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Amphibians of Parque Estadual do Forno Grande, State of Espírito Santo, Southeastern Brazil: Species composition and conservation

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Abstract. The Brazilian Atlantic rainforest still holds a rich biodiversity despite the intense habitat loss and fragmentation. This biome is considered one of the four priority global biodiversity hotspots. We studied amphibians of the Parque Estadual do Forno Grande (PEFG), a highland remnant of Atlantic Forest Central Corridor in Espírito Santo, southeastern Brazil. The data was obtained from almost three years of sampling efforts at PEFG, records gathered from literature, and specimens housed at scientific collections. We documented a total of 31 species (30 anurans and one caecilian). According to IUCN Red List, *Aplastodiscus cavicola* is categorized as Near Threatened and *Scinax belloni* as Endangered. *Megaelosia apuana* is listed as Vulnerable to extinction in the state's list. The high species richness and the occurrence of threatened species reinforce the importance of protected areas for the conservation of amphibians.

Key words: Anura, Gymnophiona, Atlantic Rainforest, mountain region.

Introdution

According to Leitão-Filho (1987), the Brazilian Atlantic rainforest is the oldest sort of vegetation in Brazil. Nevertheless, it has also been the one that has historically suffered more intensely from the process of irregular occupation of land and undue exploitation of natural resources (MMA 2000, IPEMA 2005). Despite the degradation (Turner & Corlett 1996), the Brazilian Atlantic rainforest still harbors a rich biodiversity (Myers et al. 2000). Consequently, this biome constitutes one of the four priority global biodiversity hotspots (Myers et al. 2000).

The Parque Estadual do Forno Grande (PEFG), municipality of Castelo, state of Espírito Santo is located at Serra da Mantiqueira, which extends throughout Espírito Santo and south of Bahia and, according to MMA (2000); it houses many species of restricted distribution and/or endangered taxa. For statement, 16 of the total of 133 species recorded at Espírito Santo are endemic, and six of them are known only from their type localities. Moreover, 13 of the 16 endemic species of Espírito Santo occur only in mountainous regions (above 250 m a.s.l.), five of those known only from their type localities (Almeida et al. 2011).

Due to lack of knowledge about the local fauna of amphibians, the high endemic species richness from its locality and the level of preservation that it harbors, the Parque Estadual do Forno Grande is very important for biodiversity conservation in Brazil.

Herein we present a long term sampling of the amphibians of Parque Estadual do Forno Grande, included in the main remnants of Atlantic rainforest Central Corridor, situated at Espírito Santo, Brazil.

Material and methods

Study area

Our study was carried out at the Parque Estadual do Forno Grande (PEFG; 20º31'18", 20º31'21" S and 41º05'45", 41º08'05" W; ca. 1,128 a 2,039 m a.s.l.) (Fig. 1), municipality of Castelo, state of Espírito Santo, southeastern Brazil. PEFG is included in the Atlantic rainforest morphoclimatic domain (Ab'Saber 1977), which is part of the Atlantic rainforest Biome and has a mountainous landscape of 730 ha, with height variation from 1,200 to 2,039 m. It has been preserved since its creation in 1960 as a forest reserve, being transferred to state park in September 11th, 1998, through the decree nº. 7.528/98, aiming to the conservation of local fauna and flora. The vegetation consists of High-Montane Dense Ombrophilous Forest (Dense Tropical rainforest) in transition to Stationary Semi-deciduous Forest, with ca. 1,200 mm of annual rainfall average and climate characterized as *Aw Tropical* in the Köppen-Geiger Climate system (Koppen 1936) featuring warm and wet summers and dry winters.

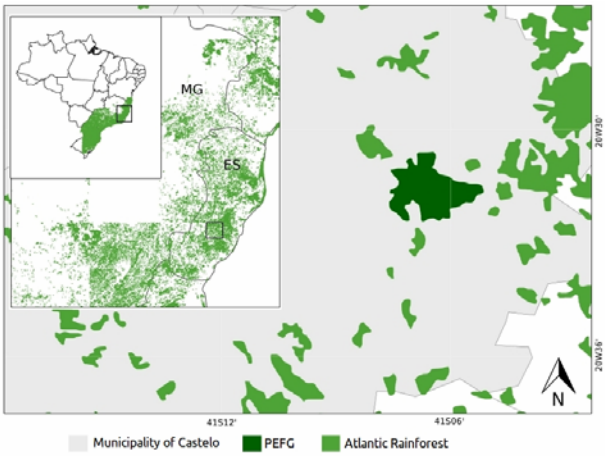

Figure 1. Parque Estadual do Forno Grande, municipality of Castelo, state of Espírito Santo, south-eastern Brazil.

Sampling

Gathering records for this work included collection of primary and secondary data. Primary data was obtained from fieldwork activities from December 2008 to October 2011, beginning monthly at the first year, and turning to seasonally (dry and rainy seasons), in subsequent years, totaling more than 150 hours of sampling effort. The fieldwork was conducted at night and morning attended by two to five researchers each incursions. Several microhabitats within and around PEFG's area were surveyed, such as swamps in opened areas and at forest borders; temporary or permanent ponds; streams in forested and open areas and rocky outcrops. It is noteworthy that a great deal of bromeliads and forest litter were surveyed for amphibians in several of these microhabitats. Adult individuals were collected using active-searching method (*sensu* Franco et al. 2002). Tadpoles were captured with fishnets.

Adult specimens were euthanized in 5% Xylocaine gel, fixed using 10% Formaldehyde solution, and later conserved in 70% Ethanol. Tadpoles were euthanized and conserved in 5% Formaldehyde solution. Voucher specimens are housed at the amphibian collections of Museu Nacional, Rio de Janeiro (MNRJ).

Secondary data include: (i) available records from literature and (ii) specimens housed at scientific collections.

The following red lists were used to point out the conservation status of the amphibians recorded at PEFG: International Union for Conservation of Nature (IUCN) (IUCN 2011), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (CITES 2010), Brazilian (MMA 2000), and state of Espírito Santo (Gasparini et al. 2007) lists of threatened species.

Results and Discussion

We registered 31 species of amphibians (Figs 2-3) at PEFG included in the Orders Anura and Gymnophiona (Table 1). These are arranged in 17 genera among nine families. Within the Order Anura, Hylidae was the most speciose family (N=17), followed by Brachycephalidae (N=4), Leptodactylidae (N=3), Cycloramphidae, (N=2), and Bufonidae, Craugastoridae, Hylodidae and Leiuperidae with one species each. The Order Gymnophiona was represented uniquely by one species from the family Caeciliidae.

The state of Espírito Santo comprehends a total of 133 species of amphibians, and the Parque Estadual do Forno Grande harbors a substantial amphibian richness of the State (23%). Populations of amphibians from the mountainous region of Espírito Santo have been studied in recent years showing high diversity: Ramos & Gasparini (2004) reported 41 species in the APA-Goiapaba-Açu; Rödder et al. (Rödder 2006, 2007) obtained 50 species at the Reserva Biológica de Santa Lúcia, and 102 species sampled throughout the municipality of Santa Teresa. There are several other regions in Espírito Santo where amphibian studies are being conducted (TSS, pers. observ. 2012).

Scinax belloni is not only endemic, but also has the neighborhood of the Parque Estadual do Forno Grande as type locality and this area probably harbors the main population of this species, which was constantly detected throughout our study.

Another endemic species, *Brachycephalus alipioi*, also reported from the vicinity of PEFG, has not been found within the area despite efforts of almost three years. Its record was obtained from the original description (vicinity of PEFG) (Pombal & Gasparini 2006) and from a voucher housed at Museu de Biologia Mello Leitão (unique as secondary data) which refers to "Parque Estadual de

Table 1. Amphibians recorded at Parque Estadual do Forno Grande, state of Espírito Santo, southeastern Brazil. Voucher specimens deposited in institutional collections or source of the record (i.e., record in the literature or personal record of authors) are provided for each species. Red List: Species included in some category of IUCN, Brazilian, Espírito Santo, and CITES lists, except not listed species. LC – Least Concern; NT – Near Threatened; VU – Vulnerable; EN – Endangered; CR – Critically Endangered.

TAXON	Red List/ Conservation	Voucher specimen or source
AMPHIBIA Gray, 1825		
ANURA Fischer von Waldheim, 1813		
Brachycephalidae Günther, 1858		
Brachycephalus alipioi Pombal & Gasparini, 2006	DD in IUCN	MBML 2850; Pombal & Gasparini (2006)
Ischnocnema abdita Canedo & Pimenta 2010	-	MNRJ 76877
Ischnocnema guentheri (Steindachner, 1864)	LC in IUCN	MNRJ 76939; 76951
Ischnocnema gr. *parva* sp. nov.	-	MNRJ 77132-33
Bufonidae Gray, 1825		
Rhinella crucifer (Wied-Neuwied, 1821)	LC in IUCN	MNRJ 76899-900; 76932
Craugastoridae Hedges, Duellman and Heinicke, 2008		
Haddadus binotatus (Spix, 1824)	LC in IUCN	MNRJ 76878; 76962-63; 77064-66
Cycloramphidae Bonaparte, 1850		
Proceratophrys boiei (Wied-Neuwied, 1824)	LC in IUCN	MNRJ 76889; 76927; 77057-60
Thoropa miliaris (Spix, 1824)	LC in IUCN	MNRJ 76876; 76879-80; 76911; 76921-24; 77063
Hylidae Rafinesque, 1815		
Aplastodiscus arildae (Cruz & Peixoto, 1987)	LC in IUCN	MNRJ 76875; 76888; 76957
Aplastodiscus cavicola (Cruz & Peixoto, 1985)	NT in IUCN	MNRJ 76890-91; 76935-36; 76956
Bokermannohyla ibitipoca (Caramaschi & Feio, 1990)	DD in IUCN	MNRJ 76913-20
Bokermannohyla caramaschii (Napoli, 2005)	LC in IUCN	MNRJ 76896-97; 76940-42; 76948; 76953; 77051-53
Dendropsophus branneri (Cochran, 1948)	LC in IUCN	MNRJ 76905-07
Dendropsophus elegans (Wied-Neuwied, 1824)	LC in IUCN	MNRJ 76925-26; 76934
Dendropsophus minutus (Peters, 1872)	LC in IUCN	MNRJ 76958-61; 77061-62
Hypsiboas albopunctatus (Spix, 1824)	LC in IUCN	MNRJ 76881; 76933; 77054-56
Hypsiboas faber (Wied-Neuwied, 1821)	LC in IUCN	MNRJ 76903-04; 76929-30
Hypsiboas pardalis (Spix, 1824)	LC in IUCN	MNRJ 76887; 76937; 76945; 76964; 77049-50
Hypsiboas polytaenius (Cope, 1870"1869")	LC in IUCN	MNRJ 84108-13
Phyllomedusa aff. *rohdei*	-	MNRJ 76938; 77039
Scinax alter (B. Lutz, 1973)	LC in IUCN	MNRJ 76892-93; 76931; 77037-38
Scinax argyreornatus (Miranda-Ribeiro, 1926)	LC in IUCN	MNRJ 76908
Scinax belloni Faivovich, Gasparini & Haddad, 2010	EN in IUCN	MNRJ 76882-86; 76895; 76898; 76952
Scinax fuscovarius (A. Lutz, 1925)	LC in IUCN	MNRJ 76946-47
Scinax aff. *x-signatus* sp. nov.	-	MNRJ 76943-44; 76954-55; 76965-71;
Hylodidae Günther, 1858		
Megaelosia apuana Pombal, Prado & Canedo, 2003	DD in IUCN; VU in ES	MNRJ 76972
Leiuperidae Bonaparte, 1850		
Physalaemus cuvieri (Fitzinger, 1826)	LC in IUCN	MNRJ 77042-48
Leptodactylidae Werner, 1896		
Leptodactylus fuscus (Schneider, 1799)	LC in IUCN	MNRJ 76894; 77040-41
Leptodactylus latrans (Linnaeus, 1758)	LC in IUCN	MNRJ 76928; 76949-50
Leptodactylus spixi Heyer, 1983	LC in IUCN	MNRJ 76901-02
GYMNOPHIONA Müller, 1832		
Caeciliidae Rafinesque, 1814		
Siphonops annulatus (Mikan, 1820)	LC in IUCN	MNRJ 76912

Forno Grande" but its geographical coordinates (20º36'13" S, 41º11'05" W) indicate PEFG's surroundings. More fieldwork might be carried out in order to record the species from this protected area or to understand their absence therein.

Regarding the conservation status of species,

A. cavicola is categorized as Near Threatened at IUCN (Cruz et al. 2010) and *S. belloni* as Endangered (Angulo et al. 2011). The species *Megaelosia apuana* is categorized as Data Deficient (Pombal 2004), but in the List of Endangered Species of Espírito Santo it is presented as Vulnerable to Extinction (Gasparini et al. 2007). The remaining species are categorized as Deficient Data or Least Concern.

The Parque Estadual do Forno Grande has been facing current conservational challenges itself, derived from illegal activities that have been taking place in and around its area, threatening the local fauna. According to the park's staff (Leoni Soares Contaifer, Espírito Santo, pers. comm. 2012), in general, PEFG suffers with the invasion of people going therein (i) touring around, (ii) catching wild birds, and (iii) collection of bromeliads for illegal trade. That provides removal of rupestral vegetation, forming clandestine trails. Furthermore, the region also has to deal with (iv) illegal hunting, (v) general deforestation, and (vi) removal of jussara palms (*Euterpe edulis*).

However, as regarding amphibians, removal of bromeliads for illegal trade and general deforestation are the main negative effects that directly affect the group. There are some species as *A. arildae*, *B. caramaschii*, *H. pardalis*, *S. fuscovarius*, *S.* aff. *x-signatus* sp. nov. that use bromeliads for some functions as sheltering, feeding and/or reproduction, or even for every single function of its life, as *Scinax belloni*, a bromeligenous species.

The highest representation of the Hylidae in this work supports the Neotropical pattern observed by Duellman (1999) and the pattern shown for many areas of the Atlantic rainforest (e.g., Heyer et al. 1990, Haddad & Sazima 1992, Pombal & Gordo 2004, Vasconcelos & Rossa-Feres 2005, Ferreira et al. 2010a). This factor is typically related to its ability to use vertical habitats due to the presence of adhesive discs at the end of its fingers (Cardoso et al. 1989). This feature decreases the competition for breeding sites allowing them to occupy a wider diversity of microhabitats (Dixon & Heyer 1968).

Concerning the distribution of some species, the first records of *Aplastodiscus arildae* for Espírito Santo obtained from the Parque Estadual do Forno Grande and another adjacent locality (Silva-Soares et al. 2011), is remarkable. Despite efforts of several researches surveying the mountains of the state of Espírito Santo over the years, the species remained unreported.

Ischnocnema abdita is a species recently described (Canedo & Pimenta 2010) which was also found at PEFG although represented by only one specimen. It was in nocturnal activity on the leaf litter and had cryptic coloration to the environment. This species is endemic to the state of Espírito Santo and presents scattered and isolated populations. Our records indicate a new location for the species; currently known to the municipalities of Santa Teresa (type locality), Cariacica, Mimoso do Sul (Canedo & Pimenta 2010), Santa Maria de Jetiba, Vargem Alta (Almeida et al. 2011), and Castelo (present work).

Scinax belloni is a small bromeligenous treefrog (group that has the entire life cycle associated to bromeliads) described by Faivovich et al. (2010). The rock formation that prevails at PEFG has high abundance of bromeliads of the genus *Alcantarea*, which, according to Faivovich et al. (2010), is the main microhabitat occupied by this species. This species has had its biological aspects recently described as its tadpole by Silva-Soares et al. (2010), advertisement call described by Peres & Simon (2011) and, its biological and reproductive traits in development (Scherrer et al. in develop.).

Bokermannohyla caramaschii is endemic to the northern sector of the Serra da Mantiqueira range in the states of Espírito Santo and Minas Gerais at altitudes up to 655 m a.s.l. According to Napoli (2005), it is characterized by lack of vocal slits and it is geographically separated from *B. circumdata* and *B. luctuosa* by a low-lying rift valley. The species is found in several municipalities of Espírito Santo (Almeida et al. 2011), but PEFG's records are the first reports for the municipality of Castelo.

Bokermannohyla ibitipoca was restricted only to Parque Estadual do Ibitipoca and Parque Estadual da Serra do Brigadeiro, two highlands of the state of Minas Gerais. However, Moura et al. (2008) reported the first record of *B. ibitipoca* in the state of Espírito Santo. These individuals were first collected at the Parque Estadual da Pedra Azul (20º24'07" S, 41º01'23" W). Our records at PEFG reaffirm its presence in the state of Espírito Santo, providing a new locality to *B. ibitipoca*.

Regarding the taxonomic position of species, *Ischnocnema* gr. *parva* sp. nov. is in process of description (Carlos A.G. Cruz, Rio de Janeiro, pers. comm. 2013). The individuals were found at the leaf litter during nighttime, apparently in activity.

Faivovich et al. (2005) has shown *P. rohdei* to be paraphyletic. However, the authors did not use tissue of *P. rohdei* of the type locality (state of Rio

Figure 2. Amphibians from Parque Estadual do Forno Grande, municipality of Castelo, state of Espírito Santo, southeastern Brazil. **A.** *Haddadus binotatus*; **B.** *Ischnocnema abdita*; **C.** *Ischnocnema* gr. *parva* sp. nov.; **D.** *Aplastodiscus cavicola*; **E.** *Aplastodiscus arildae*; **F.** *Bokermannohyla ibitipoca*; **G.** *Bokermannohyla caramaschii*; **H.** *Dendropsophus branneri*; **I.** *Dendropsophus minutus*; **J.** *Hypsiboas albopunctatus*; **K.** *Hypsiboas polytaenius*.

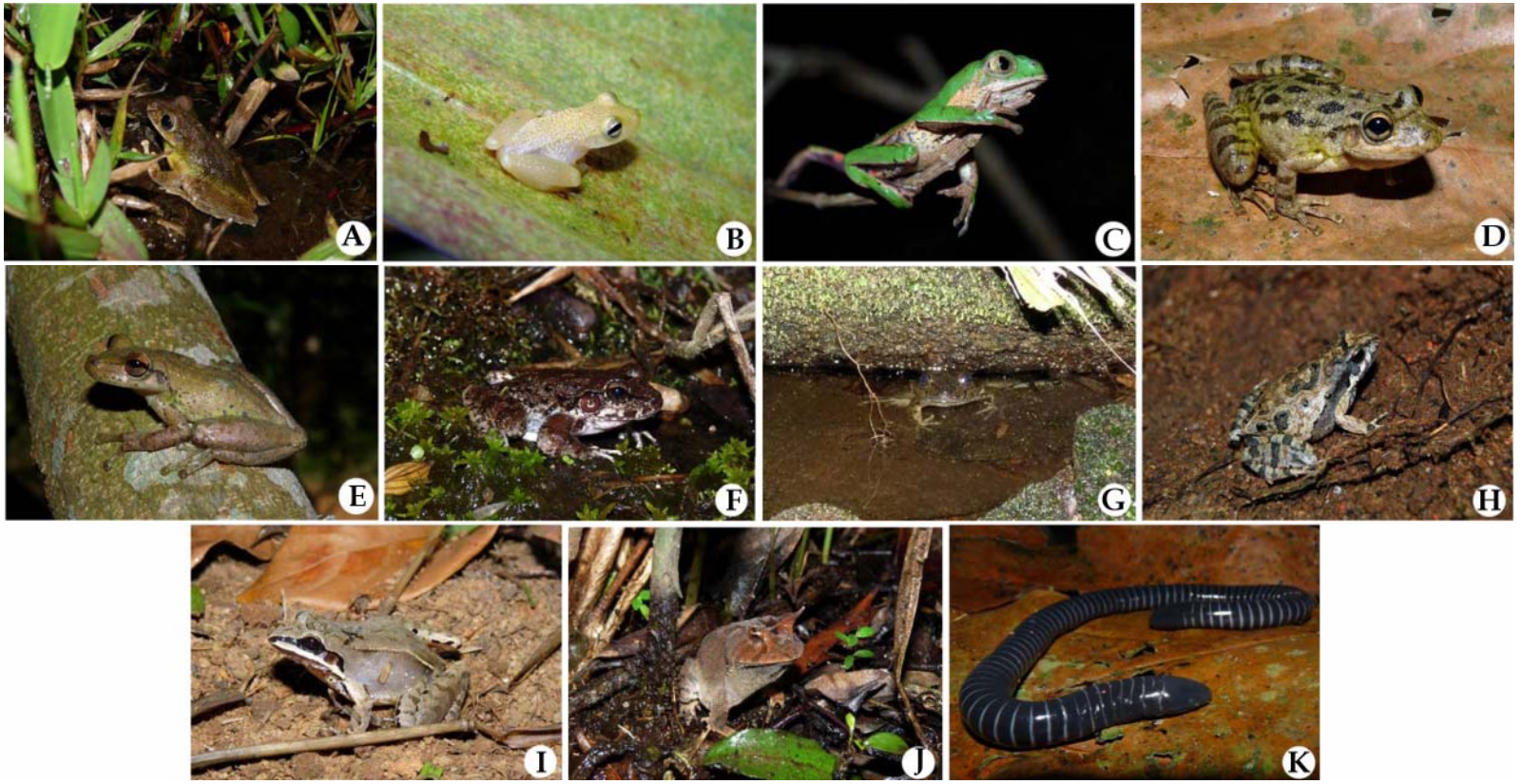

Figure 3. Amphibians from Parque Estadual do Forno Grande, municipality of Castelo, state of Espírito Santo, southeastern Brazil.
A. *Hypsiboas pardalis*; **B.** *Scinax belloni*; **C.** *Phyllomedusa rodhei*; **D.** *Scinax fuscovarius*;
E. *Scinax* aff. *x-signatus*; **F.** *Thoropa miliaris*; **G.** *Megaelosia apuana*; **H.** *Physalaemus cuvieri*;
I. *Leptodactylus spixi*; **J.** *Procerathoprhys boiei*; **K.** *Siphonops annulatus*.

de Janeiro), thus it is still not possible to define the relationship of these samples with *Phyllomedusa rohdei* from Espírito Santo. Rather, herein we consider the species as *Phyllomedusa* aff. *rohdei* ever since there is a review of this species group in progress and it is likely that this species in Espírito Santo is a different taxon (Délio Baêta, Rio de Janeiro, pers. comm. 2012).

At last, there is a confusion regarding *Scinax x-signatus* in progress of being solved. A neotype of the species has been designated, and here we know that the species occurring at PEFG and several other areas of Espírito Santo referred to as *Scinax* aff. *x-signatus* represents a new species of this complex under description (Monica C.S. Cardoso pers. comm. 2012).

Despite being an inhabitant of underground galleries and difficult to be encountered, two specimens of *Siphonops annulatus* were found in the region. Both were found at nighttime, one in an open area that had recently been mowed and another at the road in the vicinity of PEFG after a heavy rain. Apparently, both events must have stirred their habitat causing them to be driven out of their galleries.

Recently studies in mountain region have provided new records for species that were formerly known only from their type locality in Espírito Santo such as *Dendropsophus ruschii* (Peloso & Gasparini 2006), *Ischnocnema oea* (Silva-Soares et al. 2009), *Euparkerella tridactyla* (Ferreira et al. 2010b), *Megaelosia apuana* (Santos et al. 2011), or new occurrence for the state, such as *Phasmahyla guttata* (Oliveira et al. 2009), *Physalaemus signifer* (Ferreira et al. 2009), *Zachaenus carvalhoi* (Verdade et al. 2009, Motta et al. 2010), and *Aplastodiscus arildae* (Silva-Soares et al. 2011).

Moreover, through these studies, enormous effort in fieldwork and taxonomic revisions with material from mountainous regions, several amphibian species have been described recently (year 2000 up to now), some of them yet endemic to the region of their discovery: *Scinax arduous* Peixoto, 2002; *Megaelosia apuana* Pombal, Prado & Canedo, 2003; *Bokermannohyla caramaschii* (Napoli, 2005); *Proceratophrys paviotii* Cruz, Prado & Izecksohn, 2005; *Brachycephalus alipioi* Pombal & Gasparini, 2006; *Leptodactylus cupreus* Caramaschi, Feio & São Pedro, 2008; *Ischnocnema abdita* Canedo & Pimenta, 2010; and *Scinax belloni* Faivovich, Gasparini & Haddad, 2010.

Thus, these studies and their results reinforce the importance of studying amphibians at the highlands of Espírito Santo. It also demonstrates the lack of knowledge regarding the real biodiversity in this state. This fact impedes further conservation approaches to define priority areas for conservation. Current protected areas under this scenario become fundamental for conservation of amphibians. Our work at Parque Estadual do Forno Grande contributes to the knowledge of amphibians of the mountain region of Espírito Santo.

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