Bufonidae					
Rhinella diptycha (Cope, 1862)	10	27	AS, PT, FR	W	Figure 3A
Rhinella granulosa (Spix, 1824)	62	100	AS, PT, FR	M-CA	UFRN-CH
Hylidae					
Boana raniceps (Cope, 1862)	1	4	AS	W	Figure 3C
Corythomantis greeningi Boulenger, 1896	3	4	AS, FR	M-CA	UFRN-CH
Dendropsophus nanus (Boulenger, 1889)	1	–	AS	W	Figure 3E
Scinax x-signatus (Spix, 1824)	26	26	AS, FR	W	UFRN-CH
Leptodactylidae					
Leptodactylus fuscus (Schneider, 1799)	1	20	AS, FR	W	Figure 3G
Leptodactylus macrosternum Miranda-Ribeiro, 1926	30	24	AS, FR	W	UFRN-CH
Leptodactylus troglodytes Lutz, 1926	29	48	AS, PT, FR	M-CA	UFRN-CH
Leptodactylus vastus Lutz, 1930	2	2	AS, PT	M-CA	UFRN-CH
Physalaemus albifrons (Spix, 1824)	5	18	AS, PT, FR	M-CA	UFRN-CH
Physalaemus cicada Bokermann, 1966	8	5	AS, PT, FR	M-CA	UFRN-CH
Physalaemus cuvieri Fitzinger, 1826	–	1	PT	W	Figure 3M
Pleurodema diplolister (Peters, 1870)	2	23	AS, PT, FR	M-CA	UFRN-CH
Pseudopaludicola pocoto Magalhães, Loebmann, Kokubum, Haddad, and Garda, 2014	1	–	AS, PT	M-CA	Figure 3O
Microhylidae					
Dermatonotus muelleri (Boettger, 1885)	6	36	PT, FR	W	UFRN-CH
Odontophrynidae					
Proceratophrys cristiceps (Müller, 1883)	19	25	AS, PT, FR	M-CA	UFRN-CH
Pipidae					
Pipa carvalhoi (Miranda-Ribeiro, 1937)	1	–	PT	CA/AF	UFRN-CH
Phyllomedusidae					
Pithecopus gonzagai Andrade, Haga, Ferreira, Recco-Pimentel, Toledo, and Bruschi, 2020	30	44	AS, FR	CA/AF	UFRN-CH

Table 2. List of reptile species recorded at CA087–Serra de Santana and CA078–Nascente do Potengi priority areas for conservation of Caatinga, in Rio Grande do Norte state, northeastern Brazil. Sampling methods: **AS** = active search; **PT** = pitfall traps; **OE** = occasional encounters or third-party records by local people; **FR** = fauna rescue activities during vegetation suppression in wind energy enterprises. Distribution: **CA** = strictly distributed in the Caatinga; **M-CA** = mostly distributed in the Caatinga and marginally in Atlantic Forest and/or eastern Cerrado; **R-CA**: species with relictual distribution in the Caatinga; **CA/CA**: distributed in Caatinga and eastern Cerrado; **W** = widespread (common in ≥ 3 biomes). Voucher: **UFRN-CH** = Coleção Herpetológica da Universidade Federal do Rio Grande do Norte (voucher numbers are in the Appendix S1); there is a photographic record (Figures 4–5) for species that do not have a voucher in UFRN-CH.

Reptile species	Number of records		Sampling methods	Distribution	Voucher
	Serra de Santana	Nascente do Potengi			
SQUAMATA					
AMPHISBAENIA					
Amphisbaenidae					
Amphisbaena alba Linnaeus, 1758	5	12	AS, FR	W	UFRN-CH
Amphisbaena lumbricalis Vanzolini, 1996	682	–	AS, FR	CA	UFRN-CH
Amphisbaena pretrei Duméril & Bibron, 1839	18	–	AS, FR	W	UFRN-CH
Amphisbaena vermicularis Wagler, 1824	5	56	FR	W	UFRN-CH
Leposternon polystegum (Duméril, 1851)	1	12	FR	W	UFRN-CH
"LIZARDS"					
Diploglossidae					
Diploglossus lessonae Peracca, 1890	11	9	AS, PT, FR	R-CA	UFRN-CH
Gekkonidae			AS, PT		
Hemidactylus agrius Vanzolini, 1978	39	136	AS, FR	CA	UFRN-CH
Hemidactylus brasilianus (Amaral, 1935)	25	15	AS, FR	W	UFRN-CH
Hemidactylus mabouia (Moreau de Jonnés, 1818)	16	1	AS	W	UFRN-CH
Lygodactylus klugei (Smith, Martin & Swain, 1977)	78	82	AS, FR	M-CA	UFRN-CH
Gymnophthalmidae					
Acratosaura mentalis (Amaral, 1933)	31	9	AS, PT, FR	R-CA	UFRN-CH
Anotosaura vanzolinia Dixon, 1974	85	–	AS, PT, FR	R-CA	UFRN-CH
Micrablepharus maximiliani (Reinhardt & Luetken, 1862)	99	19	AS, PT, FR	W	UFRN-CH
Vanzosaura multiscutata (Amaral, 1933)	232	29	AS, PT, FR	M-CA	UFRN-CH
Iguanidae					
Iguana iguana (Linnaeus, 1758)	21	17	AS, FR	W	UFRN-CH
Leiosauridae					
Enyalius bibronii Boulenger, 1885	21	–	AS, PT, FR	R-CA	UFRN-CH
Mabuyidae			AS, PT		
Brasiliscincus heathi (Schmidt & Inger, 1951)	93	37	AS, PT, FR	W	UFRN-CH
Psychosaura agmosticha (Rodrigues, 2000)	–	42	FR	M-CA	Figure 4M
Phyllodactylidae					
Gymnodactylus geckoides Spix, 1825	240	130	AS, PT, FR	W	UFRN-CH
Phyllopezus periosus Rodrigues, 1986	27	33	AS, FR	CA	UFRN-CH
Phyllopezus pollicaris (Spix, 1825)	24	69	AS, FR	W	UFRN-CH
Polychrotidae					
Polychrus acutirostris Spix, 1825	122	70	AS, FR	W	UFRN-CH
Sphaerodactylidae					
Coleodactylus meridionalis (Boulenger, 1888)	23	1	AS, PT, FR	R-CA	UFRN-CH
Teiidae					
Ameiva ameiva (Linnaeus, 1758)	52	36	AS, PT, FR	W	UFRN-CH
Ameivula ocellifera (Spix, 1825)	1251	324	AS, PT, FR	W	UFRN-CH
Salvator merianae Duméril & Bibron, 1839	21	21	AS, PT, FR	W	UFRN-CH
Tropiduridae					
Tropidurus hispidus (Spix, 1825)	462	368	AS, PT, FR	W	UFRN-CH
Tropidurus semitaeniatus (Spix, 1825)	413	147	AS, PT, FR	M-CA	UFRN-CH

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Reptile species	Number of records		Sampling methods	Distribution	Voucher
	Serra de Santana	Nascente do Potengi			
SERPENTES					
Boidae					
Boa constrictor Linnaeus, 1758	1	17	AS, OE, FR	W	UFRN-CH
Corallus hortulana (Linnaeus, 1758)	–	2	FR	W	Figure 5B
Epicrates assisi Machado, 1945	3	4	AS, FR	M-CA	UFRN-CH
Colubridae					
Leptophis dibernardoi Albuquerque, Santos, Borjes-Nojosa & Ávila, 2022	1	7	AS, FR	M-CA	UFRN-CH
Oxybelis aeneus (Wagler, 1824)	20	7	AS, OE, FR	W	UFRN-CH
Tantilla melanocephala (Linnaeus, 1758)	–	12	FR	W	Figure 5F
Dipsadidae					
Apostolepis cearensis Gomes, 1915	8	28	AS, PT, FR	M-CA	UFRN-CH
Apostolepis longicaudata Gomes, 1921	10	–	PT, FR	CA/CE	UFRN-CH
Boiruna sertaneja Zaher, 1996	3	5	FR	M-CA	Figure 5I
Erythrolamprus poecilogyrus (Wied-Neuwied, 1824)	7	6	AS, PT, FR	W	UFRN-CH
Erythrolamprus viridis (Günther, 1862)	1	9	FR	M-CA	UFRN-CH
Leptodeira tarairiu Costa, Graboski, Grazziotin, Zaher, Rodrigues & Prudente, 2022	4	9	AS, FR	W	UFRN-CH
Lygophis paucidens Hoge, 1952	–	3	FR	W	UFRN-CH
Oxyrhopus trigeminus Duméril, Bibron & Duméril, 1854	48	74	AS, PT, FR	W	UFRN-CH
Philodryas nattereri Steindachner, 1870	38	29	AS, FR	W	UFRN-CH
Philodryas olfersii (Lichtenstein, 1823)	26	3	AS, FR	W	UFRN-CH
Pseudoboa nigra (Duméril, Bibron & Duméril, 1854)	6	32	AS, FR	W	UFRN-CH
Dryophylax almae (Franco & Ferreira, 2002)	6	–	AS	M-CA	UFRN-CH
Dryophylax phoenix (Franco, Trevine, Montingelli & Zaher, 2017)	20	39	AS, FR	M-CA	UFRN-CH
Xenodon merremii (Wagler, 1824)	1	–	AS	W	UFRN-CH
Elapidae					
Micrurus aff. *ibiboboca*	15	18	AS, PT, FR	M-CA	UFRN-CH
Leptotyphlopidae					
Epictia borapeliotes (Vanzolini, 1996)	30	5	AS, PT, OE, FR	M-CA	UFRN-CH
Viperidae					
Bothrops erythromelas Amaral, 1923	14	29	AS, FR	M-CA	UFRN-CH
Crotalus durissus Linnaeus, 1758	1	3	OE, FR	W	UFRN-CH
TESTUDINATA					
Chelidae					
Mesoclemmys tuberculata (Luederwaldt, 1926)	1	–	OE	M-CA	Figure 4X

16 amphibian species and 45 reptile species in CA078–Nascente do Potengi. Rarefaction curves for Serra de Santana showed an increasing profile for amphibians and snakes/amphisbaenians and were asymptotic for lizards (Figure 6A–C). Rarefaction curves for Nascente do Potengi were very close to asymptotes for amphibians and lizards, and asymptotic for snakes/amphisbaenians (Figure 6D–F). The Jackknife 1 estimator predicted five additional amphibian species and six additional snake/amphisbaenian species for Serra de Santana, and three additional amphibian species and two additional lizard species for Nascente do Potengi (Figure 6).

The most common amphibian in the study sites was the toad *Rhinella granulosa*, followed by the frogs *Leptodactylus troglodytes* and *L. macrosternum*, and the treefrogs *Pithecopus gonzagai* and *Scinax x-signatus* (Table 1). The most common lizards were *Ameivula ocellifera*, *Tropidurus hispidus*, *T. semitaeniatus* and *Gymnodactylus geckoides*, and the most common snakes were *Oxyrhopus trigeminus*, *Philodryas nattereri* and *Dryophylax phoenix* (Table 2). Finally, *Amphisbaena lumbricalis* stood out as the most common amphisbaenian in Serra de Santana, while *A. vermicularis* was the most common one in Nascente do Potengi (Table 2).

Figure 3. Herpetofauna recorded at Serra de Santana and Nascente do Potengi priority areas for conservation of the Caatinga in Rio Grande do Norte state, northeastern Brazil. **A** - *Rhinella diptycha*; **B** - *Rhinella granulosa*; **C** - *Boana raniceps*; **D** - *Corythomantis greeningi*; **E** - *Dendropsophus nanus*; **F** - *Scinax x-signatus*; **G** - *Leptodactylus fuscus*; **H** - *Leptodactylus macrosternum*; **I** - *Leptodactylus troglodytes*; **J** - *Leptodactylus vastus*; **K** - *Physalaemus albifrons*; **L** - *Physalaemus cicada*; **M** - *Physalaemus cuvieri*; **N** - *Pleurodema diplolister*; **O** - *Pseudopaludicola pocoto*; **P** - *Dermatonotus muelleri*; **Q** - *Proceratophrys cristiceps*; **R** - *Pipa carvalhoi*; **S** - *Pithecopus gonzagai*; **T** - *Amphisbaena alba*; **U** - *Amphisbaena lumbricalis*; **V** - *Amphisbaena pretrei*; **W** - *Amphisbaena vermicularis*; **X** - *Leposternon polystegum*.

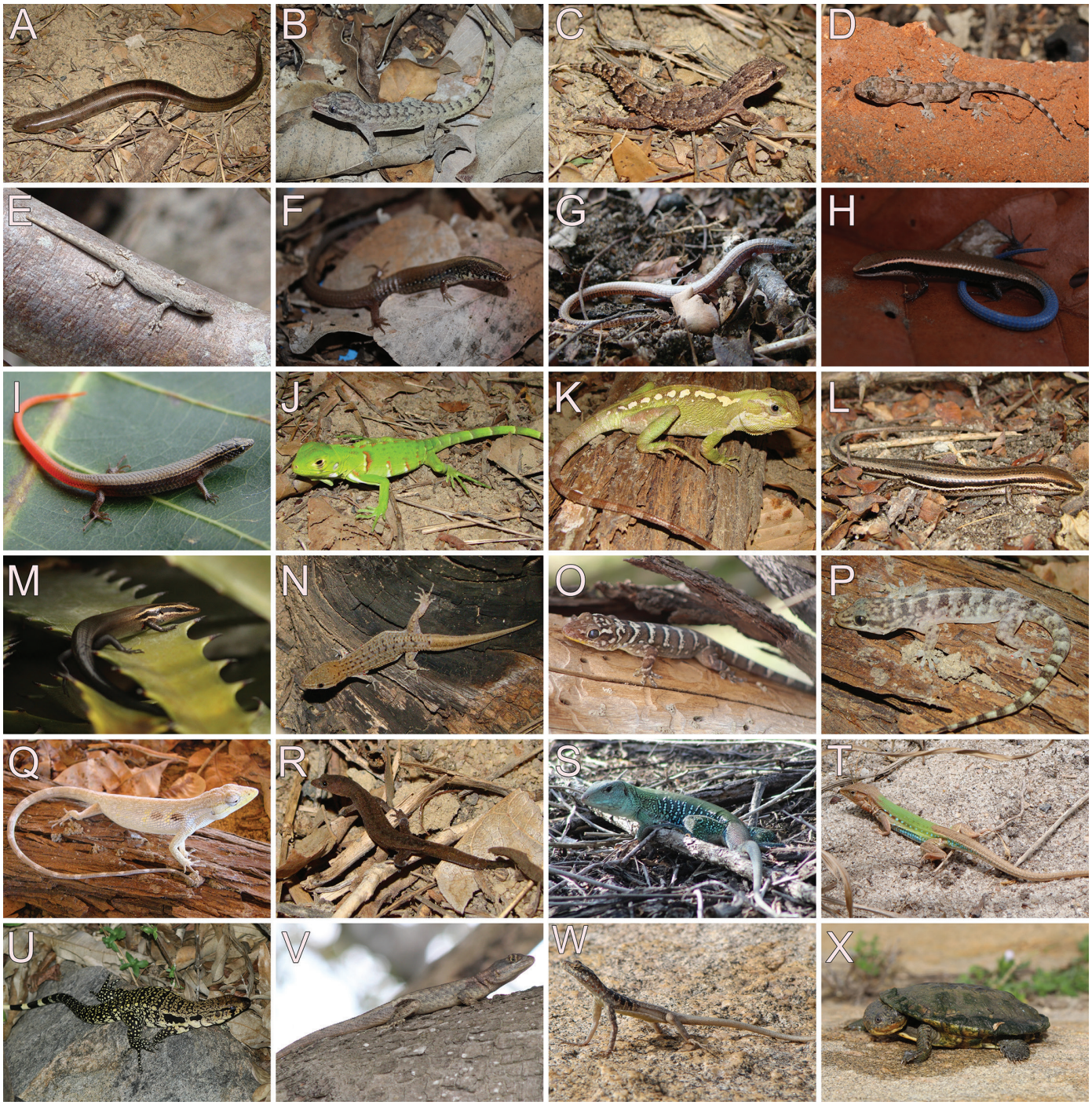

Figure 4. Herpetofauna recorded at Serra de Santana and Nascente do Potengi priority areas for conservation of the Caatinga in Rio Grande do Norte state, northeastern Brazil. **A** - *Diploglossus lessonae*; **B** - *Hemidactylus agrius*; **C** - *Hemidactylus brasilianus*; **D** - *Hemidactylus mabouia*; **E** - *Lygodactylus klugei*; **F** - *Acratosaura mentalis*; **G** - *Anotosaura vanzolinia*; **H** - *Micrablepharus maximiliani*; **I** - *Vanzosaura multiscutata*; **J** - *Iguana iguana*; **K** - *Enyalius bibronii*; **L** - *Brasiliscincus heathi*; **M** - *Psychosaura agmosticha*; **N** - *Gymnodactylus geckoides*; **O** - *Phyllopezus periosus*; **P** - *Phyllopezus pollicaris*; **Q** - *Polychrus acutirostris*; **R** - *Coleodactylus meridionalis*; **S** - *Ameiva ameiva*; **T** - *Ameivula ocellifera*; **U** - *Salvator merianae*; **V** - *Tropidurus hispidus*; **W** - *Tropidurus semitaeniatus*; **X** - *Mesoclemmys tuberculata*.

Figure 5. Herpetofauna recorded at Serra de Santana and Nascente do Potengi priority areas for conservation of the Caatinga in Rio Grande do Norte state, northeastern Brazil. **A** - *Boa constrictor*; **B** - *Corallus hortulana*; **C** - *Epicrates assisi*; **D** - *Leptophis dibernardoi*; **E** - *Oxybelis aeneus*; **F** - *Tantilla melanocephala*; **G** - *Apostolepis cearensis*; **H** - *Apostolepis longicaudata*; **I** - *Boiruna sertaneja*; **J** - *Erythrolamprus poecilogyrus*; **K** - *Erythrolamprus viridis*; **L** - *Leptodeira tarairiu*; **M** - *Lygophis paucidens*; **N** - *Oxyrhopus trigeminus*; **O** - *Philodryas nattereri*; **P** - *Philodryas olfersii*; **Q** - *Pseudoboa nigra*; **R** - *Dryophylax almae*; **S** - *Dryophylax phoenix*; **T** - *Xenodon merremii*; **U** - *Micrurus aff. ibiboboca*; **V** - *Epictia borapeliotes*; **W** - *Bothrops erythromelas*; **X** - *Crotalus durissus*.

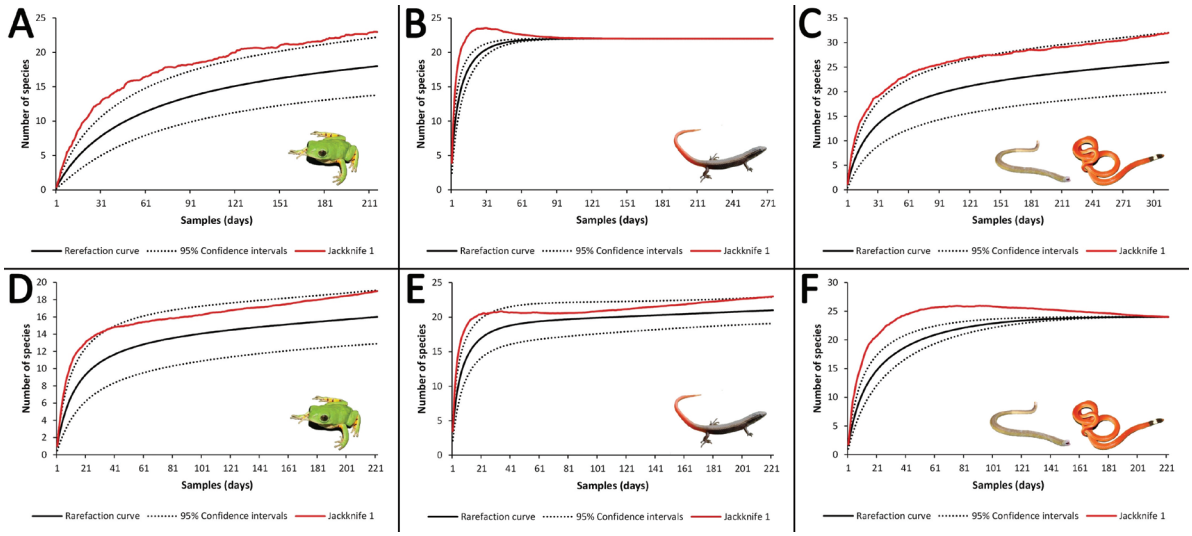

Figure 6. Rarefaction curves (black lines) with 95% confidence intervals (dotted lines) and Jackknife 1 richness estimators (red lines) for anurans, lizards, snakes and amphisbaenians in Serra de Santana (**A, B, C**) and Nascente do Potengi (**D, E, F**) priority areas for conservation of the Caatinga in Rio Grande do Norte state, northeastern Brazil.

Discussion

1. Species richness, composition, and distribution patterns

The richness of amphibians (19 species), lizards (23 species), snakes (24 species) and amphisbaenians (five species) found in Serra de Santana and Nascente do Potengi priority areas correspond, respectively, to 18.4%, 29.1%, 21.4% and 21.7% of current known richness for the Caatinga (Guedes et al. 2014, Garda et al. 2017, Mesquita et al. 2017, Ribeiro et al. 2018). These two priority areas harbor 71.9% of lizards, 50.0% of snakes, and 71.4% of amphisbaenians known for RN state (Costa et al. 2021, Marques et al. 2021). The rarefaction curve pattern indicates that our sampling is close to representing the total diversity of the herpetofauna present in the areas. Nonetheless, given the geographic proximity and climatic and biotic similarities among the sampled sites, we suggest that at least some of the species recorded solely at one of the two priority areas (e.g., *Dendropsophus nanus*, *Pseudopaludicola pocoto*, *Psychosaura agmosticha*, *Corallus hortulana*) may also occur in the other area but were not recorded due to sampling biases.

Regarding the composition and distribution patterns, most amphibian species recorded in Serra de Santana and Nascente do Potengi priority areas (N = 11, 57.9%, Table 1) have their distributions predominantly in the Caatinga, with marginal records in Atlantic Forest and/or eastern Cerrado (Narvaes & Rodrigues 2009, Linares & Melo 2011, Palmeira et al. 2011, Silva et al. 2014, Lantyer-Silva et al. 2016, Alves da Silva et al. 2020, Dubeux et al. 2020, Mângia et al. 2020, Vaz-Silva et al. 2020, Thomé et al. 2021), or are common in both the Caatinga and Atlantic Forest (Andrade et al. 2020, Lima et al. 2020). The remaining amphibian species recorded in the sampled areas (N = 8, 42.1%, Table 1) have wider geographic distributions in South America, being common in ≥ 3 biomes; most of them are widespread in the diagonal of open formations composed of Chaco, Cerrado and Caatinga biomes, also entering adjacent areas of Amazonia and Atlantic Forest (Oliveira et al. 2018, Barrio-Amorós et al. 2019, Araujo-Vieira et al. 2020, Camurugi et al. 2020, Magalhães et al. 2020, Pereyra et al. 2021).

With respect to reptiles, 45.3% of recorded species (N = 24, Table 2) have distributions entirely in the Caatinga biome or are mostly distributed in the Caatinga, but also marginally occur in adjacent biomes (Rodrigues 2003, Guedes et al. 2014, Mesquita et al. 2017, Recoder et al. 2014, Sales et al. 2015, Mesquita et al. 2017, Tavares et al. 2017, 2021, Nogueira et al. 2019, Albuquerque et al. 2022). A highlight regarding the species composition of the sampled mountainous areas is the occurrence of species with a relictual distribution pattern in mesic environments of the Caatinga, such as areas with arboreal vegetation on sandy soils, coastal areas, and/or in mountainous areas (Rodrigues 2003). This is the case for the lizards *Enyalius bibronii*, *Coleodactylus meridionalis*, *Diploglossus lessonae*, *Acratosaura mentalis* and *Anotosaura vanzolinia*; in addition to the relictual distribution in the Caatinga, some of them also occur in neighboring areas in northeastern Atlantic Forest and/or eastern Cerrado (Rodrigues 2003, Borges-Leite et al. 2014, Mesquita et al. 2017).

The remaining reptile species (N = 29, 54.7%, Table 2) have wider geographic distributions in South America; some are widespread in Atlantic Forest, Caatinga and Cerrado biomes (Vitt et al. 1996, Garda et al. 2012, Mesquita et al. 2017, Nogueira et al. 2019, Costa et al. 2021, Costa et al. 2022). The lizard *Hemidactylus mabouia* is an exotic (African) species which has been introduced and is successfully established in the New World, having colonized many countries in South America (Rocha et al. 2011).

2. New records for Rio Grande do Norte state

Two species are recorded for the first time in RN state: *Amphisbaena lumbricalis* (Figure 3U) and *Lygophis paucidens* (Figure 5M). The new records of *A. lumbricalis* presented here (several specimens from all four sampled areas of Site 3) extend its geographic distribution 100 km North from the nearest previously known locality (São Mamede, Paraíba state; Tavares et al. 2021), and increases the number of amphisbaenian species known for RN state to seven (the other species species are *A. alba*, *A. heathi*, *A. littoralis*, *A. pretrei*, *A. vermicularis*, and *Leposternon polystegum*; Costa et al. 2021). Morphometric and meristic characters

of the specimens of *A. lumbricalis* from Serra de Santana match the species diagnosis presented by Vanzolini (1996); the examined species (UFRN-CH 4711, 6351-6432) have snout-vent length ranging from 106.2 to 168.3 mm, tail length 12.2 to 18.1 mm, head width 2.4 to 3.3 mm, body width 3.6 to 4.6 mm, body annuli 223 to 239, tail annuli 19 to 22, pre-cloacal pores 4, dorsal and ventral segments per midbody annulus 12–14 and 18, respectively.

The new record of *L. paucidens* extends its geographic distribution 444 km Southeast from the nearest previously known locality (Trairi, Ceará state; Serrano et al. 2020). The individual of *L. paucidens* from Nascente do Potengi (UFRN-CH 5980, coordinates: 05.8867° S, 36.2177° W) has dorsal scales in 17-17-15 rows, ventral scales 174, subcaudal scales 70, divided anal plate, eight supralabials, nine infralabials, dorsum with three dark lines from head to tail, 10 maxillary teeth, snout-vent length 323 mm, and tail length 106 mm; these characteristics match the species diagnosis presented by Hoge (1952a, b). The specimen was also successfully identified as *L. paucidens* by using the "key to species of *Liophis*" presented by Dixon (1989). This new record increases the number of snake species known for RN state to 48 (Marques et al. 2021). The only species of the genus *Lygophis* previously reported for RN state is *L. dilepis*, which differs morphologically from *L. paucidens* mainly for having 19 rows of dorsal scales (Hoge 1952a, b, Dixon 1989).

3. Final considerations and conservation suggestions

The Caatinga undergoes strong anthropic pressures throughout its extension. Habitat destruction, mainly through deforestation and fires, selective logging for domestic use and charcoal production, illegal hunting, mining, and more recently, renewable energy projects, have devastated the territory and biodiversity of this biome (Silva et al. 2017). In this context, the lowlands and plateaus of the Caatinga stand out as the most historically impacted areas, as they are easier to access by humans, housing the main urban centers in the region. These degrading processes made the highland regions of the Caatinga, known as "*serras*", become the most conserved areas of the biome (Pereira-Filho et al. 2017). Practices such as agriculture and livestock are not favored in these "*serras*", especially in the slopes, contributing to a landscape of still conserved vegetation. For instance, Pichorim et al. (2016) demonstrated that the highest richness values for birds in Serra de Santana remain in the slopes, followed by the plateaus and the lowlands, which are more impacted by human disturbances.

With respect to the herpetofauna, the mountain range present in the two priority areas sampled in this study harbors virtually all species found in nearby lowlands of the "sertaneja" depression of Rio Grande do Norte (e.g., Freire et al. 2009, Caldas et al. 2016), plus some relevant species because they are exclusively found in mesic areas of the Caatinga. This higher richness in the "*serras*" is due to a combination of more preserved habitats and milder climatic conditions due to altitude, which favors the occurrence of some species usually not found in nearby lowlands, such as the lizards *Anotosaura vanzolinia*, *Acratosaura mentalis*, *Enyalius bibronii* and *Diploglossus lessonae*.

Despite being one of the smallest states in Brazil, Rio Grande do Norte is the national leader in onshore wind energy, currently with about 6 gigawatts of installed power (source: *Agência Nacional de Energia Elétrica – ANEEL*). Accelerated action on modern renewable energy is a current global priority in the perspective of the Sustainable Development Goals of the United Nations 2030 Agenda (https://sdgs.un.org/2030agenda). However, the expansion of wind energy in northeastern Brazil has raised several socio-environmental issues (Gorayeb et al. 2019). Regarding biodiversity protection, the licensing of wind farms by state environmental agencies does not seem to be considering the national priority areas for conservation of biodiversity, as several projects are being licensed within these areas, which is the case of the Sites 3 and 4 sampled in this study.

Our results highlight the mountain range present in Serra de Santana and Nascente do Potengi priority areas for conservation of the Caatinga as a region with elevated herpetofauna richness. Considering that the "*serras*" are being chosen as preferred areas for installing wind projects, we reinforce the need for territorial planning in RN state to define sensitive areas from a natural and social point of view, define regions with the possibility of economic development, and define new protected areas, especially in the mountain ranges. Fortunately, a new protected area within Nascente do Potengi is being discussed by the environmental agency of Rio Grande do Norte state ("*Refúgio de Vida Silvestre Serra das Araras*"; IDEMA, *Portaria-SEI* No. 447/2022).

Supplementary Material

The following online material is available for this article:

Appendix S1 - List of voucher specimens from the sampled localities of this study housed at the Herpetological Collection of Universidade Federal do Rio Grande do Norte (UFRN-CH).

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Miguel Fernandes Kolodiuk: contribution to the conception and design of the work and data acquisition; critical review of the manuscript, adding intellectual content.

Melissa Gogliath: contribution to the conception and design of the work and data acquisition; critical review of the manuscript, adding intellectual content.

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Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this work.

Data Availability

The raw data of this study is available at <https://doi.org/10.48331/scielodata.B3WOXT>.

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