

## Serra do Navio, Guiana Shield lowland area, Brazil: a region with high diversity of Squamata

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### ABSTRACT

The Guiana Region is the area bordered by the Orinoco and Negro rivers to the west, by the Amazonas River to the south and by the Atlantic Ocean to the north and east. This area is a biogeographic unit known as the Guiana Shield, with a variety of landscapes. Located in the extreme north of Brazil, in the Guiana Shield lowlands, the state of Amapá presents great diversity of habitats. In this study we provide composition and diversity data of the Squamata from Serra do Navio (SN) region, in the northeastern part of the state of Amapá, Brazil, a lowland area of the Guiana Shield. The species list was based on data obtained from herpetological collections and collection expeditions carried out at 10 sites in the municipalities of Pedra Branca do Amapari and Serra do Navio. We consider literature data from 14 sites and SN data to compare the composition of herpetofauna between the lowland and highland areas in the Brazilian Amazon. We recorded 95 species, including 57 snakes, 36 lizards, and two species of amphisbaenians. *Atractus aboiporu*, *A. trefauti*, and *Erythrolamprus rochai* were described from the data collected in this study. The Squamata community of SN consists mainly of diurnal lizards and nocturnal snakes, with terrestrial and cryptozoic habits, present in pristine and altered environments. The most abundant species of lizard and snake were *Loxopholis guianense* and *Atractus latifrons*, respectively. The SN region has 17 exclusive Squamata species, with a fauna similar to the Tumucumaque Mountains and northern Pará sites, geographically closer regions with similar altitudes.

Key words: Lizards, Snakes, Amphisbaenians, Amazonian, community.

### RESUMEN

La región de Guayana es el área bordeada por los ríos Orinoco y Negro al oeste, por el río Amazonas al sur y por el océano Atlántico al norte y al este. Esta área es una unidad biogeográfica conocida como Escudo Guayanés, con una variedad de paisajes. Ubicado en el extremo norte de Brasil, en las tierras bajas del Escudo Guayanés, el estado de Amapá presenta una gran diversidad de hábitats. En este estudio, proporcionamos datos sobre la composición y diversidad de Squamata de la región de Serra do Navio (SN), en la parte noreste del estado de Amapá, Brasil, un área de tierras bajas del Escudo de Guyana. La lista de especies se basó en datos obtenidos de colecciones herpetológicas y expediciones de recolección realizadas en 10 sitios en los municipios de Pedra Branca do Amapari y Serra do Navio. Consideramos datos de literatura de 14 sitios y datos de SN para comparar la composición de herpetofauna entre las áreas de tierras bajas y tierras altas en la Amazonía brasileña. Registramos 95 especies, incluyendo 57 serpientes, 36 lagartos y dos especies de anfisbaenias. *Atractus aboiporu*, *A. trefauti* y *Erythrolamprus rochai* se describieron a partir de los datos recopilados en este estudio. La comunidad Squamata de SN consiste principalmente en lagartos diurnos y serpientes nocturnas, con hábitos terrestres y criptozoicos, presentes en ambientes prístinos y alterados. Las especies más abundantes de lagarto y serpiente fueron *Loxopholis guianense* y *Atractus latifrons*, respectivamente. La región SN tiene 17 especies exclusivas de Squamata, y tiene una fauna similar a las montañas Tumucumaque y los sitios del norte de Pará, regiones geográficamente más cercanas y con altitudes similares.

Palabras clave: Lagartos, Serpientes, Anfibaenias, Amazónicas, Comunidad.

## Introduction

Evidence of high diversity of snake and lizard species in the Amazon region come mostly from studies of communities (e.g. Duellman, 1978; Martins and Oliveira, 1999; Bernarde and Abe, 2006; Maschio *et al.*, 2009) and herpetofaunistic inventories (e.g. Prudente and Santos-Costa, 2005; Prudente *et al.*, 2010; Santos-Costa *et al.*, 2015). It is estimated that there are about 229 species of snakes, 148 of lizards and 25 of amphisbaenians in the Brazilian Amazon, representing 56% of the 405 species of snakes, 54% of the 276 species of lizards and 35% of the 72 species of amphisbaenians recorded for Brazil (Costa and Bérnils, 2018). These numbers are growing every year due to regular descriptions of new species (e.g. Ascenso *et al.*, 2019; Melo-Sampaio *et al.*, 2019). On the other hand, some species will never be revealed to science, as the loss or fragmentation of habitats caused by human activities can lead to extinction on a local and global scale (Prudente *et al.*, 2018).

The Guiana Region is bounded by the Orinoco and Negro rivers to the west, the Amazonas River to the south and the Atlantic Ocean to the north and east (Hoogmoed, 1979). It includes Guyana, Suriname, French Guiana, southeastern of Venezuela, and northern Brazil (states of Amapá, Roraima, part of the states of Pará and Amazonas situated north of the Amazonas River) (Hoogmoed, 1979; Avila-Pires *et al.*, 2010). This area is considered as a unit known as the Guiana Shield (Gansser, 1954), with a wide variety of landscapes including sandstone tepuis, granite inselbergs, white sands forests, seasonally flooded tropical savannas, lowlands with numerous rivers, isolated mountain ranges, and coastal swamps (Huber *et al.*, 1995; Huber, 1995). The Guiana Shield highlands region, with elevations above 1,500 m is considered a distinct biogeographic region, known as Pantepui, with large number of endemic species (82% of amphibians and 62% of reptiles) (McDermid and Donnelly, 2005; Avila-Pires *et al.*, 2007; Moraes *et al.*, 2017); in contrast, the Guiana lowlands have a number of species in common with other areas of Amazonian and lower number of endemic species (52% of amphibians and 26% of reptiles) (Hoogmoed, 1979; Avila-Pires *et al.*, 2010).

Located in the extreme north of Brazil, within the Guiana Shield lowlands, the state of Amapá presents a great diversity of habitats, including Terra Firme forests, flooded floodplain and igapó forests, lakes, extensive mangrove areas, plant formations

associated with rocky outcrops and a significant portion of Amazonian cerrado in its central area (IBGE, 2014). Avila-Pires (2005) recorded 84 species of snakes, 41 of lizards and two of amphisbaenians for the state of Amapá, whereas Lima (2008) and Campos *et al.* (2015) recorded a lower diversity (45 species snakes, 33 lizards and two of amphisbaenians, and 22 species of lizards and one of amphisbaenia, respectively). Recently, in the list of reptiles of Brazil, Costa and Bérnils (2018) registered 88 species of snakes, 46 lizards, and three amphisbaenians for the state of Amapá, while Nogueira *et al.* (2019), in extensive data compilation about Brazilian snakes, indicated a total 90 species of snakes for the state.

This study represents a contribution to the understanding of the herpetofauna of the eastern Amazonian lowlands, north of the Amazon River. Here we provide the composition and diversity of Squamata species of the Serra do Navio region, in the municipalities of Pedra Branca do Amapari and Serra do Navio, state of Amapá, Brazil. We compared our results with literature data of 14 sites of the lowlands and highlands in the Brazilian Amazon, considering the altitudinal differences and distances between the areas.

## Materials and methods

The present study was carried out with data obtained from herpetological collections of the Museu Paraense Emílio Goeldi (MPEG) and Instituto de Pesquisas Científicas e Tecnológicas do Amapá (IEPA), collected in two nearby municipalities, Serra do Navio and Pedra Branca do Amapari, areas with the same altitude range and geomorphological characteristics (Fig. 1). In addition, we included samples collected from seven locations in the Pedra Branca do Amapari, two of these affected by artisanal-scale mining (garimpo), and three in the Serra do Navio (Table 1), both located in the midwest region of Amapá State, Brazil (Fig. 1). Samplings at Pedra Branca do Amapari were conducted during three expeditions in 2000 (April-December), two in the rainy season and one in the dry season, lasting between seven and ten days each (Table 1). In Serra do Navio sampling occurred during one expedition lasting ten days in November 2007.

Due to the proximity between the municipalities of Serra do Navio and Pedra Branca do Amapari, we consider here as an area defined as Serra do Navio region. This region can be characterized by

**Table 1.** Location and description of the herpetofauna sampling sites in Serra do Navio and Pedra Branca do Amapari, state of Amapá, Brazil.

Municipality	Geographic coordinates	Site description
Serra do Navio	00°59'28" N, 52°01'33" W	Encompasses flooded, primary and secondary growth forests
Serra do Navio	01°00'41" N, 52°03'29" W	Flooded and secondary growth forests
Serra do Navio	01°00'43" N, 52°05'45" W	Flooded and primary forests
Pedra Branca do Amapari	00°52'23" N, 51°52'28" W	Primary forest and understorey with uneven terrain, with William stream drainage
Pedra Branca do Amapari	00°51'47" N, 51°52'43" W	Primary forest and rust lagoon, formed by collapse of porous lateritic soil
Pedra Branca do Amapari	00°53'45" N, 51°52'55" W	Steep terrain with presence of some very robust and close trees
Pedra Branca do Amapari	00°51'34" N, 51°52'34" W	Primary forest with a more closed canopy, with drainage of the Arrependido stream, much affected by the activity of garimpo
Pedra Branca do Amapari	00°50'54" N, 51°53'12" W	Secondary growth forests on flat ground
Pedra Branca do Amapari	00°50'58" N, 51°53'17" W	Stretch of forest altered by the garimpo dominated by herbaceous and shrub vegetation
Pedra Branca do Amapari	00°51'29" N, 51°53'27" W	Slightly uneven terrain with primary forest of hill top and thin trees, between the drainages of Taperebá and Mata-Fome streams, where the terrain is stony and the water is turbid

having Equatorial (Am) climate according to the Köppen-Geiger classification, with annual rainfall above 3,300 mm in the north-central Amapá, with monsoon period between February and May, when the monthly rainfall is around 400 mm, and dry period between August to November (Alvares *et al.*, 2013). Annual mean temperature is 27°C, with daily fluctuations between 25 and 35°C and temperatures at night between 20 and 25°C (Hoogmoed and Avila-Pires, 1989). It is characterized by tropical forest with areas of Terra Firme containing submontane dense ombrophylous forest formations with emergent dozel as well as altered areas (Hoogmoed and Avila-Pires, 1989).

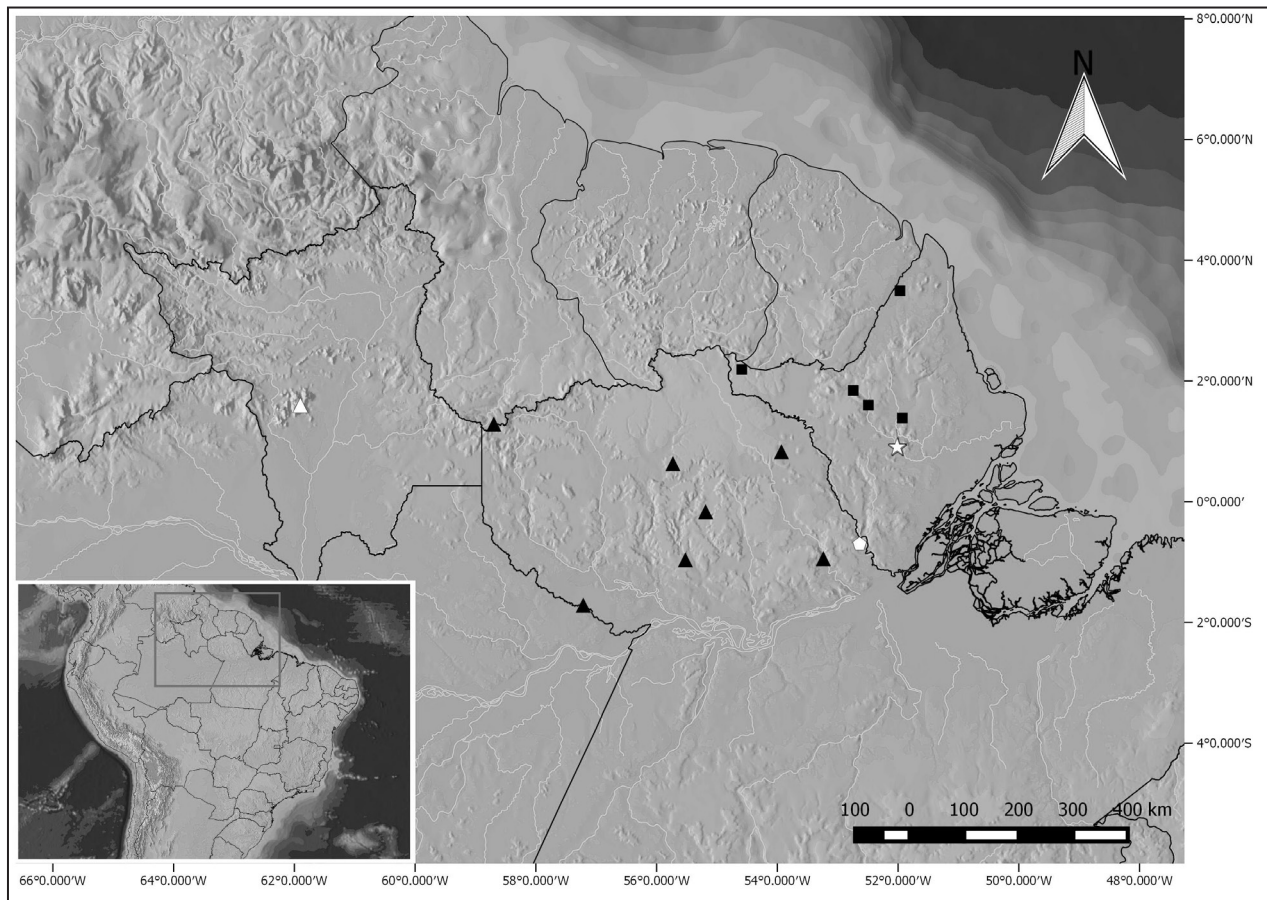
All Squamata were captured using two capture methods: Time Constrained Search (Campbell and Christman, 1982; Scott *et al.*, 1989; Martins and Oliveira, 1999) and Pitfall Traps with Drift Fences (Greenberg *et al.*, 1994; Cechin and Martins, 2000). We also obtained specimens captured by third parties and found occasionally throughout the sites described. All specimens collected in this study were deposited at the Herpetological Collection of MPEG and IEPA.

We compared the composition of the herpetofauna of the Serra do Navio region with 14 other lowland and highland areas in northern Brazilian Amazon. Considering the distances and altitudes between the analyzed areas we defined: seven sites in northern Pará State (Avila-Pires *et al.*, 2010); five sites in Tumucumaque Mountains National Park, state of Amapá (Lima, 2008); one site in Almeirim,

state of Pará (Ribeiro Junior *et al.*, 2008); one site in Serra da Mocidade, state of Roraima (Moraes *et al.*, 2017) (Fig. 1); and one site in Serra do Navio region (this study). Cluster dendrogram based on dissimilarity matrix by Jaccard index were performed in R package version 2.1.0. (Maechler *et al.*, 2019).

To describe the Squamata community we use categories of daily activity and the use of microhabitat (e.g., day or night, arboreal, terrestrial, aquatic, etc.), considering that many Amazonian snakes and lizards use more than one substrate for their activities and are active both day and night (Hoogmoed, 1973; Dixon and Soini, 1975, 1986; Cunha and Nascimento, 1978, 1993; Gasc *et al.*, 1983; Cunha *et al.*, 1985; Magnusson and Lima, 1984; Hoogmoed and Avila-Pires, 1989, 1991; Martins, 1991; Avila-Pires, 1995; Martins and Oliveira, 1999; Maciel *et al.*, 2003; Bailey *et al.*, 2005; Maschio, 2008; Vitt *et al.*, 2008; Avila-Pires *et al.*, 2010; Fraga *et al.*, 2013; Santos-Costa *et al.*, 2015; Ascenso *et al.*, 2019; Melo-Sampaio *et al.*, 2019). Here we used general information of the species found under the following conditions: active, resting, foraging, on the substrate, on the vegetation, in the water, near the water, and other. The abundance of species was considering only for the Serra do Navio region, which was defined according to Maschio (2008), where dominant species vary between 9 and 15%, intermediate between 0.53 and 4.76%, and rare when present in 0.26% of the total sampled specimens.

The taxonomic nomenclature and species identification followed: Avila-Pires (2005), Lima



**Figure 1.** Map of the areas where the herpetofaunistic inventories were made in Amazonian Brazil. Legend: White triangles – Serra da Mocidade, Roraima State; black triangles – northern Pará State (Avila-Pires *et al.*, 2010); white pentagon - Almeirim, Pará State (Ribeiro Junior *et al.*, 2008); black squares – Tumucumaque Mountains National Park (Lima, 2008); white diamond - Fazendinha Environmental Protection Area, Amapá State (Campos *et al.*, 2015); white stars – Serra do Navio region, Amapá State (this work).

(2008), Campos *et al.* (2005); Costa and Bérnils (2018); Avila-Pires *et al.* (2007); Melo-Sampaio *et al.* (2019); Vitt *et al.* (2008); Fraga *et al.* (2013); Ascenso *et al.* (2019); and Nogueira *et al.* (2019). The species conservation status was based on the IUCN (2019) classification, being divided into nine categories: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX).

## Results

We recorded 95 species for the Serra do Navio region, consisting of 57 snakes, 36 lizards, and two species of amphisbaenians (Table 2).

Among the lizards, 94% of the species are exclusively diurnal and only 6% nocturnal. Most of the registered species (67%) occur in both primary and secondary environments, while 24% were exclusively from primary forest (Table 3). Most species were

primarily cryptozoic (44%), followed by arboreal (30%) and terrestrial species (28%). Two species of amphisbaenians were exclusively fossorial. The family Gymnophthalmidae had the highest number of species ( $n=13$ ; 36.1%), *Loxopholis guianense* being the most abundant species ( $n=111$ ; 21.5%), followed by *Norops chrysolepis* (8.1%), *Chatogekko amazonicus* (8.1%), *Kentropyx calcarata* (7.3%), and *Iphisa elegans* (6.0%) (Table 3).

We registered 43% of the species of snakes as exclusively nocturnal and 38% as diurnal. Most of the registered species (61%) can occur in both primary and secondary forest environments, and 35% are species that occur exclusively in primary forest (Table 4). Species of snakes that are exclusively terrestrial and exclusively cryptozoic corresponded to 21% of the total species registered. Species that are predominantly arboreal and those that are predominantly fossorial correspond to 15 and 12%, respectively. The fossorial species accounted for approximately 5% of the total number of species

**Table 2.** List of Squamata of the Serra do Navio region, recorded in this study, and other regions of the state of Amapá, Brazil, according to Avila-Pires (2005), Lima (2008), Campos *et al.* (2015), and Costa and Bérnils (2018). The "x" followed by a "?" if a listing is uncertain.

Family / specie	Avila-Pires (2005)	Lima (2008)	Campos <i>et al.</i> (2015)	Costa and Bérnils (2018)	This study- fieldwork (n)	This study- collection data (n)
<b>Amphisbaenians</b>						
<b>Amphisbaenidae</b>						
<i>Amphisbaena alba</i> (Linnaeus, 1758)	x		x	x	1	1
<i>Amphisbaena fuliginosa</i> Linnaeus, 1758	x?	x		x	1	
<i>Amphisbaena vanzolinii</i> Gans, 1963		x		x		
<b>Lizards</b>						
<b>Dactyloidae</b>						
<i>Dactyloa punctata</i> (Daudin, 1802)	x	x		x	1	
<i>Norops auratus</i> (Daudin, 1802)	x		x	x		
<i>Norops chrysolepis</i> (Duméril and Bibron, 1837)	x	x	x	x	32	10
<i>Norops fuscoauratus</i> (D'Orbigny, 1837 in Duméril and Bibron, 1837)	x	x	x	x	7	1
<i>Norops ortonii</i> (Cope, 1868)	x		x	x	3	1
<b>Iguanidae</b>						
<i>Iguana iguana</i> (Linnaeus, 1758)	x	x	x	x	1	
<b>Gekkonidae</b>						
<i>Hemidactylus mabouia</i> (Moreau de Jonnes, 1818)	x			x		6
<b>Gymnophthalmidae</b>						
<i>Alopoglossus angulatus</i> (Linnaeus, 1758)	x		x	x	6	13
<i>Amapasaurus tetradactylus</i> Cunha, 1970	x	x		x		
<i>Arthrosaura kockii</i> (Lidth de Jeude, 1904)	x	x	x	x	14	2
<i>Arthrosaura reticulata</i> (O'Shaughnessy, 1881)	x	x		x	5	1
<i>Bachia flavescens</i> (Bonnaterre, 1789)	x	x		x	4	1
<i>Bachia</i> gr. <i>heteropa</i> (Wiegmann, 1856)		x				
<i>Bachia remota</i> Ribeiro-Júnior, da Silva and Lima, 2016				x		
<i>Cercosaura argulus</i> Peters, 1862						3
<i>Cercosaura ocellata</i> Wagler, 1830	x	x		x		1
<i>Cercosaura oshaughnessyi</i> (Boulenger, 1885)				x		
<i>Colobosaura modesta</i> (Reinhardt and Lütken, 1862)		x				
<i>Iphisa elegans</i> Gray, 1851	x	x		x	29	2
<i>Loxopholis guianense</i> (Ruibal, 1952)	x	x	x	x	47	64
<i>Loxopholis percarinatum</i> (Muller, 1923)	x		x	x		1
<i>Neusticurus bicarinatus</i> (Linnaeus, 1758)	x	x	x	x	3	4
<i>Neusticurus surinamensis</i> (Boulenger, 1900)	x	x		x	2	6
<i>Ptychoglossus brevifrontalis</i> Boulenger, 1912		x		x	1	
<i>Tretioscincus agilis</i> (Ruthven, 1916)	x	x	x	x	18	1
<i>Tretioscincus oriximinensis</i> Avila-Pires, 1995				x		
<b>Phyllodactylidae</b>						
<i>Thecadactylus rapicauda</i> (Houttuyn, 1782)	x	x	x	x	1	2
<b>Polychrotidae</b>						

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<i>Polychrus marmoratus</i> (Linnaeus, 1758)	x			x	2	
<b>Scincidae</b>						
<i>Copeoglossum nigropunctatum</i> (Spix, 1825)	x	x	x	x	11	
<i>Varzea bistrata</i> (Spix, 1825)	x			x		1
<b>Sphaerodactylidae</b>						
<i>Chatogekko amazonicus</i> (Andersson, 1918)	x	x	x	x	20	22
<i>Gonatodes annularis</i> Boulenger, 1887	x	x		x	7	4
<i>Gonatodes humeralis</i> (Guichenot, 1855)	x		x	x	2	6
<i>Lepidoblepharis heyerorum</i> Vanzolini, 1978	x	x		x	5	10
<i>Pseudogonatodes guianensis</i> Parker, 1935	x			x	4	3
<b>Teiidae</b>						
<i>Ameiva ameiva</i> (Linnaeus, 1758)	x	x	x	x	26	2
<i>Cnemidophorus cryptus</i> Cole and Dessauer, 1993	x		x	x	1	
<i>Cnemidophorus lemniscatus</i> (Linnaeus, 1758)	x?			x		13
<i>Crocodylurus amazonicus</i> (Spix, 1825)	x			x		
<i>Dracaena guianensis</i> Daudin, 1802	x			x		
<i>Kentropyx calcarata</i> Spix, 1825	x	x	x	x	23	15
<i>Kentropyx striata</i> (Daudin, 1802)	x			x		
<i>Tupinambis teguixin</i> (Linnaeus, 1758)	x	x	x	x	2	1
<b>Tropiduridae</b>						
<i>Plica plica</i> (Linnaeus, 1758)	x	x	x	x	9	12
<i>Plica umbra</i> (Linnaeus, 1758)	x	x	x	x	7	1
<i>Tropidurus hispidus</i> Spix, 1825	x?			x		
<i>Tropidurus oreadicus</i> Rodrigues 1987		x		x		
<i>Uracentron azureum</i> (Linnaeus, 1758)	x	x		x		2
<i>Uranoscodon superciliosus</i> (Linnaeus, 1758)	x	x	x	x		
<b>Snakes</b>						
<b>Aniliidae</b>						
<i>Anilius scytale</i> (Linnaeus, 1758)	x	x		x	1	2
<b>Anomalepididae</b>						
<i>Typhlophis squamosus</i> (Schlegel, 1839)	x?	x		x	3	3
<b>Boidae</b>						
<i>Boa constrictor</i> Linnaeus, 1758	x	x		x		1
<i>Corallus caninus</i> (Linnaeus, 1758)	x	x		x	1	
<i>Corallus hortulanus</i> (Linnaeus, 1758)	x	x		x	3	2
<i>Epicrates cenchria</i> (Linnaeus, 1758)	x	x		x		
<i>Epicrates maurus</i> Gray, 1849				x		
<i>Eunectes deschauenseei</i> Dunn and Conant, 1936	x					
<i>Eunectes murinus</i> (Linnaeus, 1758)	x	x				
<b>Colubridae</b>						
<i>Chironius carinatus</i> (Linnaeus, 1758)	x			x		
<i>Chironius exoletus</i> (Linnaeus, 1758)	x			x		
<i>Chironius flavolineatus</i> (Jan, 1863)		x		x		
<i>Chironius fuscus</i> (Linnaeus, 1758)	x	x		x	1	3
<i>Chironius multiventris</i> Schmidt and Walker	x			x		2
<i>Chironius scurrulus</i> (Wagler, 1824)	x			x		

<i>Dendrophidion dendrophis</i> (Schlegel, 1837)	x	x	x	1	
<i>Drymarchon corais</i> Boie, 1827	x	x	x	2	1
<i>Drymoluber dichrous</i> (Peters, 1863)	x		x	1	1
<i>Leptophis ahaetulla</i> (Linnaeus, 1758)	x		x	1	1
<i>Mastigodryas boddaerti</i> (Santzen, 1796)	x		x		1
<i>Mastigodryas bifossatus</i> (Raddi, 1820)	x?	x	x		
<i>Oxybelis aeneus</i> (Wagler, 1824)	x?		x	1	
<i>Oxybelis fulgidus</i> (Daudin, 1803)	x?		x		
<i>Phrynonax poecilonotus</i> (Günther, 1858)	x?				
<i>Phrynonax polylepis</i> (Peters, 1867)			x		
<i>Rhinobothryum lentiginosum</i> (Scopoli, 1785)	x	x	x	1	
<i>Spilotes pullatus</i> (Linnaeus, 1758)	x	x	x	1	
<i>Spilotes sulphureus</i> (Wagler, 1824)	x		x	2	1
<i>Tantilla melanocephala</i> (Linnaeus, 1758)	x?	x	x		
<b>Dipsadidae</b>					
<i>Apostolepis quinquelineata</i> Boulenger, 1896	x		x	4	
<i>Atractus aboiporu</i> Melo-Sampaio, Passos, Fouquet, Prudente and Torres-Carvajal, 2019				3	
<i>Atractus latifrons</i> (Günther, 1868)	x			7	
<i>Atractus torquatus</i> (Duméril, Bibron and Duméril, 1854)			x		
<i>Atractus trefauti</i> Melo-Sampaio, Passos, Fouquet, Prudente and Torres-Carvajal, 2019				2	1
<i>Atractus zidoki</i> Gasc and Rodrigues, 1979	x		x	4	1
<i>Cercophis auratus</i> (Schlegel, 1837)	x?				
<i>Clelia clelia</i> (Daudin, 1803)		x	x	1	
<i>Dipsas catesbyi</i> (Santzen, 1796)	x?	x	x		1
<i>Dipsas indica</i> Laurenti, 1768	x?	x	x	1	
<i>Dipsas pavonina</i> Schlegel, 1837	x?				
<i>Dipsas variegata</i> (Duméril, Bibron and Duméril, 1854)	x?	x	x		
<i>Drepanoides anomalus</i> (Jan, 1863)	x?			1	1
<i>Erythrolamprus aesculapii</i> (Linnaeus, 1766)	x	x	x	2	
<i>Erythrolamprus breviceps</i> (Cope, 1860)	x			1	
<i>Erythrolamprus cobella</i> (Linnaeus, 1766)	x		x		
<i>Erythrolamprus miliaris</i> (Linnaeus, 1758)	x		x		2
<i>Erythrolamprus poecilogyrus</i> (Wied, 1824)	x		x		1
<i>Erythrolamprus reginae</i> (Linnaeus, 1758)	x	x	x	2	
<i>Erythrolamprus rochai</i> Ascenso, Costa and Prudente, 2019				2	
<i>Erythrolamprus taeniogaster</i> (Jan, 1863)			x		
<i>Erythrolamprus typhlus</i> (Linnaeus, 1758)	x	x	x	1	
<i>Helicops angulatus</i> (Linnaeus, 1758)	x	x	x	1	
<i>Helicops hagmanni</i> Roux, 1910			x		
<i>Helicops leopardinus</i> (Schlegel, 1837)	x		x		
<i>Helicops polylepis</i> Günther, 1861			x		
<i>Helicops trivittatus</i> (Gray, 1849)			x		

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<i>Hydrodynastes bicinctus</i> (Herrmann, 1804)	x?		x		
<i>Hydrodynastes gigas</i> (Duméril, Bibron and Duméril, 1854)	x?	x	x		1
<i>Hydrops triangulares</i> (Wagler, 1824)	x?	x			
<i>Imantodes cenchoa</i> (Linnaeus, 1758)	x	x	x	1	
<i>Imantodes lentiferus</i> (Cope, 1894)			x		
<i>Leptodeira annulata</i> (Linnaeus, 1758)	x	x	x		1
<i>Ligophis lineatus</i> (Linnaeus, 1758)	x		x		
<i>Oxyrhopus formosus</i> (Wied, 1820)	x?				
<i>Oxyrhopus melanogenys</i> (Tschudi, 1845)		x	x		1
<i>Oxyrhopus occipitalis</i> (Wied-Neuwied, 1824)			x		
<i>Oxyrhopus petolarius</i> (Linnaeus, 1758)	x	x	x	1	
<i>Oxyrhopus trigeminus</i> (Duméril and Bibron, 1854)	x		x		
<i>Philodryas argentea</i> (Daudin, 1803)	x	x	x	1	1
<i>Philodryas viridissima</i> (Linnaeus, 1758)	x	x	x	2	2
<i>Philodryas olfersii</i> (Lichtenstein, 1823)	x		x		
<i>Pseudoboa coronata</i> Schneider, 1801	x			1	
<i>Pseudoboa neuwiedii</i> (Duméril, Bibron and Duméril, 1854)	x	x	x	1	
<i>Pseudoeryx plicatilis</i> (Linnaeus, 1758)	x	x	x		
<i>Sibon nebulatus</i> (Linnaeus, 1758)	x?		x		
<i>Siphlophis cervinus</i> (Laurenti, 1768)			x		
<i>Siphlophis compressus</i> (Daudin, 1803)	x?	x	x	2	
<i>Taeniophallus brevirostris</i> (Peters, 1863)	x	x	x	4	
<i>Taeniophallus nicagus</i> (Cope, 1895)	x		x	1	
<i>Thamnodynastes lanei</i> Bailey, Thomas and Silva Jr., 2005			x		1
<i>Thamnodynastes pallidus</i> (Linnaeus, 1758)			x		
<i>Xenodon rabdocephalus</i> (Wied, 1824)	x	x	x	1	3
<i>Xenodon severus</i> (Linnaeus, 1758)	x?		x	1	
<i>Xenodon werneri</i> (Eiselt, 1963)		x	x		
<i>Xenopholis scalaris</i> (Wucherer, 1861)	x			1	
<i>Xenopholis undulatus</i> (Jensen, 1900)			x		
<b>Elapidae</b>					
<i>Leptomicrurus collaris</i> (Schlegel, 1837)			x		
<i>Micrurus diutius</i> (Burger, 1955)			x		
<i>Micrurus filiformis</i> (Günther, 1859)			x		
<i>Micrurus hemprichii</i> (Jan, 1858)	x?		x		
<i>Micrurus lemniscatus</i> (Linnaeus, 1758)	x		x	3	3
<i>Micrurus psyches</i> (Daudin, 1803)	x?		x		
<i>Micrurus surinamensis</i> (Cuvier, 1817)	x	x	x		1
<b>Leptotyphlopidae</b>					
<i>Epictia albifrons</i> (Wagler, 1824)	x			1	
<i>Epictia tenella</i> Klauber, 1939		x	x		
<i>Siagonodon cupinensis</i> (Bailey and Carvalho, 1946)	x				



<i>Siagonodon septemstriatus</i> (Schneider, 1801)	x?					1
<i>Trilepida dimidiata</i> (Jan, 1861)						
<i>Trilepida macrolepis</i> (Peters, 1857)	x?					
<b>Typhlopidae</b>						
<i>Amerotyphlops brongersmianus</i> (Vanzolini, 1976)	x?					
<i>Amerotyphlops reticulatus</i> (Linnaeus, 1758)	x			x		2
<b>Viperidae</b>						
<i>Bothrops atrox</i> (Linnaeus, 1758)	x	x		x		2 2
<i>Bothrops bilineatus</i> (Wied, 1821)	x	x		x		1
<i>Bothrops brazili</i> Hoge, 1954	x	x		x		5
<i>Bothrops taeniatus</i> Wagler, 1824	x					1
<i>Crotalus durissus</i> Linnaeus, 1758	x			x		
<i>Lachesis muta</i> (Linnaeus 1766)	x	x		x		

recorded. Dipsadidae was the family with the highest number of species (35 species; 61.4% of total). *Atractus latifrons* was the most abundant species (n= 7; 5.38%), followed by *Typhlops squamosus* and *Micrurus lemniscatus* (each with 4.61%), and

*Atractus zidoki* (3.85%) (Table 4).

Using the method of Pitfall Traps with Drift Fences, ten lizards (*Alopoglossus angulatus*, *Arthrosaura kockii*, *Bachia flavescens*, *Iphisa elegans*, *Kentropyx calcarata*, *Lepidoblepharis heyerorum*, *Plica*

**Table 3.** Data on activity, habitat and microhabitat of lizards recorded in the Serra do Navio region (in alphabetical order). Legend: D= Diurnal, N= Nocturnal, FP= Primary Forest, FS= Secondary Forest, Tr= Terrestrial, Cz= Cryptozoic, Aq= Aquatic, Fss= Fossorial, Arb= Arboreal. Conservation Status (IUCN, 2019): LC= Least Concern; References: 1= Hoogmoed (1973), 2= Gasc *et al.* (1983), 3= Cunha *et al.* (1985), 4= Dixon and Soini (1986), 5= Hoogmoed and Avila-Pires (1989), 6= Martins (1991), 7= Avila-Pires (1995), 8= Vitt *et al.* (2008), 9= Magnusson and Lima (1984), 10= Dixon and Soini (1975), 11= Hoogmoed and Avila-Pires (1991), 12= Avila-Pires *et al.* (2010).

Species	Activity		Habitat			Microhabitat				Conservation Status (IUCN, 2019)	References
	D	N	FP	FS	Tr	Cz	Aq	Fss	Arb		
<i>Amphisbaena alba</i>			x	x				x		LC	1, 4
<i>Amphisbaena fuliginosa</i>			x	x				x		LC	4
<i>Alopoglossus angulatus</i>	x	x	x	x		x				LC	5, 6, 7, 11
<i>Ameiva ameiva</i>	x		x	x	x					LC	3, 4, 5, 7, 11
<i>Arthrosaura kockii</i>	x		x			x				LC	7, 11
<i>Arthrosaura reticulata</i>	x	x	x	x		x				LC	1, 4, 5, 6, 7
<i>Bachia flavescens</i>	x	x	x	x		x				LC	1, 6, 7
<i>Cercosaura argulus</i>	x		x	x	x					LC	4, 5, 7
<i>Cercosaura ocellata</i>	x		x	x	x					LC	3,7,14
<i>Chatogekko amazonicus</i>	x		x			x				LC	7, 10, 11
<i>Cnemidophorus cryptus</i>	x			x	x						7
<i>Cnemidophorus lemniscatus</i>	x			x	x					LC	3, 7
<i>Copeoglossum nigropunctatum</i>	x		x	x		x				LC	7, 11
<i>Dactyloa punctata</i>	x		x	x					x		
<i>Gonatodes annularis</i>	x	x	x			x					1, 5, 7, 11
<i>Gonatodes humeralis</i>	x		x	x		x				LC	5, 7, 8, 11
<i>Hemidactylus mabouia</i>		x		x	x						7
<i>Iguana iguana</i>	x		x	x	x				x	LC	7, 8
<i>Iphisa elegans</i>	x		x			x				LC	7, 10, 11
<i>Kentropyx calcarata</i>	x		x	x	x					LC	1, 5, 6, 7, 9, 11

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<i>Lepidoblepharis heyerorum</i>	x	x	x	x						LC	5, 7, 11
<i>Loxopholis guianense</i>	x		x	x						LC	1, 2, 5, 7
<i>Loxopholis percarinatum</i>	x		x							LC	1, 7
<i>Neusticurus bicarinatus</i>	x		x	x	x			x		LC	1, 3, 6, 7
<i>Neusticurus surinamensis</i>	x		x						x		7, 11, 12
<i>Norops chrysolepis</i>	x		x	x					x		1, 4, 6, 7
<i>Norops fuscoauratus</i>	x		x	x					x		4, 7
<i>Norops ortonii</i>	x			x					x		4, 7
<i>Plica plica</i>	x		x						x		4, 7
<i>Plica umbra</i>	x		x						x	LC	4, 7
<i>Polychrus marmoratus</i>	x		x	x					x	LC	1, 4, 7
<i>Pseudogonatodes guianensis</i>	x		x		x					LC	7
<i>Ptychoglossus brevifrontalis</i>	x		x	x					x	LC	4, 7
<i>Thecadactylus rapicauda</i>		x	x	x					x	LC	7, 11
<i>Tretioscincus agilis</i>	x		x	x					x	LC	7, 12
<i>Tupinambis teguixin</i>	x		x	x	x					LC	4, 7
<i>Uracentron azureum</i>	x		x	x					x	LC	7
<i>Varzea bistrata</i>	x		x	x					x	LC	7, 11

**Table 4.** Data on activity, habitat and microhabitat of snakes recorded in the Serra do Navio region (in alphabetical order). Legend: D= Diurnal, N= Nocturnal, FP= Primary Forest, FS= Secondary Forest, Tr= Terrestrial, Cz= Cryptozoic, Aq= Aquatic, Fss= Fossorial, Arb= Arboreal. Conservation Status (IUCN, 2019): LC= Least Concern; References: 1= Cunha and Nascimento (1978), 2= Cunha *et al.* (1985), 3= Dixon and Soini (1986), 4= Hoogmoed and Avila-Pires (1991), 5= Cunha and Nascimento (1993), 6= Martins and Oliveira (1999), 7= Maschio (2008), 8= Avila-Pires *et al.* (2010), 9= Santos-Costa *et al.* (2015), 10= Maciel *et al.* (2003), 11= Bailey *et al.* (2005), 12= Fraga *et al.* (2013), 13= Ascenso *et al.* (2019); 14= Melo-Sampaio *et al.* (2019).

Species	Activity		Habitat		Microhabitat					Conservation Status (IUCN, 2019)	References
	D	N	FP	FS	Tr	Cz	Aq	Fss	Arb		
<i>Amerotyphlops reticulatus</i>			x	x				x		LC	1, 3, 19
<i>Apostolepis quinquilineata</i>			x					x			2, 8
<i>Anilius scytale</i>	x	x	x	x			x	x		LC	1, 2, 3, 9
<i>Atractus aboiporu</i>		x				x					14
<i>Atractus latifrons</i>		x	x	x		x				LC	3, 7, 12
<i>Atractus zidoki</i>		x	x	x				x		LC	5, 22
<i>Atractus trefauti</i>		x	x					x			3
<i>Boa constrictor</i>		x	x	x	x				x		1, 6
<i>Bothrops atrox</i>		x	x	x		x					1, 4, 6, 14
<i>Bothrops bilineatus</i>		x	x	x					x		1, 2
<i>Bothrops brazili</i>		x	x			x					1, 2, 3
<i>Bothrops taeniatus</i>		x	x						x	LC	14
<i>Chironius fuscus</i>	x		x	x	x					LC	3, 5, 6, 7
<i>Chironius multiventris</i>	x		x	x		x				LC	5, 6, 7
<i>Clelia clelia</i>		x	x	x	x					LC	1, 5, 6, 7
<i>Corallus caninus</i>		x	x						x	LC	1, 3, 6, 7
<i>Corallus hortulanus</i>		x	x	x					x	LC	1, 6, 7
<i>Dendrophidion dendrophis</i>	x		x	x	x					LC	1, 3, 6
<i>Dipsas catesbyi</i>		x	x	x	x				x	LC	1, 8, 12
<i>Dipsas indica</i>		x	x	x					x	LC	1, 3, 6

<i>Drepanoides anomalus</i>		x	x		x		LC	3, 6, 7	
<i>Drymarchon corais</i>	x		x	x		x	LC	1, 2, 5, 7	
<i>Drymoluber dichrous</i>	x		x	x		x	LC	1,3, 6, 7	
<i>Epictia albifrons</i>		x	x				x	LC	17
<i>Erythrolamprus aesculapii</i>	x		x	x	x		LC	1, 2, 3, 6	
<i>Erythrolamprus breviceps</i>	x		x	x	x	x	LC	3, 6,12	
<i>Erythrolamprus miliaris</i>	x		x	x	x		LC	3	
<i>Erythrolamprus poecilogyrus</i>	x			x	x			10	
<i>Erythrolamprus reginae</i>	x		x	x	x	x	LC	3, 6, 7, 12	
<i>Erythrolamprus rochai</i>								13	
<i>Erythrolamprus typhlus</i>	x		x	x	x	x	LC	1, 5, 12	
<i>Helicops angulatus</i>		x	x			x	LC	1, 2, 3, 5, 6	
<i>Hydrodynastes gigas</i>	x		x	x		x		15	
<i>Imantodes cenchoa</i>		x	x	x			x	LC	1, 5, 12
<i>Leptodeira annulata</i>		x	x	x			x	LC	2,6, 7, 19
<i>Leptophis ahaetulla</i>	x		x	x			x	LC	1, 6
<i>Mastigodryas boddaerti</i>	x		x	x	x		LC	1, 2, 5, 6, 7	
<i>Micrurus lemniscatus</i>		x	x			x	LC	6, 7	
<i>Micrurus surinamensis</i>	x	x	x			x	LC	1, 5, 6	
<i>Oxybelis aeneus</i>	x		x	x			x	LC	2, 3, 6
<i>Oxyrhopus melanogenys</i>		x	x			x	LC	3, 6	
<i>Oxyrhopus petolaris</i>		x	x		x		LC	1, 2, 3, 5	
<i>Philodryas argentea</i>	x		x	x			x	LC	1, 3, 4, 6
<i>Philodryas viridissima</i>	x		x	x	x		x	LC	1, 3, 6,
<i>Pseudoboa coronata</i>	x	x	x	x	x		LC	1, 3, 6	
<i>Pseudoboa neuwiedi</i>	x	x	x		x		x	LC	8, 12
<i>Rhinobothryum lentiginosum</i>	x	x	x	x	x		x		1, 2, 5, 6
<i>Siagonodon septemstriatus</i>			x	x			x	LC	1, 5
<i>Siphlophis compressus</i>		x	x		x		x	LC	8, 12
<i>Spilotes pullatus</i>	x		x	x	x		LC	1, 5, 12	
<i>Spilotes sulphureus</i>	x		x	x		x	x	LC	5, 6, 7,
<i>Taeniophallus brevirostris</i>	x		x			x	LC	1, 3, 6	
<i>Taeniophallus nicagus</i>	x		x			x	LC	6	
<i>Thamnodynastes lanei</i>		x	x		x	x			11
<i>Typhlophis squamosus</i>			x	x			x	LC	1, 6
<i>Xenodon rabdocephalus</i>		x	x	x	x		LC	1, 3, 5, 6	
<i>Xenodon severus</i>	x		x		x		LC	1, 3	
<i>Xenopholis scalaris</i>	x	x	x		x		LC	1, 2, 3, 6	

*plica*, *Pseudogonatodes guianensis*, *Thecadactylus rapicauda*, and *Tretioscincus agilis*) and seven snakes were collected (*Amerotyphlops reticulatus*, *Atractus trefauti*, *Atractus zidoki*, *Dendrophidion dendrophis*, *Erythrolamprus aesculapii*, *E. reginae*, and *Typhlops squamosus*). We recorded four species of lizards (*Gonatodes annularis*, *Neusticurus bicarinatus*, *Norops chrysolepis*, and *Norops ortonii*) and eight of

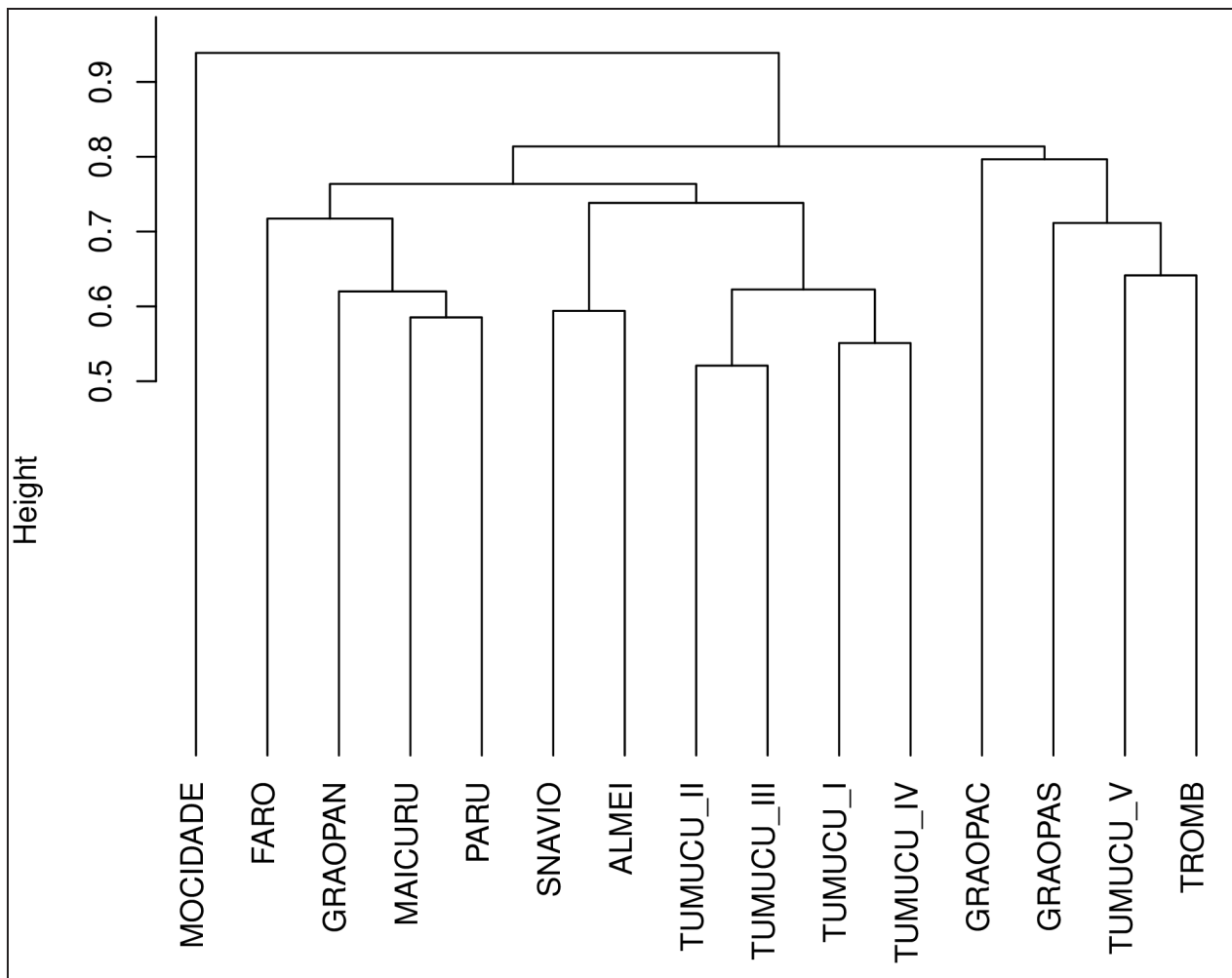
snakes (*Corallus hortulanus*, *Dipsas indica*, *Oxybelis aeneus*, *Philodryas viridissima*, *Philodryas argentea*, *Pseudoboa coronata*, *Rhinobothryum lentiginosum*, and *Xenopholis scalaris*) using the method of Time Constrained Search. We recorded seven species of lizards (*Ameiva ameiva*, *Arthrosaura reticulata*, *Chaetogekko amazonicus*, *Gonatodes humeralis*, *Leposoma guianense*, *Norops fuscoauratus*, and *Plica umbra*),

and one of snake using both methods (*Drepanoides anomalus*).

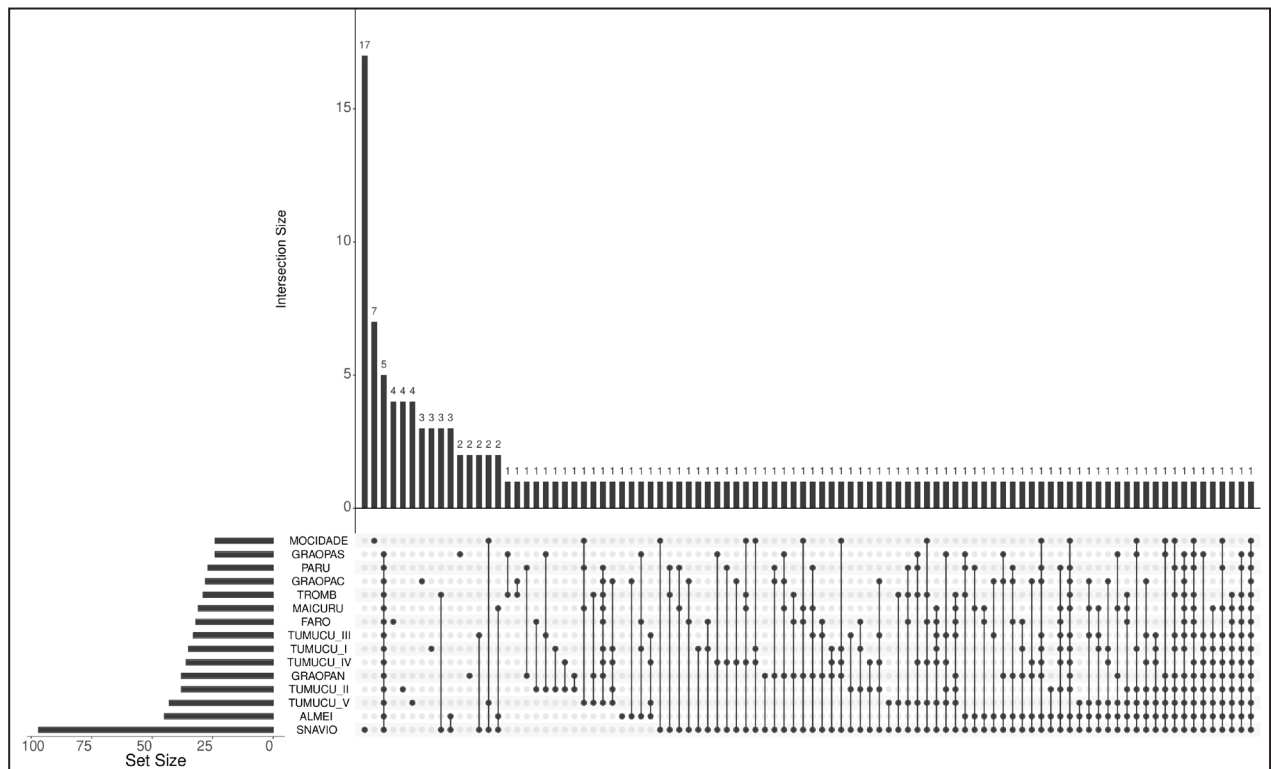
Among the 15 sites we compared, Serra do Navio is the region with the largest number of snakes and lizard species (n= 95) and the largest number of exclusive species (17 species, four lizards - *Amphisbaena alba*, *Cnemidophorus lemniscatus*, *Hemidactylus mabouia*, *Varzea bistrata*; and 13 snakes - *Atractus trefauti*, *Atractus latifrons*, *Atractus aboiporu*, *Atractus zidoki*, *Drepanoides anomalus*, *Erythrolamprus breviceps*, *Erythrolamprus miliaris*, *Erythrolamprus poecilogyrus*, *Erythrolamprus rochai*, *Oxybelis aeneus*, *Siagonodon septemstriatus*, *Thamnodynastes lanei*, and *Xenodon severus*) (Fig. 2). Serra do Navio shares 16 species with Serra da Mocidade and 41 species with Almeirim (Fig. 2).

*Ameiva ameiva* was the only species that occurs

in all localities and five other species occurred at all sites (*Bachia flavescens*, *Chatogecko amazonicus*, *Kentropyx calacarata*, *Loxopholis guianense*, *Siagonodon septemstriatus*, and *Plica umbra*) except Serra da Mocidade. Comparing with the other sites analyzed, Serra da Mocidade has seven exclusive species (*Atractus riveroi*, *Chironius septentrionalis*, *Dipsas pavonina*, *Drymobius rhombifer*, *Micrurus remotus*, *Norops planiceps*, and *Tretioscincus oriximinensis*) among 24 species known for the region (Moraes *et al.*, 2017). In fact, the dissimilarity analysis using Jaccard index showed Serra da Mocidade as the most exclusive site, while Serra do Navio is close to Almeirim (Fig. 3). Most sites in northern Pará constitute a clade with four sites in Tumucumaque, while the northernmost area of Tumucumaque, Trombetas, and Grão Pará another clade (Fig. 3).



**Figure 2.** Cluster dendrogram based on dissimilarity matrix by Jaccard index. Localities are as follow: MOCIDADE - Serra da Mocidade, Roraima State; GRAOPAC - Central Grão-Pará Ecological Station; GRAOPAS - South Grão-Pará Ecological Station; GRAOPAN - North Grão-Pará Ecological Station; ALMEI - Almeirim; SNAVIO - Serra do Navio; TUMUCU\_I - TUMUCU\_V - Tumucumaque Mountain National Park sites; MAICURU - Maicuru Biological Reserve; PARU - Paru State Forest; FARO - Faro State Forest; TROMB - Trombetas State Forest.



**Figure 3.** Number of species (number above bars) and species sharing and exclusivity by site analyzed (balls indicate the presence of species at the site). Localities are as follow: MOCIDADE - Serra da Mocidade, Roraima State; GRAOPAC – Central Grão-Pará Ecological Station; GRAOPAS – South Grão-Pará Ecological Station; GRAOPAN - North Grão-Pará Ecological Station; ALMEI – Almeirim; SNAVIO – Serra do Navio; TUMUCU\_I – TUMUCU\_V – Tumucumaque Mountain National Park sites; MAICURU – Maicuru Biological Reserve; PARU – Paru State Forest; FARO – Faro State Forest; TROMB – Trombetas State Forest.

## Discussion

The total of 95 species record for the Serra do Navio region represents a significant part of Squamata diversity known for the state of Amapá, which total 160 species by considering the data from Avila-Pires (2005), Lima (2008), Campos *et al.* (2015) and Costa and Bérnils (2018). Among 17 exclusive species of Serra do Navio, three species (*Atractus aboiporu*, *A. trefauti*, and *Erythrolamprus rochai*) were recently described from the collections performed in this study, clearly indicating the importance of further herpetological inventories and studies of communities in the Amazon (Ascenso *et al.*, 2019; Melo-Sampaio *et al.*, 2019).

Some species of lizards and snakes commonly known in Amapá were not recorded in this study, such as *Amphisbaena vanzolini*, *Amapasaurus tetradactylus*, *Chironius flovolineatus*, *Colobosaura modesta*, *Epicrates cenchria*, *Eunectes murinus*, *Lachesis muta*, *Mastigodryas bifossatus*, *Norops auratus*, and *Uranoscodon superciliosus* (Lima, 2008; Campos *et al.*, 2015). Probably, this result owes to the insufficient sampling effort and the collection methods

used. Another aspect that may have influenced this result is related to habit and species abundance. Efficiency in the registration of fossil and aquatic species requires a specific collection methodology, as well as the registration of rare and difficult to detect species. For lizards, the most efficient sampling method was the Pitfall Traps with Drift Fences, responsible for registering mainly cryptic species, such *Alopoglossus angulatus*, *Arthrosaura kockii*, *Bachia flavescens* and *Iphisa elegans*, which were hardly registered by other techniques, illustrating the importance of passive sampling in the study of leaf litter or fossorial/semifossorial species (Ribeiro Junior *et al.*, 2008). For snakes the Time Constrained Search was the methodology registered more species, eight in total, against seven registered by Pitfall Traps with Drift Fences, however, with regard to richness estimates, this method is considered limited because there is a tendency for the observer to find more conspicuous and / or larger species (Hartmann *et al.*, 2009). According to the parameters of abundance of Maschio (2008), the species present in this work reached an intermediate level of abundance, less than 5%, except *Leposoma guianense*, which was dominant (22%).

The Serra do Navio community consists mainly of diurnal lizards and nocturnal snakes, with terrestrial and cryptozoic habits, present in pristine and altered environments. This pattern is observed in several studies developed in the Amazon (Silva *et al.*, 2011; Santos-Costa *et al.*, 2015).

Despite the primarily diurnal habit of lizards, some species, such as *Alopoglossus angulatus*, *Arthrosaura reticulata*, *Bachia flavescens*, *Gonatodes annularis*, and *Lepidoblepharis heyerorum* may exhibit nocturnal behavior (Avila-Pires, 1995). Hoogmoed and Avila-Pires (1989) observed that the large number of small diurnally active lizards at night in the Serra do Navio region was related to daytime unfavorable daytime microclimate conditions. On the other hand, according to the authors, moonlight was insufficient to activate daytime lizards. The same patterns was observed for snakes, where some nocturnal species can be active during day, such as *Bothrops atrox*.

In forest environments it is common to note that some species of snakes may use different substrates, such as *Philodryas viridissima*, which is mainly arboreal but may eventually forage on the forest floor (Dixon and Soini, 1986; Martins and Oliveira, 1999). This behavior allows it to capture more prey in different microhabitats, as well as providing opportunities for rest, such as when individuals sleep on the foliage or in an area at least 30 cm above the ground to avoid attacks by terrestrial predators such as snakes, ants and spiders (Martins, 1993; Santos-Costa *et al.*, 2015). The foraging substrate may also vary among the lizards, for example *Neusticurus bicarinatus*, a semi-aquatic species, and *Tretioscincus agilis*, an arboreal species, may forage on the forest floor (Cunha *et al.*, 1985; Avila-Pires, 1995).

Dissimilarity analysis showed a general pattern of clustering by spatial proximity, and a most singular fauna at Serra da Mocidade, which must be attributed to the altitudinal distinctiveness (mean 996m), reaching at least twice the altitude of the other sites (0-500m). Fortunately, sampling methods and effort were similar at the sites we compared, with all the studies using pitfall traps and active search, and lasting 7–14 days. We also checked for taxonomic consistence among the studies. While Moraes *et al.* (2017) found a mixed compositional influence at Serra da Mocidade including assemblages typical of other mountain ranges and lowland forest habitats in the region, at the other sites reported here most of the taxa were widely distributed in Amazonia or,

at least, north of Amazonas River.

Compared to the herpetofauna from other 14 north Brazilian Amazon sites, Serra do Navio had a most similar species composition to the Tumucumaque Mountains and northern Pará sites, geographically closer regions.

Regarding the conservation status of the 95 species registered for the Serra do Navio region, 75 are listed as "Least Concern" according to IUCN (2019), and for the remaining of the species there are no results (Tables 3 and 4). For the lizard *Copeoglossum nigropunctatum* there is a tendency for the population decrease, according to IUCN (2019), due to the populations being severely fragmented. *Amapasaurus tetradactylus*, described based on two specimens from the upper Maracá basin, Amapá, Brazil, remained known for more than 30 years based only on these two specimens (Avila-Pires *et al.*, 2013). Although classified with "Least Concern" status in IUCN (2019) *A. tetradactylus* is considered rare and currently only 37 specimens collected in eight localities are known, five of them in the state of Amapá (Avila-Pires *et al.*, 2013).

The fact that only four collections expeditions resulted in the description of three new species of snakes indicates an urgent need for further herpetological inventories in this region, highlighting the importance of community studies in the Amazon in general. Mainly when considering the increase in deforestation in the region, promoted by mining activity. On the occasion of the collections expeditions in Pedra Branca do Amapari, two of the seven sampled areas were affected by artisanal-scale mining (garimpo), a process that causes extensive environmental degradation, soil pollution and watercourses polluted by mercury, which can lead to the accumulation of this metal in food chains (Jernelov and Lann, 1971; Veiga and Hinton, 2002; Asner *et al.*, 2013; Teixeira *et al.*, 2018).

Furthermore, a recent study indicates that small-scale mining represents 64% of the total mining area in the Brazilian Amazon, a fact of concern due to socio-environmental impacts for Amazonian ecosystems and for local communities, since it does not follow environmental protocols for the recover degraded areas (Lobo *et al.*, 2018). Currently, all seven areas inventoried at that time are located in an industrial-mineral complex, in operation since 2007, with an expected useful life of 20 years. If artisanal-scale mining activity already causes significant impacts, those caused by industrial-scale activity are

even more extensive, although not only restricted to the mine area, they may include impacts related to the establishment of mining infrastructure, opening of new roads and urban expansion to support a growing workforce (Sonter *et al.*, 2017).

The state of Amapá presents great importance in a conservationist scenario, as it is inserted in the largest area of endemism in the Amazon, Guianan area of endemism. The association of primary and secondary data contributed to obtain a more representative list of Squamata species that occur in the state. However, studies covering other regions can assist in the recognition of species not yet reported for Amapá, as well as new taxa.

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## Appendix

### Material analyzed

**Lizards and amphisbaenians-** *Alopoglossus angulatus*- Pedra Branca do Amapari: MPEG 19585, MPEG 19595, MPEG 19597-8, MPEG 19608, MPEG 19611, MPEG 19613; Serra do Navio: MPEG 15033, MPEG 15095, MPEG 15150-5, MPEG 15182-5. *Ameiva ameiva*- Pedra Branca do Amapari: MPEG 19174, MPEG 19607, MPEG 19610, MPEG 19614, MPEG 19697-18; Serra do Navio: MPEG 2472, MPEG 15110. *Amphisbaena alba* - Pedra Branca do Amapari: MPEG 19217; Serra do Navio: MPEG 1189. *Amphisbaena fuliginosa* - Pedra Branca do Amapari: MPEG 19591. *Arthrosaura kockii*- Pedra Branca do Amapari: MPEG 19056, MPEG 19060, MPEG 19182, MPEG 19185, MPEG 19201-2, MPEG 19664-71; Serra do Navio: MPEG 12170-1. *Arthrosaura reticulata*- Pedra Branca do Amapari: MPEG 19181, MPEG 19210, MPEG 19586, MPEG 19594, MPEG 19596; Serra do Navio: MPEG 15059. *Bachia flavescens*- Pedra Branca do Amapari: MPEG 19672-5; Serra do Navio: MPEG 1878. *Cercosaura argulus*- Serra do Navio: MPEG 15149, MPEG 15186-7. *Cercosaura ocellata*- Serra do Navio: MPEG 15115. *Chatogekko amazonicus*- Pedra Branca do Amapari: MPEG 19057, MPEG 19059, MPEG 19196, MPEG 19198, MPEG 19602, MPEG 19639-53, MPEG 21820; Serra do Navio: MPEG 12168, MPEG 15018-9, MPEG 15028-9, MPEG 15063-6, MPEG 15093, MPEG 15101-2, MPEG 15131-2, MPEG 15137, MPEG 15191-5, MPEG 15204. *Cnemidophorus cryptus*- Serra do Navio: IEPA 1908. *Cnemidophorus lemniscatus*- Serra do Navio: MPEG 15017, MPEG 15037, MPEG 15075-8, MPEG 15090-1, MPEG 15096, MPEG 15112, MPEG 15116, MPEG 15190, MPEG 15205. *Copeoglossum nigropunctatum*- Pedra Branca do Amapari: MPEG 19186, MPEG 19609, MPEG 19636-7, MPEG 19814-20. *Dactyloa punctata*- Serra do Navio: IEPA1907. *Gonatodes annularis*- Pedra Branca do Amapari: MPEG 19213, MPEG 19592, MPEG 19627-31; Serra do Navio: MPEG 15080, MPEG 15087, MPEG 15100, MPEG 15148. *Gonatodes humeralis*- Pedra Branca do Amapari: MPEG 19061, MPEG 19063; Serra do Navio: MPEG 15030, MPEG 15126, MPEG 15177, MPEG 16175-7. *Hemidactylus mabouia*- Serra do Navio: MPEG 15022-7. *Iphisa elegans*- Pedra Branca do Amapari: MPEG 19200, MPEG 19207, MPEG 19600, MPEG 19772-97; Serra do Navio: MPEG 15081, MPEG 15188. *Kentropyx calcarata*- Pedra Branca do Amapari: MPEG 19184, MPEG 19195, MPEG 19197, MPEG 19199, MPEG 19589, MPEG 19599, MPEG 19757, MPEG 19798-13; Serra do Navio: MPEG 15015-6, MPEG 15039, MPEG 15073, MPEG 15082, MPEG 15097, MPEG

15111, MPEG 15123-4, MPEG 15129, MPEG 15138, MPEG 15173-4, MPEG 15180-1. *Lepidoblepharis heyerorum*- Pedra Branca do Amapari: MPEG 19623-6, MPEG 19638; Serra do Navio: MPEG 15040, MPEG 15051, MPEG 15061-2, MPEG 15079, MPEG 15134-6, MPEG 15146, MPEG 15178. *Loxopholis guianense*- Pedra Branca do Amapari: MPEG 19203-4, MPEG 19208, MPEG 19211, MPEG 19581, MPEG 19603, MPEG 19605, MPEG 19616-7, MPEG 19719-56; Serra do Navio: MPEG 1919, MPEG 1992, MPEG 12169, MPEG 12172, MPEG 15034-5, MPEG 15042-7, MPEG 15054-8, MPEG 15067-71, MPEG 15083-6, MPEG 15088-9, MPEG 15094, MPEG 15103-7, MPEG 15121-2, MPEG 15130, MPEG 15139, MPEG 15141-3, MPEG 15156-72, MPEG 15196-8, MPEG 15201-3. *Loxopholis percarinatum*- Serra do Navio: MPEG 15140. *Neusticurus bicarinatus*- Pedra Branca do Amapari: MPEG 19175, MPEG 19179-80; Serra do Navio: MPEG 15031, MPEG 15038, MPEG 15048, MPEG 15176. *Neusticurus surinamensis*- Pedra Branca do Amapari: MPEG 19058, MPEG 19618; Serra do Navio: IEPA1906, MPEG 15032, MPEG 15049, MPEG 15072, MPEG 15074, MPEG 15098, MPEG 15109. *Norops chrysolepis*- Pedra Branca do Amapari: MPEG 19178, MPEG 19183, MPEG 19205, MPEG 19212, MPEG 19215-6, MPEG 19593, MPEG 19601, MPEG 19612, MPEG 19662, MPEG 19676-96; Serra do Navio: MPEG 1700-1, MPEG 15041, MPEG 15052-3, MPEG 15119-20, MPEG 15133, MPEG 15199-200, MPEG 19173. *Norops fuscoauratus*- Pedra Branca do Amapari: MPEG 19062, MPEG 19587, MPEG 19654-6, MPEG 19659, MPEG 19661; Serra do Navio: MPEG 15036. *Norops ortonii*- Pedra Branca do Amapari: MPEG 19657-8, MPEG 19660, MPEG 19663. *Plica plica*- Pedra Branca do Amapari: MPEG 1828, MPEG 19189-91, MPEG 19209, MPEG 19590, MPEG 19619-22; Serra do Navio: MPEG 2471, MPEG 15014, MPEG 15020-1, MPEG 15092, MPEG 15118, MPEG 15125, MPEG 15144-5, MPEG 15175, MPEG 15189. *Plica umbra*- Serra do Navio: MPEG 2470, MPEG 15050, MPEG 19176-7, MPEG 19192-4, MPEG 19206. *Polychrus marmoratus*- Pedra Branca do Amapari: MPEG 19583-4. *Pseudogonatodes guianensis*- Pedra Branca do Amapari: MPEG 19606, MPEG 19632-4; Serra do Navio: MPEG 15060, MPEG 15147, MPEG 15179. *Ptychoglossus brevifrontalis*- Pedra Branca do Amapari: MPEG 19615. *Thecadactylus rapicauda*- Pedra Branca do Amapari: MPEG 19635; Serra do Navio: MPEG 1851, MPEG 15099. *Tretioscincus agilis*- Pedra Branca do Amapari: MPEG 19187-8, 19214, MPEG 19604, MPEG 19758-71; Serra do Navio: MPEG 12173. *Tupinambis teguixin*- Pedra Branca do Amapari: MPEG 19582, MPEG 31197; Serra do Navio: MPEG 2473. *Uracentron azureum*- Serra do Navio: MPEG 1784, MPEG 6467. *Varzea bistriata*- Serra do Navio: MPEG 15128.

**Snakes-** *Amerotyphlops reticulatus*- Pedra Branca do Amapari: MPEG 19782, MPEG 22849. *Anilius scytale*- Pedra Branca do Amapari: MPEG 19686; Serra do Navio: MPEG 26349-50. *Apostolepis quinquilineata*- Pedra Branca do Amapari: MPEG 22842-3, MPEG 19822, MPEG 19824. *Atractus aboiporu*- Pedra Branca do Amapari: MPEG 19783, MPEG 25796-7. *Atractus latifrons*- Pedra Branca do Amapari: MPEG 19781, MPEG 25790-5. *Atractus trefauti*- Pedra Branca do Amapari: MPEG 25788, MPEG 26584; Serra do Navio: MPEG 16382. *Atractus zidoki*- Pedra Branca do Amapari: MPEG 23225-8; Serra do Navio: MPEG 16437. *Boa constrictor*- Serra do Navio: MPEG 18349. *Bothrops atrox*- Pedra Branca do Amapari: MPEG 19793, MPEG 26581; Serra do Navio: MPEG 26564-5.

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*Bothrops bilineatus*- Pedra Branca do Amapari: MPEG 22850. *Bothrops brazili*- Pedra Branca do Amapari: MPEG 19688–90, MPEG 19697, MPEG 19790. *Bothrops taeniatus*- Pedra Branca do Amapari: MPEG 19680. *Chironius fuscus*- Pedra Branca do Amapari: MPEG 25757; Serra do Navio: MPEG 180, MPEG 26593–4. *Chironius multiventris*- Serra do Navio: MPEG 330, MPEG 18351. *Clelia clelia*- Pedra Branca do Amapari: MPEG 25758. *Corallus caninus*- Pedra Branca do Amapari: MPEG 19683. *Corallus hortulanus*- Pedra Branca do Amapari: MPEG 19678, MPEG 19935, MPEG 26595; Serra do Navio: MPEG 26566, MPEG 26596. *Dendrophidion dendrophis*- Pedra Branca do Amapari: MPEG 26012. *Dipsas catesbyi*- Serra do Navio: MPEG 26578. *Dipsas indica*- Pedra Branca do Amapari: MPEG 22848. *Drepanoides anomalus*- Pedra Branca do Amapari: MPEG 22851; Serra do Navio: MPEG 26585. *Drymarchon corais*- Pedra Branca do Amapari: MPEG 19791, MPEG 25759; Serra do Navio: MPEG 18350. *Drymoluber dichrous* - Pedra Branca do Amapari: MPEG 19792; Serra do Navio: MPEG 18348. *Epictia albifrons*- Pedra Branca do Amapari: MPEG 22846. *Erythrolamprus aesculapii*- Pedra Branca do Amapari: MPEG 19700, MPEG 22841. *Erythrolamprus breviceps*- Pedra Branca do Amapari: MPEG 19698. *Erythrolamprus miliaris*- Serra do Navio: MPEG 334–5. *Erythrolamprus poecilogyrus*- Serra do Navio: MPEG 196. *Erythrolamprus reginae*- Pedra Branca do Amapari: MPEG 19780, MPEG 19788. *Erythrolamprus rochai*- Pedra Branca do Amapari: MPEG 25680–1. *Erythrolamprus typhlus*- Serra do Navio: IEPA1910. *Helicops angulatus*- Pedra Branca do Amapari: MPEG 19685. *Hydrodynastes gigas*- Serra do Navio: MPEG 26580. *Imantodes cenchoa*- Serra do Navio:

IEPA1909. *Leptodeira annulata*- Serra do Navio: MPEG 26576. *Leptophis ahaetulla*- Pedra Branca do Amapari: MPEG 19684; Serra do Navio: MPEG 26574. *Mastigodryas boddaerti*- Serra do Navio: MPEG 181. *Micrurus lemniscatus*- Pedra Branca do Amapari: MPEG19692–4; Serra do Navio: MPEG 16695, MPEG 26571–2. *Micrurus surinamensis*- Serra do Navio: MPEG 26570. *Oxybelis aeneus*- Pedra Branca do Amapari: MPEG 22840. *Oxyrhopus melanogenys*- Serra do Navio: MPEG 26579. *Oxyrhopus petolaris*- Pedra Branca do Amapari: MPEG 19696. *Philodryas argentea* Pedra Branca do Amapari: MPEG 19687; Serra do Navio: 26590. *Philodryas viridissima*- Pedra Branca do Amapari: MPEG 19681–2; Serra do Navio: MPEG 327, MPEG 329. *Pseudoboa coronata*- Pedra Branca do Amapari: MPEG 19676. *Pseudoboa neuwiedii*- Pedra Branca do Amapari: MPEG 26591. *Rhinobothryum lentiginosum*- Pedra Branca do Amapari: MPEG 19789. *Siagonodon septemstriatus*- Serra do Navio: MPEG 18492. *Siphlophis compressus*- Pedra Branca do Amapari: MPEG 26574, MPEG 26576. *Spilotes pullatus*- Serra do Navio: IEPA1911. *Spilotes sulphureus*- Pedra Branca do Amapari: MPEG 19794, MPEG 25760; Serra do Navio: MPEG 333. *Taeniophallus brevirostris*- Pedra Branca do Amapari: MPEG 19699, MPEG 19785, MPEG 19820–1. *Taeniophallus nicagus*- Pedra Branca do Amapari: MPEG 19786. *Thamnodynastes lanei*- Serra do Navio: MPEG 26589. *Typhlophis squamosus*- Pedra Branca do Amapari: MPEG 19787, MPEG 22844–5; Serra do Navio MPEG 26586–8. *Xenodon rabdocephalus*- Pedra Branca do Amapari: MPEG 19691; Serra do Navio: MPEG 328, MPEG 331–2. *Xenodon severus*- Pedra Branca do Amapari: MPEG 22847. *Xenopholis scalaris*- Pedra Branca do Amapari: MPEG 19677.

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