

Research article

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## Squamate reptiles from seasonal semi-deciduous forest remnants in southwestern Bahia, Brazil

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**Abstract.** We present a list of Squamata from Serra do Mandim and Serra Azul, both in the Atlantic Forest domain of Southern Bahia, Brazil. We recorded 27 species (21 snakes and six lizards). Most species can be characterized as generalists with a wide distribution as *Phyllopezus pollicaris*, *Salvator merianae*, *Corallus hortulanus*, *Philodryas olfersii*, *Oxyrhopus trigeminus* and *Pseudoboa nigra*. However, some of the species are considered as being difficult to sample and restricted to forest fragments such as *Bothrops bilineatus*, *Dipsas sazimai* and *Echianthera cephalostriata*. The snake fauna of both areas represents 70% of the species previously known for the semi-deciduous forests of the state of Bahia. Although the study region is under severe anthropogenic pressure, especially due to the expansion of livestock areas, some forest remnants still withstand a rich reptile diversity.

**Key words.** Snakes, lizards, richness, biodiversity, species distribution.

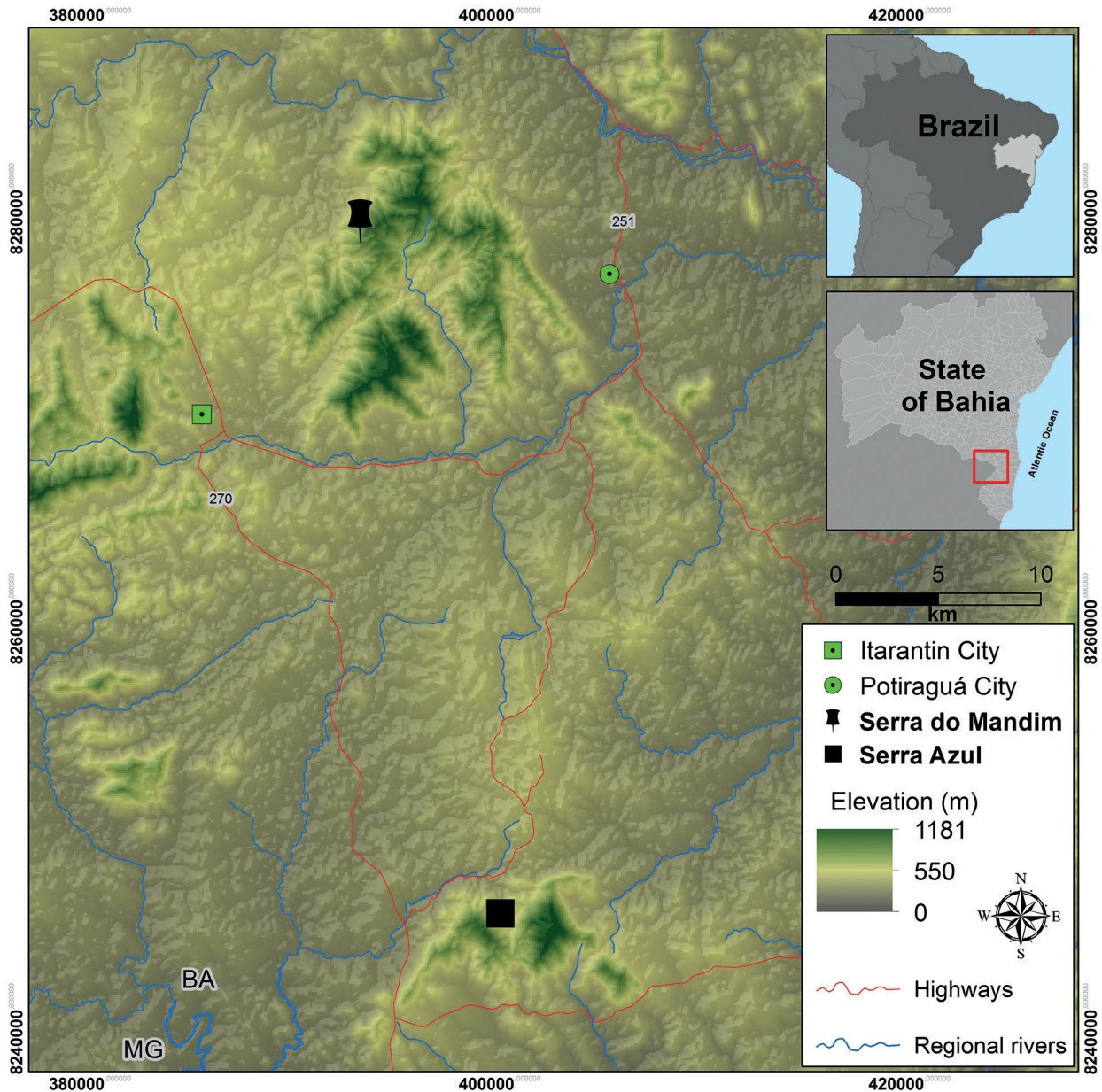
### INTRODUCTION

Habitat loss and fragmentation are considered serious threats for terrestrial reptiles (Böhm et al. 2013). Low dispersion capacity, small home ranges and a low tolerance to temperature variations turn this group, especially forest species, susceptible to changes in their natural environments (Gibbons et al. 2000). A recent study on the conservation status of the world's reptiles showed that 20% of the species are in some kind of threat category, while another 20% are classified as data deficient (Böhm et al. 2013). These authors also state that in tropical environments the number of threatened reptile species has rapidly increased due to ongoing accelerated habitat destruction.

Despite Brazil harboring one of the largest reptile diversities on the planet (Uetz et al. 1995; Costa & Bérnils 2018), a lack of information for a large part of this tax-

onomical group is the common share, mainly concerning natural history aspects and distribution patterns (Rodrigues 2005). While a growing number of taxonomical studies have recently led to the description of several new species (e.g., Recoder et al. 2014; Fernandes & Hamdan 2014; Hamdan & Fernandes 2015; Barbo et al. 2016; Rodrigues et al. 2017; Silveira & Santos-Jr 2018; Silva et al. 2018), there is still a long way to go before this rich reptile diversity is fully understood. The assessment of the conservation status of 732 species and sub-species showed that 13% of the species must be considered as threatened or nearly threatened, while nearly 9% were characterized as “data deficient” species (ICMBio 2014).

Knowledge of the conservation status of species is essential for the implementation of conservation actions in order to mitigate the effects of anthropic actions on endangered species. In Bahia, the number of studies on reptiles has increased recently and information is now



**Fig. 1.** Studied area in the Serra do Mandim (black clamp) in the municipality of Itarantim and in the Serra Azul (black square) in the municipality of Potiraguá, in southwestern Bahia, Brazil.

available for reptiles inhabiting the central (Freitas et al. 2012), western (Freitas et al. 2016a), northern (Freitas 2014; Freitas et al. 2016b; Marques et al. 2016; Freitas et al. 2018; Freitas et al. 2019) and southern (Dixo 2001; Argôlo 2004; Dias et al. 2014) regions of the state, while the southwestern part of the state still shows a large gap concerning information on its reptiles.

The Mandim and Azul Mountains are located in southwestern Bahia - Brazil, in the municipalities of Itarantim and Potiraguá, in a region classified as semi-deciduous seasonal forest (Ibge 1997; Salino et al. 2006). They are

within the boundaries of the Rio Pardo and Rio Jequitinhonha basins, bordering the northeast of Minas Gerais. While they belong to the Atlantic Forest domain, they suffer great influence by the Caatinga and Cerrado domains. A project entitled “Biodiversity and conservation in the Jequitinhonha and Mucuri valleys” was carried out in the region, which, through biological inventories, showed that even suffering high levels of degradation, the region still maintains a great amphibian, bird, and mammal diversity (Pinto & Bede 2006). The same authors identified several priority areas for conservation



**Fig. 2.** Study areas in the southwestern region of Bahia. Fugiama farm in the Serra do Mandim (A, C and E). A: Semi-deciduous forest fragment; C: stream; E: permanent pond. Serra Azul farm in the Serra Azul (B, D and F). B: Semi-deciduous forest fragment; D: stream; F: permanent pond.

and emphasized the importance of more research aimed at other still under sampled groups, as, for example, reptiles. Therefore, the objective of our study was to inventory squamate reptile species from the Serra Azul and

Serra do Mandim, aiming to fill a gap in the knowledge of the group for the state.

## MATERIAL AND METHODS

Between January 2015 and March 2016 six field campaigns were undertaken to sample squamate reptiles in two Atlantic Forest areas characterized as seasonal semi-deciduous forest in southwestern Bahia: at the “Serra do Mandim” (15°37'58" S, 39°59'01" W) in the municipality of Itarantim, and at the “Serra Azul” (15°52'01" S, 39°55'54" W) in the municipality of Potiraguá (Fig. 1). During every campaign each area was sampled between three and four days and nights, resulting in a total sampling effort of 44 field days by two researchers.

The climate of the region corresponds to the “Am” type of Köppen (1936), with average rainfall of 800 to 1100 mm and a temperature range between 23.5°C and 25°C (Ibge 1997). The mountains have gradients of 300–800 m of altitude.

Reptiles were sampled through active search (Rödel & Ernst 2004) at 14 sampling sites in each area, including 12 transects with 50 m length within the forest, a 120 m transect along a stream and a permanent pond (Fig. 2). All available microhabitats within five meters left and right of the transects were sampled (fallen trunks, leaf litter, vegetation and burrows). Due to increased humidity and high concentration of amphibians at the ponds, these sites were potentially more prone to reveal foraging snakes. During each field expedition, forest transects were sampled for 40 minutes and streams were sampled for 90 minutes. The surroundings of the ponds were searched for 30 minutes. The total sample effort was 60 hours in each of the areas. Occasional encounters during the team’s displacement between sample points were also recorded. Additionally to nocturnal sampling squamate reptiles were also sampled during the day from 14h to 17h on a 10 km trail leading to the areas where the transects were located.

The reptiles were collected by hand or using snake hooks and transferred to cotton bags or plastic boxes. The license to capture reptiles was issued by ICMBio (number 13709). Specimens were killed with 20% benzocaine (1mg/g), fixed in 10% formalin for seven days and stored in 70% ethanol. They were further identified using original descriptions available in the literature and deposited in “Museu de Zoologia da Universidade Estadual de Santa Cruz-MZUESC” (Appendix I).

To evaluate sample efficiency, we constructed a rarefaction curve with 1000 randomizations, using the total number of registered individuals in the study area. We used abundance data per sample to extrapolate the richness through the non-parametric estimators Chao2, Jackknife 1 and 2 and Bootstrap (Magurran 1998; Gotelli & Colwell 2001). The analyses were made using the software PAST 3.07 (Paleontological Statistics Software Package for Education and Data Analysis).

## RESULTS AND DISCUSSION

During our study we recorded 27 species of Squamata, 21 belonging to snakes and six to lizards (Table 1, Figs 3–4). Among the snakes, the Dipsadidae family was represented by 12 species, followed by Colubridae with four. Regarding lizards only the family Tropicuridae was represented by two species, while the other families only had one representative. Of all recorded Squamata, none is listed in the Brazilian list of threatened taxa (ICM-Bio-Portaria MMA nº 444/2014 and nº 445/2014).

The comparison with the reptile fauna from surrounding areas near Serra do Mandim and Serra Azul is hampered by the absence of such kind of studies. In general, the recorded squamate fauna (n=27) can be considered larger than that of other sampled areas in the region, as some municipalities from the northeast of the state of Minas Gerais (n=11, Feio & Caramaschi 2002) and from the APA da Lagoa Encantada, between the cities of Ilhéus, Floresta Azul and Almadina (n=17, Dias et al. 2014). Other studies undertaken in Atlantic Forest areas revealed larger squamate reptile richness, as the one by Argôlo (2004) reporting 61 species of snakes from cocoa plantations in southeastern Bahia. It is worth mentioning that this study was conducted during a time span of 12 years. Hamdan & Lira-Da-Silva (2012) reported the occurrence of 30 species of snakes for the seasonal semi-deciduous Forest of the state of Bahia. We managed to report 70% of the species reported for this kind of vegetation in the state.

Most of the recorded species show a wide distribution, occurring both in the Atlantic Forest and in the Caatinga domain, such as *Phyllopezus pollicaris*, *Salvator merianae*, *Corallus hortulanus*, *Philodryas olfersii*, *Oxyrhopus trigeminus*, *Pseudoboa nigra* and *Xenodon merremii* (Vanzolini et al. 1980; Rodrigues 1986; Argôlo 2009; Hamdan & Lira-Da-Silva 2012; Marques et al. 2012c). Others are typical from Caatinga environments, such as *Tropidurus hispidus* (Vanzolini et al. 1980; Rodrigues 2003) while others are restricted to the Atlantic Forest domain such as *Dipsas sazimai* and *Echinanthera cephalostriata*. Despite having a wide distribution range in the Atlantic Forest, *D. sazimai* has only been reported thrice from the state of Bahia (Roberto et al. 2014). This species is rare and typical of forest environments and following Fernandes et al. (2010) it should be considered potentially endangered. *Echinanthera cephalostriata* can be found in the Atlantic Forest domain from Santa Catarina to southwestern Bahia state (Argôlo & Jesus 2008). In Bahia, it is considered a rare species, with occurrence associated with montane forest, above 600m altitude (Argôlo 2009). These two species (*D. sazimai* and *E. cephalostriata*) have been included in the recently launched list of threatened species of the state of Bahia (SEMA 2017) as vulnerable (VU) and endangered (EN), respectively.

**Table 1.** Richness and composition of Squamata species recorded at the Serra do Mandim and at the Serra Azul in southwestern Bahia, Brazil. Sampling method: OE-opportunistic encounter; FT-Forest transect; P-pond; ST-Stream transect.

\*Nomenclature follows Costa &amp; Bérnils (2018).

Family/species*	S. Mandim	Serra Azul	Total
<b>LIZARDS</b>			
<b>Phyllodactylidae</b>			
<i>Phyllopezus pollicaris</i> (Spix, 1825)	–	OE	01
<b>Dactyloidae</b>			
<i>Norops fuscoauratus</i> (D’Orbigny, Duméril & Bibron, 1837)	FT	–	01
<b>Leiosauridae</b>			
<i>Enyalius catenatus</i> (Wied, 1821)	FT, ST, OE	FT, OE	21
<b>Tropiduridae</b>			
<i>Tropidurus torquatus</i> (Wied, 1820)	P, OE	–	02
<i>Tropidurus hispidus</i> (Spix, 1825)	–	P	01
<b>Teiidae</b>			
<i>Salvator merianae</i> (Duméril & Bibron, 1839)	–	OE	01
<b>SNAKES</b>			
<b>Boidae</b>			
<i>Corallus hortulanus</i> (Linnaeus, 1758)	FT, ST	–	02
<b>Colubridae</b>			
<i>Chironius fuscus</i> (Linnaeus, 1758)	–	FT, ST	03
<i>Mastigodryas bifossatus</i> (Raddi, 1820)	OE	P, OE	03
<i>Oxybelis aeneus</i> (Wagler in Spix, 1824)	ST	OE	02
<i>Tantilla melanocephala</i> (Linnaeus, 1758)	–	OE	03
<b>Dipsadidae</b>			
<i>Dipsas sazimai</i> Fernandes, Marques e Argôlo, 2010	FT	FT, OE	05
<i>Echinanthera cephalostriata</i> Di-Bernardo, 1996	–	FT	02
<i>Erythrolamprus miliaris</i> (Linnaeus, 1758)	OE	P	02
<i>Erythrolamprus poecilogyrus</i> (Wied, 1825)	–	OE	03
<i>Imantodes cenchoa</i> (Linnaeus, 1758)	–	ST, OE	03
<i>Oxyrhopus petolarius</i> (Linnaeus, 1758)	–	FT	02
<i>Oxyrhopus trigeminus</i> Duméril, Bibron e Duméril, 1854	OE	P, OE	04
<i>Philodryas olfersii</i> (Liechtenstein, 1823)	OE	–	01
<i>Pseudoboa nigra</i> (Duméril, Bibron & Duméril, 1854)	–	OE	01
<i>Sibynomorphus neuwiedi</i> (Thering, 1911)	FT	FT	02
<i>Thamnodynastes nattereri</i> (Mikan, 1828)	ST, OE	FT	04
<i>Xenodon merremii</i> (Wagler in Spix, 1824)	OE	OE	05
<b>Leptotyphlopidae</b>			
<i>Trilepida salgueiroi</i> (Amaral, 1955)	–	OE	01
<b>Viperidae</b>			
<i>Bothrops jararaca</i> (Wied, 1824)	FT, ST	FT, ST, OE	18
<i>Bothrops leucurus</i> Wagler in Spix, 1824	ST, P, OE	P, OE	07
<i>Bothrops bilineatus</i> (Wied-Neuwied, 1821)	ST	–	02
<b>Total</b>	<b>16</b>	<b>22</b>	<b>102</b>



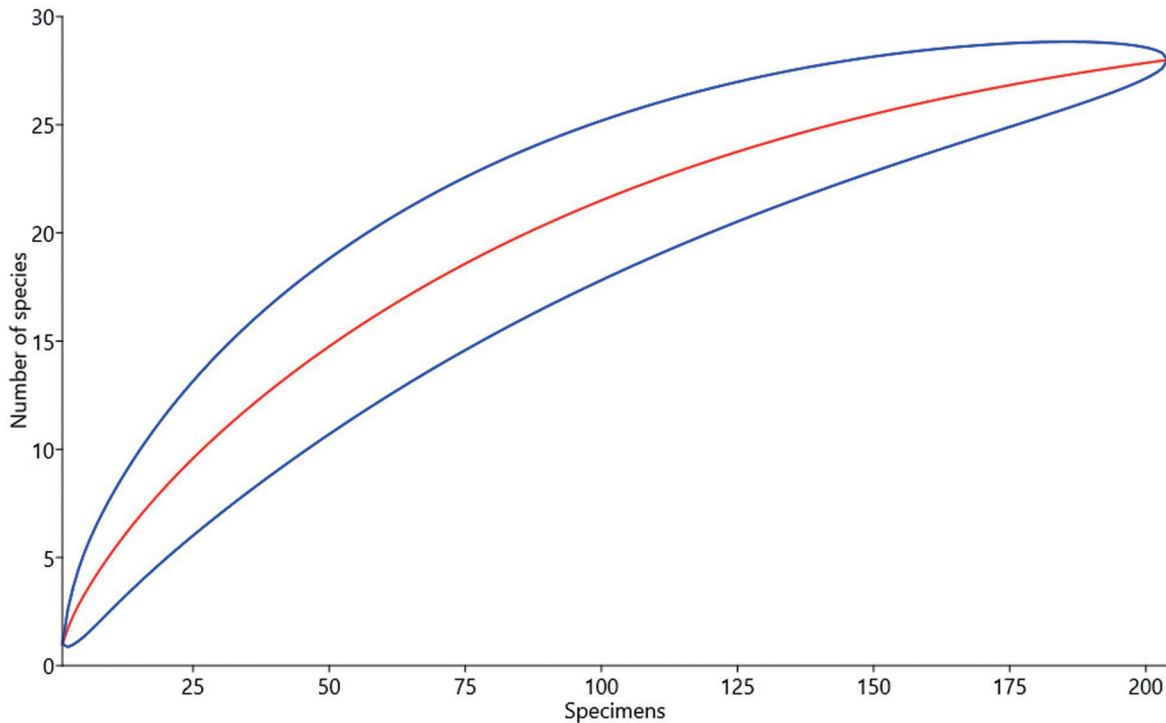
**Fig. 3.** Squamata recorded at Serra do Mandim and Serra Azul in southwestern Bahia, Brazil. **A.** *Norops fuscoauratus*; **B.** *Enyalius catenatus* (male); **C.** *E. catenatus* (juvenile); **D.** *Chironius fuscus*; **E.** *Dipsas sazimai*; **F.** *Imantodes cenchoa*.

The rarefaction curve did not reach the asymptote and remained in ascending function (Fig. 5), even though 69% to 86% of the species indicated by the richness estimators (Chao 2 =  $32.1 \pm 4.3$ ; Jackknife 1 =  $36.2 \pm 4.2$ . Jackknife 2 = 39.2 and Bootstrap = 31.4) were sampled. However, the use of additional sampling methods as pit-

falls (Cechin & Martins 2000) and funnel traps (Greenberg et al. 1994) could lead to an increase in the diversity of sampled Squamata for the region, since they allow the record of species that have specific habits and are hardly sampled during active search, such as fossorial snakes and lizards (Macedo et al. 2008).



**Fig. 4.** Squamata recorded at Serra do Mandim and Serra Azul in southwestern Bahia, Brazil. **A.** *Echinanthera cephalostriata*; **B.** *Mastigodryas bifossatus*; **C.** *Oxyrhopus trigeminus*; **D.** *O. petolarius*; **E.** *Oxybelis aeneus*; **F.** *Trilepida salgueiroi*; **G.** *Bothrops jararaca*; **H.** *B. bilineatus*.



**Fig. 5.** Rarefaction curve based on individuals of Squamata for two regions of semi-deciduous seasonal forest in Serra do Mandim and Serra Azul in southwestern Bahia, Brazil. The center line corresponds to the mean obtained with 1000 randomizations, and the lines above and below correspond to the associated standard deviation.

The present study contributes to fill a gap in the knowledge of Squamata of the southwestern region of Bahia, presenting a list with 27 species of snakes and lizards for the Serra do Mandim and Serra Azul. Although the region is suffering great anthropic pressure, mainly related to the agricultural expansion, the forest remnants still have conditions to support and maintain species considered difficult to sample in the Atlantic Forest, such as *Dipsas sazimai* and *Echinanthera cephalostriata*.

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## APPENDIX I.

List of vouchers deposited in the Museu de Zoologia da Universidade Estadual de Santa Cruz-MZUESC.

### LIZARDS

PHYLLODACTYLIDAE. *Phyllopezus pollicaris*: MZUESC 15911. DACTYLOIDAE. *Norops fuscoauratus*: MZUESC 15931. LEIOSAURIDAE. *Enyalius catenatus*: MZUESC 15901-15906, 15916, 15917, 15920, 15921, 15922, 15930. TROPIDURIDAE. *Tropidurus torquatus*: MZUESC 15939, 15942. *Tropidurus hispidus*: MZUESC 16546.

### SNAKES

BOIDAE. *Corallus hortulanus*: MZUESC 15929. COLUBRIDAE. *Chironius fuscus*: MZUESC 15934, 15935. *Mastigodryas bifossatus*: MZUESC 16541. *Oxybelis aeneus*: MZUESC 15910, 15919. *Tantilla melanocephala*: MZUESC 15924, 15943, 16538. DIPSADIDAE.

*Dipsas sazimai*: MZUESC 15908, 15913, 15926, 16548. *Echianthera cephalostriata*: MZUESC 15909, 15928. *Erythrolamprus miliaris*: MZUESC 15907, 15940. *Erythrolamprus poecilogyrus*: MZUESC 15944, 16540, 16543. *Imantodes cenchoa*: MZUESC 15914. *Oxyrhopus petolaris*: MZUESC 15945, 16544. *Oxyrhopus trigeminus*: MZUESC 14687, 15923. *Philodryas olfersi*: MZUESC 16547. *Pseudoboa nigra*: MZUESC 16537. *Sibynomorphus neuwiedi*: MZUESC 15927, 15932. *Thamnodynastes nattereri*: MZUESC 15912, 15933. *Xenodon merremii*: MZUESC 16534-16536, 16539, 16542. LEPTOTYPHLOPIDAE. *Trilepida salgueiroi*: MZUESC 16545. VIPERIDAE. *Bothrops jararaca*: MZUESC 14469, 14470, 14471, 15915, 15918, 15936, 15937. *Bothrops leucurus*: MZUESC 15925, 15938. *Bothrops bilineatus*: MZUESC 16549.