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Lists of Species

Rapid survey of the herpetofauna in an area of forest management in eastern Acre, Brazil

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Abstract: Timber exploitation is the most profitable and popular use of forest. To evaluate how this activity affects biodiversity is of crucial importance for conservation. Therefore, we carried out a herpetofauna survey in a forest area under a reduced–impact management, in Sena Madureira municipality, state of Acre (Brazil). We used active searching, both day and night, and pitfall traps. In the pre-exploitation phase the search was conducted basically in forests and forest edges; in the post-exploitation phase we also searched in sites such as secondary roads, skid trails and timber storage yards. We recorded 38 amphibian species and 28 reptile species; 17 snakes, nine lizards and two crocodilians. It is expected that this survey can contribute to programs of environmental monitoring in forest management areas in Amazonia.

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Introduction

The Amazon has approximately 60% of the forest remnants of the world (Whitmore 1997). The Amazon Forest provides ecosystem services to the whole world, and plays a vital role in the maintenance of biodiversity, hydrological cycle and carbon sequestration (Fearnside 2008).

Estimates of the deforestation in the Amazon show that from 1961 to 2003, 6% of the area was converted to plantations, 62% to pastures and 32% was deforested (Ramankutty *et al.* 2007). Currently the deforestation rates in the Brazilian Amazon are measured by the "Instituto Nacional de Pesquisas Espaciais" (INPE), with visual interpretation of Landsat images through the Amazon Deforestation Project (PRODES; INPE 2009). These data are considered scientifically sound, though underestimated (Laurance *et al.* 2002), since the method does not detect other human activities such as changes that cause loss of forest canopy, such as superficial fires, edge effects, hunting, small scale mining and selective logging (Cochrane *et al.* 1999; Nepstad *et al.* 1999).

Timber exploitation is the most popular and profitable use of forest (Azevedo-Ramos *et al.* 2005) and has a significant effect on the biological functioning of the forest (Malhi *et al.* 2008). Industrial logging has been dramatically increasing in the Amazon (Laurance *et al.* 2001), with expansion rates of 12,000–20,000 $km^2.year^{-1}$, a value that is very similar to deforestation rates (Malhi *et al.* 2008).

The direct impacts of this practice include road building and opening of yards and clearings during the operations, which cause tree mortality, erosion and soil compaction, grass invasion and microclimate changes associated with the loss of the canopy cover (Uhl and Vieira 1989). Moreover, it grants access to other activities such as hunting, mining and farming (Laurance 2001). Evaluating how this activity affects biodiversity is of crucial importance for good management (Azevedo-Ramos *et al.* 2005). Some studies have been examining the effect of timber exploitation on the forest fauna (e.g. Thiollay 1992; Weisenseel *et al.* 1993; Laurance and Laurance 1996; Johns 1996; Vasconcelos *et al.* 2000; Willot *et al.* 2000; Basset *et al.* 2001; Ochoa 2000; among others), among them studies on herpetofauna (Pearman 1997; Vitt *et al.* 1998; Vitt and Caldwell 2001; Vonesh 2001, Lima *et al.* 2001; Fredericksen and Fredericksen 2002; Demaynadier and Hunter 1998; Ernst *et al.* 2006; Lemckert 1999; Renken *et al.* 2004; Vallan *et al.* 2004).

The species richness of reptiles and amphibians in the Brazilian Amazon is poorly known. Studies have enumerated 232 amphibian species, but this may be underestimated (Avila-Pires *et al.* 2007); 149 snake species, about 100 lizard species, and four crocodilian species (Avila-Pires *et al.* 2007). In the state of Acre, few studies have been conducted on the fauna of anurans (e.g. Souza 2009) and the herpetofaunal community, (Bernarde *et al.* 2011, 2013). In the Alto Juruá region, 126 species of amphibians were recorded for the "Reserva Extrativista do Alto Juruá" and "Parque Nacional da Serra do Divisor", which is considered one of the regions with the greatest diversity of anurans on the planet (Souza 2009). The number of anurans has been increased with a new records (e.g. Sampaio and Souza 2009; Melo-Sampaio *et al.* 2010; Venancio *et al.* 2010; Bernarde *et al.* 2010) and descriptions of new species (e.g. Nunes-de-Almeida and Toledo 2012; Melo-Sampaio *et al.* 2013 and Peloso *et al.* 2014)

Knowledge about the richness of species of snakes and lizards in the state of Acre is still lacking (Silva *et al.* 2010).

The aim of this study was to evaluate the impact of timber extraction on the herpetofauna in a forest in southwestern Amazonia.

Materials and Methods

Study area

The survey was carried out in São Jorge I Farm (09°26′ 11″ S, 68°37′19″ W), located in Sena Madureira municipality (Figure 1), property of the company Laminados Triunfo Ltda. The area comprises 3,798.23 ha, of which 3,461.85 ha were destined for logging using techniques of reduced impact, logging intensity of 30 m^3/ha and a cutting cycle of 25 years. The predominant forest type is open forest with palm trees, with some open forest with bamboos. The relief is slightly hilly, the annual average temperature is 25°C, and the annual average rainfall is 2,125 mm (Acre 2006).

Data collection

The study was carried out in two phases. The first sampling period was carried out from May to June 2008, when the herpetofauna was surveyed before cutting, skidding and removal of trees, hereafter called "timber pre-exploitation phase". The second sampling period was carried out eleven months later, in May 2009, when the trees had been removed from the forest, hereafter called "timber post-exploitation phase", using the following sampling methods:

1) Active Search (Vanzolini and Papavero 1967; Lema and Leitão-de-Araujo 1985; Franco *et al.* 2002). This method consisted of searching in all micro-environments: leaf litter, under fallen logs, holes in the ground and in trees, aquatic environments, and others, during the day and night. We also recorded amphibians and reptiles that were found by chance.

2) Pitfall traps (Heyer *et al.* 1994). Three trap sequences were built, following the recommendations of Cechin and Martins (2000). These traps consist of containers buried in the ground and interconnected by a guide fence (canvas or plastic screen). Each trap array was composed of five 50L plastic buckets, buried 10 m apart and connected by a canvas fence about 1 m high. The three trap sequences were monitored daily for 10 days.

The same methods were repeated with the same number of researchers at the same locations, but after logging, additional locations were added.

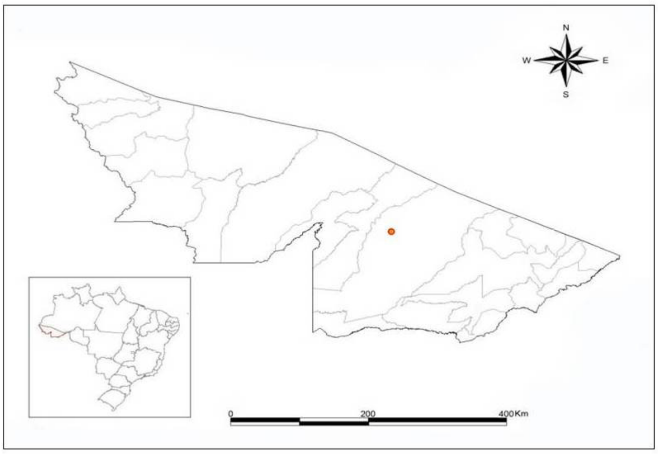

Figure 1. Map of state of Acre, showing the location of São Jorge I Farm (red dot), located in Sena Madureira municipality.

Both sampling phases were conducted over 10 days, with 111 h of search in each phase. In the pre-exploitation phase amphibian and reptiles were recorded in forest environments and in forest edges; in the post-exploitation phase we also searched in human altered locations, such as secondary roads and timber storage yards. Specimens were killed with lidocaine (applied to the abdomen of amphibians or injected into reptiles), fixed in a solution of 10% formalin and preserved in a 70% ethanol solution. All vouchers were deposited in the herpetological collection of "Universidade Federal do Acre" campus "Ciências da Natureza", Rio Branco, Acre State, Brazil (IBAMA permit 12178-2) (Appendix 1).

Nomenclature follows Frost (2014) for amphibians and Pyron *et al.* (2013) for reptiles.

Results

We recorded 38 species of amphibians and 28 species of reptiles; 17 snakes, nine lizards and two crocodilians (Figures 2 and 3). In the first phase we found 28 anuran species, nine lizard species, 14 snake species and only one crocodilian species. In the second phase we recorded 33 anuran species, four lizards, seven snake species and two crocodilian species.

The 38 anuran species (Table 1) are in the following families: Aromobatidae (2), Bufonidae (4), Ceratophryidae (1) Dendrobatidae (2), Hylidae (17), Leptodactylidae (4), Leiuperidae (2), Microhylidae (2), and Craugastoridae (4). The 17 snake species (Table 2) are represented by the families Boidade (2); Colubridade (13), Elapidae (1), Viperídae (1). The lizards are represented by the Gymnophthalmidae (2), Iguanidae (1), Polychrotidae (2), Sphaerodactylidae (1), Teiidae (3). The two crocodilians are in the family Alligatoridae.

Discussion

The greatest number of anurans were found in the forest: 30 species in the inner forest, six associated with temporary ponds in the forest and 12 in temporary ponds formed on roads and in timber storage yards. Only nine species were found at forest edges, six in dams, and five in temporary ponds (Table 1). Five species of frogs (*Rhaebo guttatus*, *Rhinella castaneotica*, *Osteocephalus* sp, *Chiasmocleis bassleri* and *Hamptophryne boliviana*), were found only in the first phase. However, ten species were found only in the second phase (Table 1).

Roads and timber storage yards surveyed in phase 2 aided the formation of temporary ponds, in which some generalist species that depend on water for reproduction were recorded: three species of the genus *Phyllomedusa* (*P. tomopterna, P. camba* and *P. bicolor*), two of the genus *Dendropsophus* (*D. brevifrons* and *D. parviceps*), three of the genus *Hypsiboas* (*H. fasciatus, H. lanciformis* and *H. punctatus*), two species of *Scinax* (*S. ruber* and *S. garbei*) plus *Trachycephalus typhonius*, *Engystomops freibergi* and *Rhinella marina*.

The increase in the number of sites for reproduction in managed areas may make anuran species more abundant, and therefore also raise the abundance of other animals, such as snakes, lizards and other frogs (Vitt and Caldwell 2001). We recorded the presence of a terrestrial predator

(*Ceratophrys cornuta*), a large frog that feeds on other frogs (Duellman and Lizana 1994). Species considered as generalists, occupying more than three environments (*Rhinella marina*, *Hypsiboas fasciatus*, *Phyllomedusa bicolor* and *Trachycephalus typhonius*), may be favored and may increase their abundance, thereby affecting other species in the area.

Although some species are able to colonize altered environments in the Amazon, others are affected by the loss of reproductive habitats (e.g. Aichinger 1991; Tocher 1998). In general, human interventions lead to an impoverishment of the structure and diversity of vegetation (Liddle and Scorgie 1980). Such a change alters the habitat of many species, causing the disappearance of specialist species in favor of generalist species (Van Rooy and Stumpel 1995)

Decreased diversity of frogs due to formation of forest in pasture areas was observed in a adjacent state, Municipality of Espigão do Oeste in Rondônia State (Bernarde 2007), where Bernarde and Macedo (2008) also reported greater richness and diversity of frogs in forest floor litter. Many animals use the leaf-litter as a microhabitat for reproduction, refuge from dessication, protection from predators, feeding, and social behaviors. We found species from the families Aromobatidae (*Allobates* sp. and *A. femoralis*) and Dendrobatidae (*Ameerega hahneli* and *A. trivittata*). In the leaf litter, these anurans lay eggs on rolled or folded dry leaves and transport their tadpoles to small water bodies, such as bromeliad pools, leaf axils, fallen fruit capsules or tree holes (Caldwell 1998; Lima *et al.* 2006).

We also found in the leaf litter and on trees some species of the genus *Pristimantis* (*P. fenestratus, Pristimantis* sp. 1, *Pristimantis* sp. 2). This group exhibits the most specialized form of reproduction, which is independent of

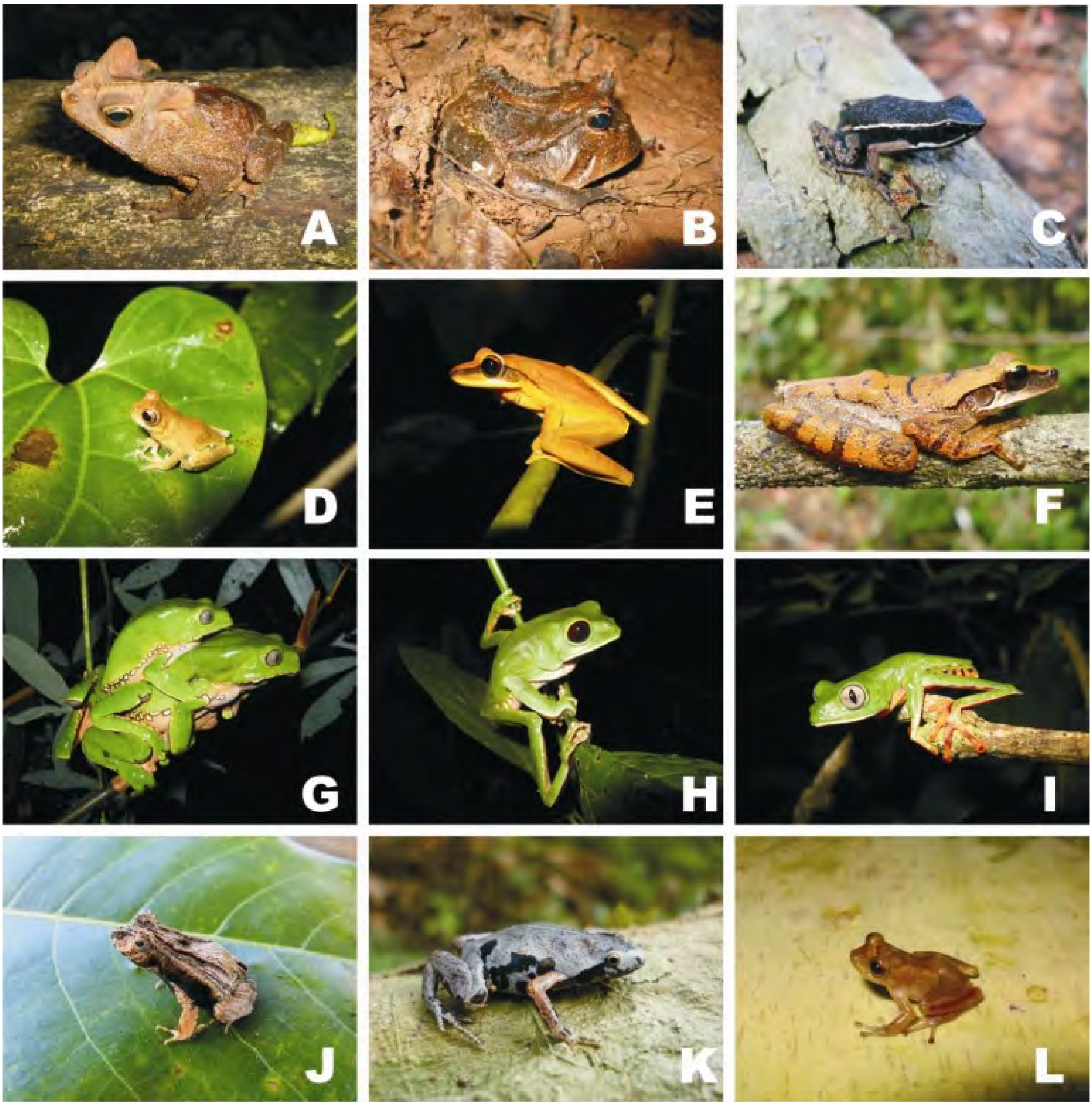

Figure 2. Amphibian species from Sena Madureira municipality, state of Acre. Legend: A- *Rhinella margaritifera*, B- *Ceratophrys cornuta*, C- *Ameerega hahneli*, D- *Dendropsophus parviceps*, E- *Hypsiboas lanciformis*, F- *Osteocephalus* sp., G- *Phyllomedusa bicolor* in amplexus, H- *Phyllomedusa camba*, I- *Phyllomedusa tomopterna*, J- *Edalorhina perezi*, K- *Chiasmocleis bassleri*, L- *Pristimantis* gr. *unistrigatus*.

Table 1. Amphibians recorded in São Jorge I Farm, Sena Madureira municipality, state of Acre. Legend: 1- first sampling period (timber pre-exploitation phase) and 2- second sampling period (timber post-exploitation phase).

TAXON	PHASE
Aromobatidae	
Allobates femoralis (Boulenger, 1884 "1883")	1, 2
Allobates sp.	1, 2
Bufonidae	
Rhaebo guttatus (Schneider, 1799)	1
Rhinella castaneotica (Caldwell, 1991)	1
Rhinella margaritifera (Laurenti, 1768)	1,2
Rhinella marina (Linnaeus, 1758)	1,2
Ceratophryidae	
Ceratophrys cornuta (Linnaeus, 1758)	2
Dendrobatidae	
Ameerega hahneli (Boulenger, 1884 "1883")	1,2
Ameerega trivittata (Spix, 1824)	1,2
Hylidae	
Dendropsophus brevifrons (Duellman & Crump, 1974)	2
Dendropsophus leucophyllatus (Beireis, 1783)	2
Dendropsophus parviceps (Boulenger, 1882)	2
Hypsiboas boans (Linnaeus, 1758)	1, 2
Hypsiboas fasciatus (Günther, 1859 "1858")	1, 2
Hypsiboas geographicus (Spix, 1824)	1, 2
Hypsiboas lanciformis (Cope, 1871)	1, 2
Hypsiboas punctatus (Schneider, 1799)	1, 2
Osteocephalus taurinus Steindachner, 1862	2
Osteocephalus sp.	1
Phyllomedusa bicolor (Boddaert, 1772)	1, 2
Phyllomedusa camba De la Riva, 2000 "1999"	2
Phyllomedusa tomopterna (Cope, 1868)	2
Scinax garbei (Miranda-Ribeiro, 1926)	2
Scinax ruber (Laurenti, 1768)	1,2
Scinax sp.	1,2
Trachycephalus typhonius (Linnaeus, 1758)	1,2
Leiuperidae	
Edalorhina perezi Jiménez de la Espada, 1871 "1870"	1,2
Engystomops freibergi (Donoso-Barros, 1969)	1,2
Leptodactylidae	
Leptodactylus andreae Müller, 1923	1,2
Leptodactylus hylaedactylus (Cope, 1868)	1,2
Leptodactylus leptodactyloides (Andersson, 1945)	2
Leptodactylus pentadactylus (Laurenti, 1768)	1,2
Microhylidae	
Chiasmocleis bassleri Dunn, 1949	1
Hamptophryne boliviana (Parker, 1927)	1
Strabomantidae	
Oreobates quixensis Jiménez de la Espada, 1872	1,2
Pristimantis fenestratus (Steindachner, 1864)	1,2
Pristimantis sp.1	1,2
Pristimantis sp.2	2
TOTAL	**28 / 33**

aquatic environments, and is characterized by eggs laid on the ground (Heinicke *et al.* 2007). The absence of a larval phase in these anurans makes these species sensitive to humidity. Therefore, the conservation and survival of the eggs depend on high humidity in the environment, which prevents their desiccation (Duellman 1988). Species of the genus *Pristimantis* are sensitive to logging and effects of logging, since they exhibit a high susceptibility to environmental variables and may diminish their abundance in exploited areas (Pearman 1997).

Based on the ecological characteristics of Amazon Forest lizards the temperature may play an important role on the determination of the distribution of habitat and microhabitats of each species (Vitt and Zani 1996). In the present survey we recorded six lizard species in the inner forest and three heliothermic lizard species (*Ameiva ameiva, Kentropyx calcarata* and *Tupinambis teguixin*) occupying the forest edges and human altered areas such as secondary roads, timber storage yards and clearings (Table 3). These lizards have a preference for open environments with sparse vegetation cover, and are strongly influenced by environmental degradation, mainly the removal of trees in exploited areas (Vitt *et al.* 1998; Lima *et al.* 2001), benefiting from the increase of insolation in these sites (Vitt *et al.* 1998; Fredericksen *et al.* 1999).

In other locations near the state of Acre, researchers found decreased numbers of frogs (Bernarde *et al.* 1999; Bernarde 2007), snakes (Bernarde and Abe 2006) and lizards (Macedo *et al.* 2008) in pasture areas in Espigão do Oeste, Rondônia State. These authors suggest that terrestrial and arboreal lizards are unable to colonize open habitats after deforestation, corroborating Vitt and Caldwell (2001).

A study carried out in an area of small-scale logging in Porto Walter municipality (Acre) showed that heliothermic lizards benefit from basking on fallen logs. In this study, Vitt and collaborators (1998), suggest that there is an increase in the density of heliothermic lizards resulting from the increase in density of fallen trees in the exploited forest. This increase in heliothermic lizards may affect other lizard populations that inhabit the forest because of competition for resources and predation (Vitt *et al.* 1998). Similarly, the heliothermic lizards found in this study may exert predation pressure on other animals, including other lizard species.

We cannot compare species abundance and richness between in the two phases (pre and post-exploitation, since the survey was carried out for only two months in 2008 and one month in 2009. Rapid surveys provide only some of the necessary information needed for decision-making regarding the impact of environmental changes on the resident species (Avila-Pires *et al.* 2007).

Figure 3. Reptile species from Sena Madureira municipality, state of Acre. Legend: A- *Alopoglossus angulatus*, B- *Norops fuscoauratus*, C- *Ameiva ameiva*, D- *Corallus hortulanus*, E- *Epicrates cenchria*, F- *Cleia clelia*, G- *Dipsas catesbyi*, H- *Leptophis ahaetulla*, I- *Erythrolamprus dorsocorallinus*, J- *Xenodon severus*, K- *Micrurus leminiscatus*, L- *Caiman crocodilus*.

Table 2. Richness and abundance of snakes and crocodilians found in São Jorge I Farm, Sena Madureira municipality, state of Acre. Legend: ne- non-estimated; for the column of the phase they correspond: 1- first sampling period (timber pre-exploitation phase) and 2- second sampling period (timber post-exploitation phase).

TAXON	PHASE
SQUAMATA	
Boidade	2
Corallus hortulanus (Linnaeus, 1758)	1
Epicrates cenchria (Linnaeus, 1758)	
Colubridae	1, 2
Chironius laurenti Dixon, Wiest & Cei, 1993	1
Drymarchon corais (Boie, 1827)	2
Leptophis ahaetulla (Linnaeus, 1758)	1
Rhinobotryum lentiginosum (Scopoli, 1785)	
Dipsadidae	1
Clelia clelia (Daudin, 1803)	1, 2
Dipsas catesbyi (Sentzen, 1796)	1
Helicops angulatus (Linnaeus, 1758)	2
Imantodes cenchoa (Linnaeus, 1758)	1,2
Leptodeira annulata (Linnaeus, 1758)	1
Erythrolamprus dorsocorallinus Esqueda, Natera, La Marca & Ilija-Fistar, 2007	1
Oxyrhopus occipitalis (Wied-Neuwied, 1824)	1
Oxyrhopus petolarius (Linnaeus, 1758)	1
Xenodon severus (Linnaeus, 1758)	
Elapidae	1
Micrurus lemniscatus (Linnaeus, 1758)	
Viperidae	1, 2
Bothrops atrox (Linnaeus, 1758)	
CROCODYLIA	
Alligatoridae	1, 2
Caiman crocodilus(Linnaeus, 1758)	2
Paleosuchus palpebrosus (Cuvier, 1807)	
TOTAL	**15/09**

Table 3. Lizard species found in the inner forest, forest edge, secondary roads and timbre storage yards. Thermoregulation behavior according to Vitt et al. (1998). Legend: NH- non-heliothermic; H- heliothermic; 1- first sampling period (timber pre-exploitation phase) and 2- second sampling period (timber post-exploitation phase).

TAXON	PHASE
Gymnophthalmidae	
Alopoglossus angulatus (Linnaeus, 1758)	1
Cercosaura ocellata Wagler, 1830	1
Iguanidae	
Iguana iguana (Linnaeus, 1758)	1
Polychrotidae	
Norops fuscoauratus D'Orbigny, 1837	1,2
Norops nitens (Wagler, 1830)	1
Sphaerodactylidae	
Gonatodes humeralis (Guichenot, 1855)	1
Teiidae	
Ameiva ameiva (Linnaeus, 1758)	1,2
Kentropyx calcarata Spix, 1825	1,2
Tupinambis teguixin (Linnaeus, 1758)	1,2
TOTAL	**09/04**

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Appendix 1. Voucher list

Amphibians - *Chiasmocleis bassleri*: UFAC-4175. *Edalorhina perezi*: UFAC-4176. *Hamptophryne boliviana*: UFAC-4177. *Hypsiboas fasciatus*: UFAC-4174. *Osteocephalus* sp.: UFAC-4169, UFAC-4170. *Pristimantis fenestratus:* UFAC-4173*. Pristimantis* sp.1: UFAC-4172. *Pristimantis* sp.2: UFAC-4178, UFAC-4179, UFAC-4180. *Scinax ruber:* UFAC-4171. **Reptiles** - *Erythrolamprus dorsocorallinus*: UFAC-0396, UFAC-0398.