



## Restinga lizards (Reptilia: Squamata) at the Imbassaí Preserve on the northern coast of Bahia, Brazil

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**Abstract:** This study presents the diversity of lizard species at the Imbassaí Preserve, located in the Mata de São João municipality, on the northern coast of Bahia region, Brazil, with special attention to the threatened and endemic species. We present the main results on richness and abundance, from a long term monitoring program and especially from the period between November 2008 and June 2010. We applied the visual search method associated with pitfall traps and random encounters, on a 200m linear transect, in four different vegetation habitats. We detected 26 lizard species, distributed in 19 genera of 10 families. The study reveals a high diversity area for lizards, within the restinga ecosystem along the northern coast line, and therefore contributes to the knowledge of the herpetofauna on the northern coast of the Bahia region, as well as to future management and monitoring programs.

**Keywords:** Atlantic Forest, herpetofauna, northeast, restinga.

**Portuguese Abstract:** Este estudo apresenta a diversidade de espécies de lagartos na Reserva Imbassaí, localizada no município de Mata de São João, na região do litoral norte da Bahia, Brasil, com atenção especial para as espécies endêmicas e ameaçadas. Nós apresentamos os principais resultados sobre a riqueza e abundância, a partir de um programa de monitoramento de longa duração e especialmente do período entre novembro de 2008 e junho de 2010. Nós aplicamos o método da procura visual, associado à armadilhas de direcionamento e queda e encontros ocasionais, ao longo de um transecto linear de 200m, em quatro diferentes fitofisionomias. Nós detectamos 26 espécies de lagartos, distribuídas entre 19 gêneros e dez famílias. O estudo revela uma área de elevada diversidade de lagartos, em ecossistema de restinga ao longo da linha costeira, e assim contribuindo para o conhecimento sobre a herpetofauna do litoral norte da Bahia, bem como para futuros programas de manejo e monitoramento.

## INTRODUCTION

Squamates are the most speciose clade of reptiles. They comprise 7200 species, and even excluding snakes, there are still 4450 species, which leaves lizards with the greatest number of extant species among living reptile groups (Vitt & Caldwell 2009). In Brazil there are 308 species (7.11% of the global diversity). These are distributed in 14 families mainly inhabiting the Atlantic and Amazon forest biomes (Martins & Molina 2008).

The Atlantic Forest biome brings together diverse ecosystems, including the rainforest, flooded forests, mangroves, swamps and the coastal sand dune plains, locally known as restinga (Câmara 2003). Even though it is classified as a global biodiversity hotspot, the entire biome and its associated ecosystems suffer from severe habitat loss due to urban growth and other human associated impacts, including tourism, industry and agriculture, mainly on the coastal lands of Brazil (Primack & Rodrigues 2001; Tabarelli et al. 2003, 2005). Among all of these disturbed areas, the northern coast of Bahia demands special attention for its extent and unique landscape features (Dias & Rocha 2005; Tinôco et al. 2008, 2010). As a result of this, most of the 20 endangered and endemic Brazilian reptile species, nine of them lizards, occur in the Atlantic Forest, and 13 of these are limited to coastal ecosystems, especially the restinga, (Tabarelli et al. 2003, 2005; Martins & Molina 2008).

Throughout this region where the restinga is the dominant landscape component, the construction of hotel resorts, highways, residential estates and villages, dating from the early 1960s (Kottak 2006) are contributing to the loss of large tracts of habitat, where the fauna is to some extent, still unknown, especially for those elements for which the actual biodiversity is not well described, as is the case for the herpetofauna (Dias & Rocha 2005; Tinôco et al. 2008, 2010).

The verified development within the region reflects on the stability of the natural communities, and may be interfering with its natural balance, in such a way that important biodiversity elements may be disappearing or declining. Therefore, this also reflects on the high relevance of such studies, the outcomes of which include the bringing to light of the actual status of the fauna and flora on a long term basis (Tinôco et al. 2008, 2010).

Reptiles are, in the above context, especially well adapted to the restinga environment, first because their physiology allows most taxa to adapt to the low levels of moisture and to the high temperatures (Rocha 2000). However, although some local efforts have been made in the southeast of the country (Rodrigues 2005), little is known about this fauna in the restinga ecosystem of the northern coast of Bahia. This knowledge is therefore, a fundamental tool for taking action to protect this diversity, and to discuss the current status of the taxa described as endemic or

threatened to extinction (Dias & Rocha 2005; Tinôco et al. 2008, 2010).

This overall knowledge is well described in other parts of the country where restinga is present, as in the case of Guriri, in Espírito Santos State (Teixeira 2001), Jurubatiba, in Rio de Janeiro (Rocha et al. 2004) and Juréia, in São Paulo (Marques & Sazima 2004). These are significant studies conducted over ten years in some cases, but there are no accounts of comparable long term monitoring programs on the coast of Bahia, especially concerning reptiles, and more specifically, lizard species.

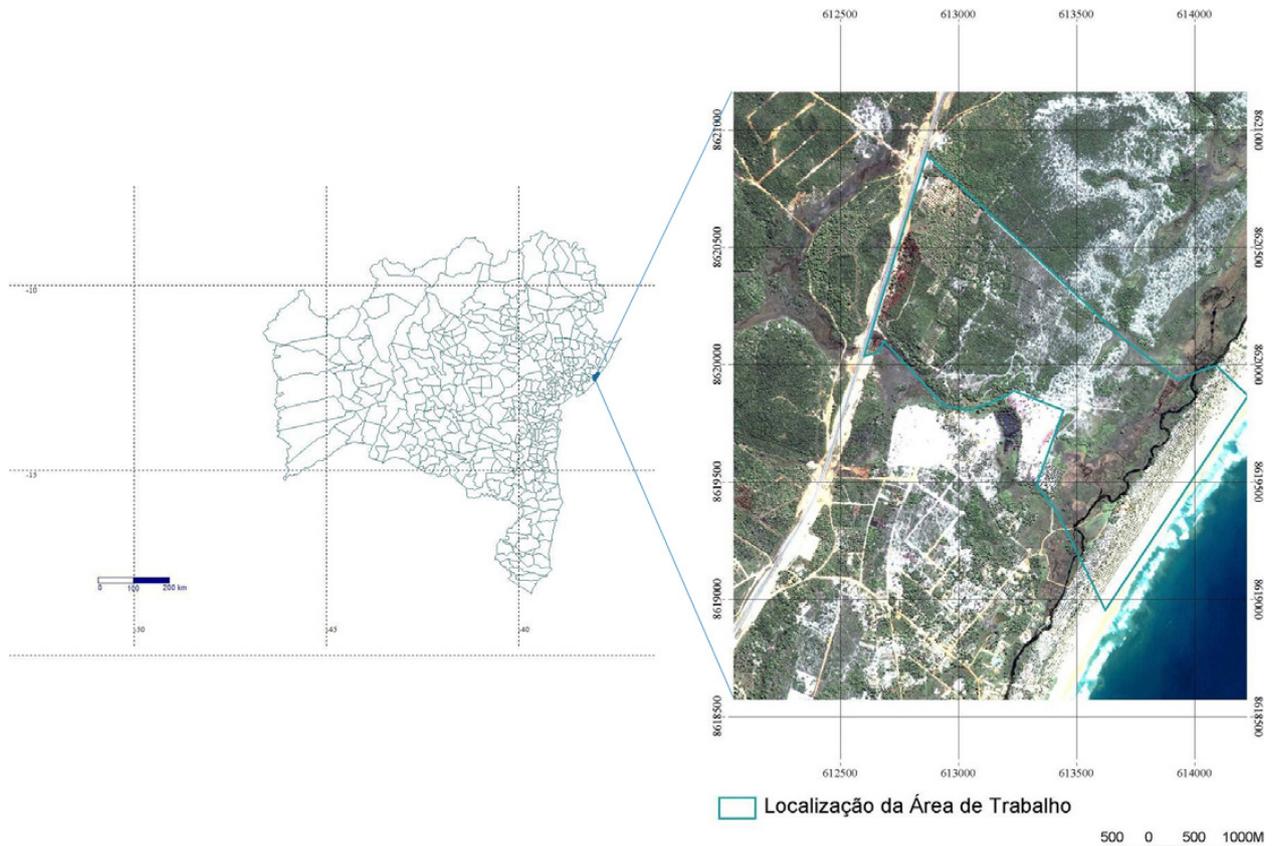
Following these assumptions, this study presents the lizard species composition and overall diversity at Imbassaí Preserve, including notes on the use of habitat in four vegetation type habitats, and distinctive contributions to herpetofaunal knowledge, giving special attention to endangered and endemic species.

## MATERIALS AND METHODS

### Study site

The study was conducted in the Imbassaí Preserve, a private preserve, one of a few protected areas within the region that includes the restinga ecosystem, in Mata de São João municipality, on the northern coast of Bahia, in Brazil (Image 1). The northern coast region of the state lies along 220km of coastline, all of which incorporates the restinga ecosystem in connection with important patches of rainforest remnants. The study site is also within the borders of the North Coast Environmental Protection Area (NCEPA), locally known as APA (“Area de Proteção Ambiental do Litoral Norte” Decreto N° 1.046/1992).

The region is dominated by a tropical climate, with 1,500–2,100 mm annual rainfall, with greatest precipitation between the months of May and August, and annual air temperature varying along a 23–35 °C gradient (Queiroz 2007). The Imbassaí Preserve (12°28'43.11”S & 37°57'28.64”W) is part of a more extensive property (138ha) of natural and developed areas, and it is comprised of residential villages, resort hotels, a commercial village, and a natural preserved environmental zone, which represents over 40% of the entire property, which is preserved as a part of a mitigation plan proposed by the governmental licensing process.



**Image 1. Study site location - Reserve Imbassaí, northern coast of Bahia, northeast of Brazil. (Map: C.M. Menezes 2008)**

The landscape also includes a traditional village and other private properties, which have been left undisturbed nearby. The study site is composed of four dominant vegetation habitat types: herbaceous beach vegetation (BV; Images 2A,B), temporary and permanently flooded zones (HZ; Images 2B,C), scrub vegetation (SV; Images 2D,E) and dry restinga forest (RF; Images 2E,F).

### Data collection and analysis

Six surveys were conducted between November 2008 and June 2010 every two months, including all seasonal variations within a year. Each survey consisted of four simultaneous sample days in all four sampled vegetation type habitats (BV, HZ, SV, and RF). Each sampled site, consisted of a linear transect of 200 m, where visual searching technique and pitfall trapping were used. The visual search was conducted by two surveyors for two hour periods.

The six surveys were conducted from 0600hr to 1800hr, and covered all sample sites, and the four vegetation type habitats, where animals were searched

for throughout the 12 daylight hour period during the one year study. All surveys also included a night search in all sampled vegetation type habitats, consisting of visual searching from 1900 to 2100 hr. Sample design consisted of the application of two main techniques: (1) the time constrained visual search, consisting of active searching, where all micro habitats and refuges were searched by two experienced surveyors, during two hours, totaling 384 hours effort, and; (2) drift fence pitfall trapping, using two 20 litter buckets, with a 10m long and 0.4m high black plastic construction sheet fixed with wooden poles. We used 50 such traps, which remained open for four consecutive days, in all four vegetation type habitats; (3) finally, random encounters (RE) were also recorded, and consisted of the record of any animal detected by chance along the transect, and outside of the search hours.

All recorded specimens had their location and habitat type registered, biometric information taken, and were marked (fluorescent elastomer) and released at the point of capture. The study was conducted under permit 03/2009 - NUFAU - IBAMA/BA, for the



**Image 2. Restinga vegetation type at the Reserva Imbassaí, northern coast of Bahia, Brazil**  
**A - Herbaceous beach vegetation; B - Imbassaí river on the border of beach vegetation and the humid vegetation zone;**  
**C - Temporary humid zone flooded; D - Scrub vegetation; E - Transition between the scrubby vegetation and the dry**  
**restinga forest; F - Restinga Dry Forest. Photos by D. Couto-Ferreira.**

Imbassaí Preserve Long Term Monitoring Program.

General counts are presented, including abundance and richness as the main data summaries. Shannon and Simpson diversity indices were calculated. The choice of these indices takes into account the presence

of rare and common species, and therefore gives a broader view of the local lizard diversity.

Species conservation status categories classification (Data Deficient - DD; Least Concern - LC; Vulnerable - VU; Endangered - EN) considered the IUCN Red

List, when listed, otherwise, the national red list was applied. Categories are indicated on the species list table.

## RESULTS

We registered 26 lizard species for the study site, distributed into 19 genera and 10 families: Amphisbaenidae (n=3), Iguanidae (n=1), Polychrotidae (n=2), Tropiduridae (n=3), Gekkonidae (n=2), Phyllodactylidae (n=4), Sphaerodactylidae (n=1), Teiidae (n=5), Gymnophthalmidae (n=3) e Scincidae (n=2). The most abundant species, in descending order were: *Tropidurus hygomi* Reinhardt & Luetken, 1861 (n=1599) a local restinga endemic species, *Cnemidophorus ocellifer* (Spix, 1825) (n=641), *Coleodactylus meridionalis* (Boulenger, 1888) (n=103), *Mabuya macrorhyncha* Hoge, 1947 (n=69), *Phyllopezus pollicaris* (Spix, 1825) (n=46), *Bogertia lutzae* Loveridge, 1941 (n=27), *Hemidactylus mabouia* (Moreau de Jonnés, 1818) (n=21), *Cnemidophorus abaetensis* Dias, Rocha & Vrcibradic, 2002, a local restinga endangered species according to the Brazilian red list (n=18), *Tupinambis merianae* (Duméril & Bibron, 1839) (n=7), *Iguana iguana* (Linnaeus, 1758) (n=4), *Hemidactylus brasiliensis* (Amaral, 1935) (n=4), *Micrablepharus maximiliani* (Reinhardt & Luetken, 1862) (n=3) *Tropidurus hispidus* (Spix, 1825) (n=3), *Anolis ortonii* Cope, 1868 (n=3), *Gymnodactylus darwini* (Gray, 1845) (n=2), *Kentropyx calcarata* Spix, 1825 (n=2), *Amphisbaena vermicularis* Wagler, 1824 (n=2), and *Amphisbaena alba* Linnaeus, 1758, *Amphisbaena octostega* (Duméril, 1851), *Ameiva ameiva* (Linnaeus, 1758), *Cercosaura ocellata* Wagler, 1830, *Colobossaura modesta* (Reinhardt & Lütken, 1862), *Mabuya agilis* (Raddi, 1823), *Phyllopezus periosus* Rodrigues, 1986, *Polychrus acutirostris* Spix, 1825 and *Tropidurus semitaeniatus* (Spix, 1825) (all n=1) (Table 1; Images 3–5).

About 59 % of the detected species were using one vegetation type habitat, the other 25% were recorded using two of those habitats, 3% used three habitat types, and 11% were using all four. However, when looking at each vegetation type as a distinct habitat, the humid zones recorded 51% of the use, the beach vegetation and restinga forest 40%, and the scrub vegetation habitat type 33% of lizards' richness (Table

**Table 1. Lizard species list for the Reserve Imbassaí, restinga ecosystem, northern coast of Bahia, Brazil**  
N - number of individuals; Vegetation type (1 - BV, 2 - HZ, 3 - SV, 4 - RF).

Family (Author) / Species (Author)	N	Vegetation type	Categ.
<b>Amphisbaenidae Gray, 1825</b>			
<i>Amphisbaena alba</i> Linnaeus, 1758	1	4	LC
<i>Amphisbaena vermicularis</i> Wagler, 1824	2	4	
<i>Amphisbaena octostega</i> (Duméril, 1851)	1	4	
<b>Iguanidae Opperl, 1811</b>			
<i>Iguana iguana</i> (Linnaeus, 1758)	4	1, 2	
<b>Polychrotidae Fitzinger, 1843</b>			
<i>Polychrus acutirostris</i> Spix, 1825	1	2	
<i>Anolis ortonii</i> Cope, 1868	3	4	
<b>Tropiduridae Bell, 1843</b>			
<i>Tropidurus hispidus</i> (Spix, 1825)	3	3	
<i>Tropidurus hygomi</i> Reinhardt & Lütken, 1861	1599	1, 2, 3, 4	
<i>Tropidurus semitaeniatus</i> (Spix, 1825)	2	2	LC
<b>Gekkonidae Gray, 1827</b>			
<i>Hemidactylus mabouia</i> (Moreau de Jonnés, 1818)	21	1, 3	
<i>Hemidactylus brasiliensis</i> (Amaral, 1935)	4	2, 3	
<b>Phyllodactylidae Gamble, Bauer, Greenbaum &amp; Jackman, 2008</b>			
<i>Bogertia lutzae</i> Loveridge, 1941	27	2, 3	
<i>Gymnodactylus darwini</i> (Gray, 1845)	2	1	
<i>Phyllopezus periosus</i> Rodrigues, 1986	1	4	
<i>Phyllopezus pollicaris</i> (Spix, 1825)	46	1	
<b>Sphaerodactylidae Underwood, 1954</b>			
<i>Coleodactylus meridionalis</i> (Boulenger, 1888)	103	2, 3, 4	
<b>Teiidae Gray, 1827</b>			
<i>Ameiva ameiva</i> (Linnaeus, 1758)	1	2	
<i>Cnemidophorus abaetensis</i> Dias, Rocha & Vrcibradic, 2002	18	3, 4	VU
<i>Cnemidophorus ocellifer</i> (Spix, 1825)	641	1, 2, 3, 4	
<i>Tupinambis merianae</i> (Duméril & Bibron, 1839)	7	2, 3	LC
<i>Kentropyx calcarata</i> Spix, 1825	2	4	
<b>Gymnophthalmidae Merrem, 1820</b>			
<i>Cercosaura ocellata</i> Wagler, 1830	1	2	
<i>Colobossaura modesta</i> (Reinhardt & Luetken, 1862)	1	2	
<i>Micrablepharus maximiliani</i> (Reinhardt & Luetken, 1862)	3	1, 2	
<b>Scincidae Gray, 1825</b>			
<i>Mabuya macrorhyncha</i> Hoge, 1947	69	1, 2, 3, 4	
<i>Mabuya agilis</i> (Raddi, 1823)	1	1	



**Image 3. Restinga's lizards' species, Reserva Imbassaí, northern coast of Bahia, Brazil**

**A - *Amphisbaena alba* (Amphisbaenidae); B - *Iguana iguana* (Iguanidae); C - *Polychrus acutirostris* (Polychrotidae);**

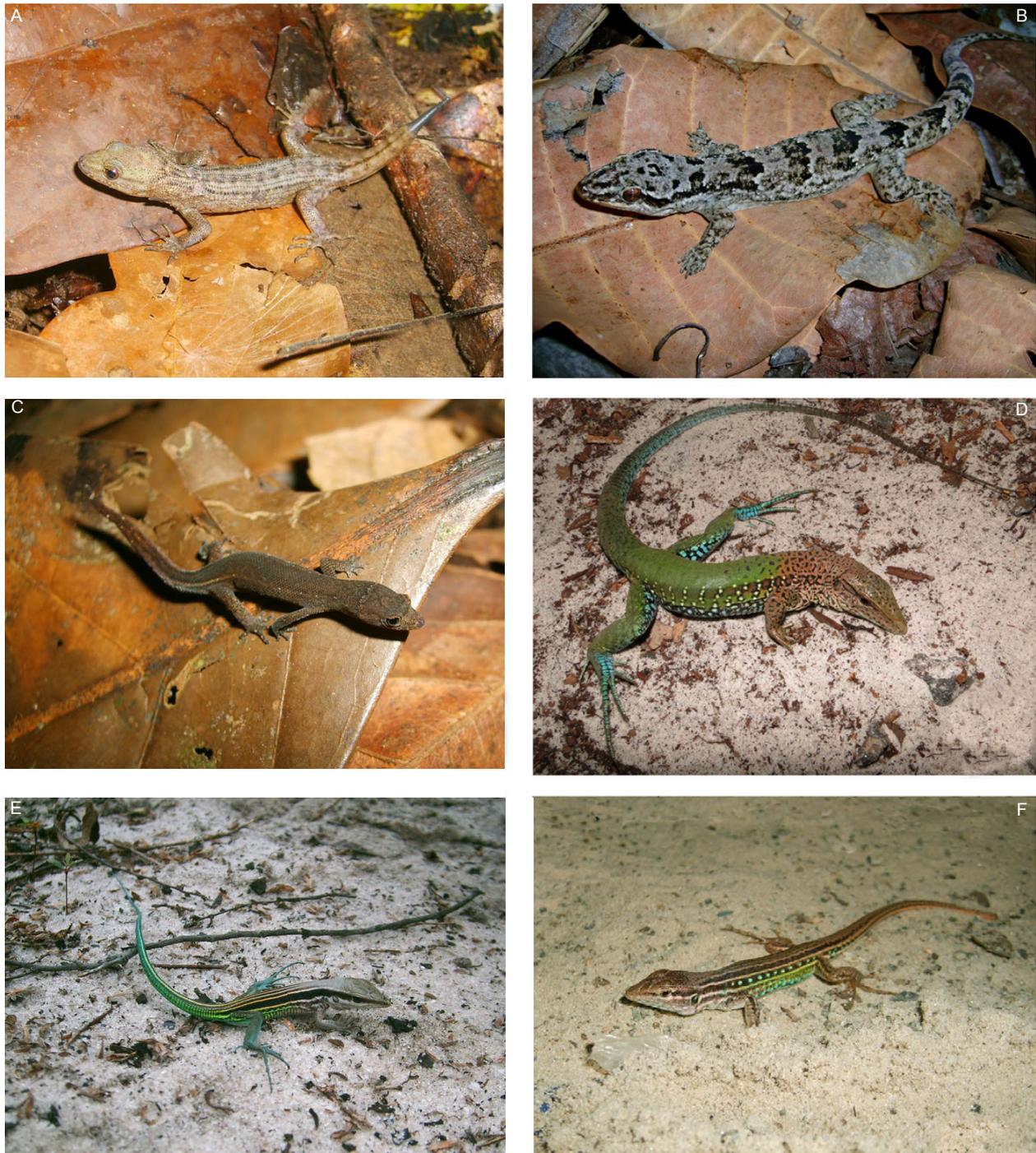
**D - *Tropidurus hygomi* (Tropiduridae); E - *Hemidactylus brasiliensis* (Gekkonidae); F - *Hemidactylus mabouia* (Gekkonidae).**

**Photos by R. Marques.**

1).

The Imbassaí Preserve lizard diversity is reflected in Shannon and Simpson diversity indices of 2.23 and 0.83, respectively. The humid vegetation habitat were associated with the highest diversity indices

(Shannon=2.1; Simpson=0.8) followed by dry forest habitat (Shannon=2.11; Simpson=0.79). Beach vegetation had the lowest values, although it showed a high abundance (Shannon=1.37; Simpson=0.62), preceded by the scrub vegetation type habitat



**Image 4. Restinga's lizards' species, Reserva Imbassaí, northern coast of Bahia, Brazil**  
**A - *Gymnodactylus darwinii* (Phyllodactylidae); B - *Phyllopezus periosus* (Phyllodactylidae); C - *Coleodactylus meridionalis* (Sphaerodactylidae); D - *Ameiva ameiva* (Teiidae); E - *Cnemidophorus abaetensis* (Teiidae); F - *Cnemidophorus ocellifer* (Teiidae).** Photos by R. Marques.

(Shannon=1.41; Simpson=0.63). Despite differences, all vegetation type habitats supported relatively high diversity levels.

## DISCUSSION AND CONCLUSIONS

When we consider the Brazilian list of reptile species (Bérnils 2010), the study recorded nearly 11% of Brazilian lizard diversity. Some species had



**Image 5. Restinga's lizards' species, Reserva Imbassaí, northern coast of Bahia, Brazil**  
**A - *Tupinambis merianae* (Teiidae); B - *Cercosaura ocellata* (Gymnophthalmidae); C - *Mabuya macrorhyncha* (Scincidae); D - *Anolis ortonii* (Polychrotidae).** Photos by R. Marques.

been undetected in previous studies, and some of these had been recorded earlier in the Caatinga and Cerrado biomes at the Atlantic Forest biome's border and adjacent to the restinga ecosystem. These include: *Tupinambis merianae* and *Phyllopezus periosus* (Vanzolini et al. 1980; Rodrigues 2003; IUCN 2010).

Previous long term studies in large areas concerning the importance of lizard species in other biomes enhance the relevance of the restinga ecosystem for understanding lizard diversity in Brazil. Vitt et al. (2008) detected 35 species on the Adolpho Ducke Preserve (Amazon), that study was conducted in a 10,000ha area (72 times larger than the Imbassaí Preserve) and Colli et al. (2002) found 34 species within five municipalities in the Cerrado biome. Here, we present a small, but interesting portion of lizard diversity when compared to those studies, considering just a small fraction of the entire restinga's

ecosystem.

Studies on the Atlantic Forest and associated restinga ecosystem herpetofauna, most of which were conducted in the southeastern region of Brazil, are not as extensive as those mentioned above, in the Amazon and the Cerrado. Teixeira (2001) recorded eight lizards species in a 12-month survey in Espírito Santo State, Marques & Sazima (2004) detected nine lizards species in a three-year survey, Rocha et al. (2004) recorded eight species in the Jurubatiba restinga habitats; Carvalho et al. (2007) registered 12 species for Marambaia Island (7,700 ha), off the coast of the Rio de Janeiro State, and the Centro de Ecologia e Conservação Animal (ECOA 2010) reported 19 lizard species in a seven-year monitoring program, in the Parque Metropolitano de Pituacu (Salvador, Bahia, Brazil), urban Atlantic Forest remnant (~400 ha). Given these figures, and noting that the studies

are not directly comparable, it is clear that the present study reports an important contribution to the overall restinga lizard fauna and adds relevance to the studies mentioned above.

Dias & Rocha (2005) in a study in the same region as this (covering three different localities), and also including another three localities on the south coast of Bahia, recorded 23 lizard species. However, some of the species recorded here, were not registered in that study, such as, *Amphisbaena vermicularis*, *Amphisbaena octostega*, *Polychrus acutirostris*, *Anolis ortonii*, *Tropidurus hispidus*, *Tropidurus semitaeniatus*, *Hemidactylus brasiliensis*, *Gymnodactylus darwini*, *Phyllopezus periosus*, *Phyllopezus pollicaris*, *Tupinambis merianae* and *Colobossaura modesta*.

Though using different sample designs and time spans, these studies place into context the contribution of the Bahian northern coast to the overall lizard diversity in Brazil. Moreover, this clearly indicates that this is a highly significant region for the conservation of lizards, as it brings together elements (lizard species) from three of the four major biomes: Atlantic Forest, Caatinga and Cerrado, indicating its high biological importance, especially when considering endangered and endemic species.

The Bahian Sand Dune Lizard *Cnemidophorus abaetensis* and the Sand Dune Lava Lizard *Tropidurus hygomi* are both endemic to this restinga ecosystem in Bahia (Dias & Rocha 2005; Tinôco et al. 2010). The first is listed as endangered on the Brazilian red list (Martins & Molina 2008), and is of high relevance to this study, due to the gap of information concerning their actual conservation status within the region. This could, in some cases, stifle appropriate management policies by public authorities, justified by the lack of consistent published results. These lizards are critically restricted to the scrub and beach vegetation habitats, and therefore more vulnerable to restinga disturbance from the Capital City Salvador to the northern border of the State of Sergipe (Image 4E). Understanding of habitat use may represent an important tool for their conservation in a highly disturbed landscape.

The Bahian Sand Dune lizard and the Sand Dune Lava lizard are among the five Brazilian lizard species with geographical distributions restricted to the coastal restinga. The first one is also listed as Vulnerable in the Brazilian Red List of Threatened Species (Martins &

Molina 2008). However, the other three species found here, are listed on the IUCN Red List, *Amphisbaena alba*, *Tropidurus semitaeniatus*, and the presumably introduced *Tupinambis merianae*, all under the Least Concern category (IUCN 2010). *Tropidurus hygomi* although in high abundance, is endemic to the region, occurs mostly on the beach vegetation dunes, and is thus highly vulnerable although it is not listed in any of the categories or lists.

In this study, the distribution of the Bahian Sand Dunes Lizard *Cnemidophorus abaetensis* was concentrated mainly in the scrub vegetation and the dry forest habitats as suggested by Tinôco et al. (2010). That possibly indicates an important threat to the species' conservation, as local legislation designates all scrub vegetation as development sites, and along the entire northern coast most of the scrub vegetation habitat is being destroyed or degraded for the construction of large hotel resorts and residential estates (Tinôco et al. 2010). These may lead to major gaps in the taxon's distribution and thereby compromise its long term survival within the region. We believe that a combination of a management plan for the entire ecosystem, the establishment of protected areas linked by fauna corridors which can allow the preservation of the major vegetation type habitats and in accordance with the environmental public policies, may result in a better perspective for the conservation of this and the local populations of other taxa.

Our surveys recovered 93.1% (excepting only *Tupinambis teguixin* (Linnaeus, 1758) and *Amphisbaena nigricauda* (Gans, 1966)) of the known lizard diversity for the northern coast of the state of Bahia, representing 11.2% of Brazilian lizard biodiversity. This results in a high diversity index, especially for the dry forest and aquatic vegetation habitats, which are already protected by Brazilian and state legislation, and reveals, in a highly disturbed ecosystem, threatened, endemic, introduced, and new records for taxa such as the Sand Dune Lava Lizard *Tropidurus hygomi* and the Bahian Sand Dune Whiptail *Cnemidophorus abaetensis*, among four other threatened species.

This study contributes 13 new species records for the region, filling some distribution gaps on the northern coast of Bahia for endangered or endemic species, giving important support for the development of a management plan and conservation actions to protect

lizards, particularly endemic and endangered species on the northern coast of Bahia. It indicates a relevant diversity index for four vegetation type habitats, apart from dry forest and aquatic vegetation habitats, which are already covered by protective legislation. Finally, these important contributions call for action and new policies providing real protection for the high lizard diversity of the Atlantic Forest ecosystem.

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