



<http://dx.doi.org/10.11646/zootaxa.3846.3.2>

<http://zoobank.org/urn:lsid:zoobank.org:pub:EC1E6FEE-F155-418D-98CD-7A5F86D8D692>

A new diminutive frog species of *Adelophryne* (Amphibia: Anura: Eleutherodactylidae) from the Atlantic Forest, southeastern Brazil

RICARDO LOURENÇO-DE-MORAES^{1,5}, RODRIGO BARBOSA FERREIRA², ANTOINE FOUQUET³ & ROGÉRIO PEREIRA BASTOS⁴

¹Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais (PEA), Universidade Estadual de Maringá (UEM), CEP: 87020-900, Maringá, PR, Brazil.

²Dept. Wildland Resources and Ecology Center 5230 Old Main Hill, Utah State University Logan, 84322, UT, USA.

³CNRS Guyane-USR3456 Immeuble Le Relais 2, Avenue Gustave Charlery 97300, Cayenne, French Guiana.

⁴Laboratório de Herpetologia e Comportamento Animal, Departamento de Ecologia, Instituto de Ciências Biológicas, Universidade Federal de Goiás, Campus Samambaia, 74001-970, Cx. Postal 131, Goiânia, GO, Brazil.

⁵Corresponding author. Email: ricardo_lmoraes@hotmail.com

Abstract

The genus *Adelophryne* is composed of diminutive frogs occurring in northern Amazonia and the Atlantic Forest. Herein we describe a new species of *Adelophryne* found in the leaf litter of primary and secondary forests in the mountainous region of Espírito Santo state, southeastern Brazil. The new species is characterized by its small body size, two phalanges in the finger IV, and a glandular ridge line that runs from the posterior part of eye to the insertion of the forelimb. This species is sensitive to edge effect and conversion of native forest into coffee and *Eucalyptus* plantations and may be listed as Endangered (EN) under B1ab(iii) criteria of the IUCN Red List.

Key words: Biodiversity, Conservation, Espírito Santo, Morphology, Natural history, Santa Teresa, Taxonomy

Resumo

O gênero *Adelophryne* é composto por espécies diminutas que ocorrem no norte da Amazônia e na Mata Atlântica. Descrevemos uma nova espécie de *Adelophryne* encontrada na serrapilheira de florestas primárias e secundárias na região montanhosa do estado do Espírito Santo, sudeste do Brasil. A nova espécie é caracterizada pelo pequeno tamanho, duas falanges no dedo IV e uma linha glandular rígida que vai da parte posterior do olho em direção aos membros anteriores. Esta espécie apresentou sensibilidade aos efeitos de borda e a conversão das florestas em plantações de café e *Eucalyptus* e pode ser classificada como Em Perigo pelos critérios B1ab(iii) Lista Vermelha da IUCN.

Palavra-chave: Biodiversidade, Conservação, Espírito Santo, Morfologia, História natural, Santa Teresa, Taxonomia.

Introduction

The current massive species decline generates pressure on biologists to document and describe the world's biodiversity (Barnosky *et al.* 2011). This is particularly critical in the tropics, which host the bulk of biodiversity on Earth (Gaston & Williams 1996) but still remains largely under-documented (Haddad *et al.* 2013). The Atlantic Forest of Brazil provides a dramatic contrast, harboring a large number of endemic species in small-isolated forest patches (Becker *et al.* 2007). Despite being flagged among the “biodiversity hotspots” (Myers *et al.* 2000), this biome is still being degraded at a fast/steady pace (Ribeiro *et al.* 2009). In the last decades many studies have revealed a large underestimation of amphibian species occurring in the Atlantic Forest (Giam *et al.* 2012) and previously unrecognized lineages sometimes >10 millions of years old (e.g. Fouquet *et al.* 2012).

Adelophryne Hoogmoed & Lescure, 1984 is a genus of small-sized, agile, cryptic, and secretive frog species

that inhabit the leaf litter of forest floor (Hedges *et al.* 2008). These traits make these species difficult to be collected (MacCulloch *et al.* 2008; Lourenço-de-Moraes *et al.* 2012), which is reflected by the low number of exemplars in scientific collections. The genus occurs in the Atlantic Forest and northern Amazonia (Hedges *et al.* 2008; Lourenço-de-Moraes *et al.* 2012; Fouquet *et al.* 2012; Frost 2014).

Currently eight species are known within this genus: *A. adistola* Hoogmoed & Lescure, 1984; *A. gutturosa* Hoogmoed & Lescure, 1984; *A. maranguapensis* Hoogmoed, Borges & Cascon, 1994; *A. baturitensis* Hoogmoed Borges & Cascon, 1994; *A. pachydactyla* Hoogmoed Borges & Cascon, 1994; *A. patamona* MacCulloch, Lathrop, Kok, Minter, Khan, & Barrio-Amorós, 2008; *A. mucronatus* Lourenço-de-Moraes, Solé & Toledo, 2012 and *A. meridionalis* Santana, Fonseca, Neves & Carvalho, 2012. In a molecular phylogeny, Fouquet *et al.* (2012) corroborated the monophyly of *Adelophryne* and revealed a number of unnamed species including some from the Atlantic Forest.

During surveys in a mountainous region of Atlantic Forest, we found a new species of *Adelophryne*. Here we describe this new species and provide information on its natural history, threats, and conservation status.

Materials and Methods

The new species was found within and around the Reserva Biológica Augusto Ruschi (REBIO, 19° 54' S, 40° 32' W), municipality of Santa Teresa, Espírito Santo state, Brazil (Fig. 1). The elevation of sampled sites range from 745 to 922 m. Summer is hot and humid whereas the winter is mild to cold, typical of a humid tropical climate type according to Köppen-Geiger's climate classification (Peel *et al.* 2007). The rains primarily fall between October and March. Santa Teresa is in the Atlantic Forest biome, specifically classified as montane and sub-montane rainy forest composed of non-deciduous trees (*sensu* Rizzini 1979).

Specimens were hand-captured on the leaf litter during surveys from August to December 2012 and June to July 2013. Sampling took place within plots of 5 m x 5 m. Each plot was surveyed simultaneously by four people during 20 minutes at night. To evaluate human disturbance we surveyed 336 plots, including 42 plots at forest edge of primary forest, 42 plots inside primary forest at both 50 m and 200 m from the forest edge, and 42 plots at 50 m from the forest edge and within the three most widespread matrix-habitat types in this area (coffee plantation, *Eucalyptus* spp. plantation, and secondary growth forest). Defensive behavior was tested in laboratory for seven adults following the methodology proposed by Williams *et al.* (2000). Pearson's chi-square exact test (χ^2) was used to compare habitat use across sites using a Monte Carlo simulation based on 999 replicates. This analysis was performed using the package 'MASS' (Ripley *et al.* 2014) with the program R 2.8.1 (R Development Core Team, 2004).

All specimens were collected by RBF and the Bromeligenous Project's team at the type locality. Voucher specimens were deposited in the Zoological Collections of Universidade Estadual de Santa Cruz, Ilhéus (MZUESC), Museu Nacional, Rio de Janeiro, Rio de Janeiro (MNRJ), Coleção Zoológica da Universidade Federal de Goiás (ZUFG), and Museu de Biologia Mello Leitão (MBML).

Measurements were taken under a stereomicroscope with digital calipers. The measurements follow Lourenço-de-Moraes *et al.* (2012): snout-vent length (SVL); head length (HL); head width (HW); eye diameter (ED); upper eyelid width (UEW); interorbital distance (IOD); internarial distance (IND); eye-nostril distance (END); nostril to tip of snout distance (NSD); eye to tip of snout distance (ETSD); foot length (FL = measured from the proximal edge of the inner metatarsal tubercle to the tip of Toe IV and from the heel to the proximal edge of the inner metatarsal tubercle); thigh length (THL); and tibia length (TL). The description of snout shape in lateral view follows Cei (1980). The terminology of ventral and dorsal views follows Heyer *et al.* (1990). The terminology of the tympanum, fingers, toes, and subdigital pads follows Hoogmoed *et al.* (1994). The description of finger and toe tips follows Lourenço-de-Moraes *et al.* (2012). The terminology of skin texture follows Kok & Kalamandeen (2008). Skeletal characters were determined from six cleared and stained individuals. Sex was determined from presence of vocal sac, SVL, and examination of gonads of cleared individuals. In addition, eggs were visible through the skin of the ventral region of some females. Comparisons between species were made from direct examination of specimens (CFBH, DHMECN, MNRJ, MZUESC, MZUFV, and ZUEC; see Appendix for details) and from original species descriptions (Hoogmoed & Lescure 1984; Hoogmoed *et al.* 1994; MacCulloch *et al.* 2008; Lourenço-de-Moraes *et al.* 2012; Santana *et al.* 2012).

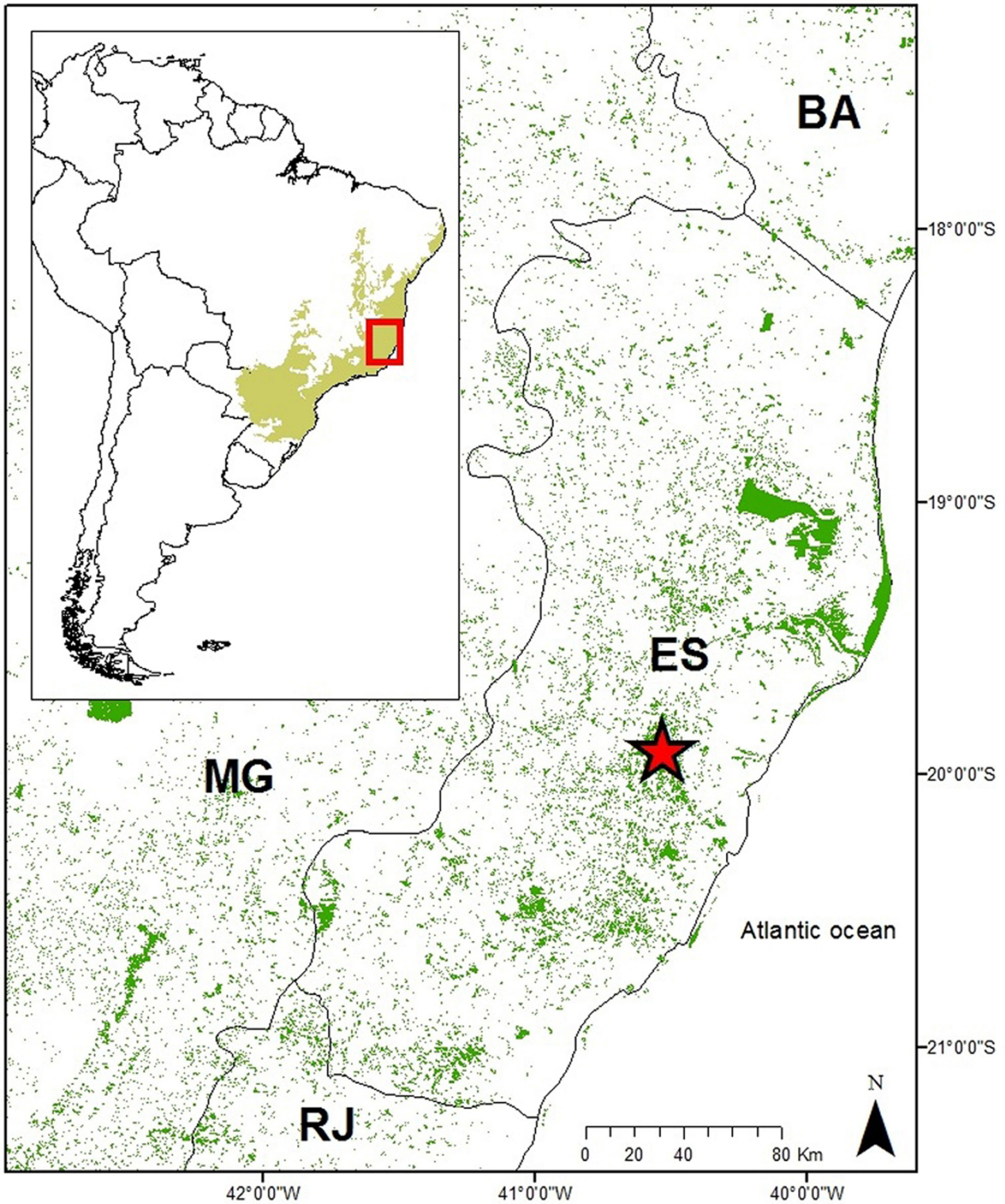


FIGURE 1. Type locality of *Adelophryne glandulata* **sp. nov.**, municipality of Santa Teresa, Espírito Santo state, Brazil. Forest remnants (green) across the original extension of Atlantic Forest (beige). States = BA (Bahia), ES (Espírito Santo), MG (Minas Gerais), and RJ (Rio de Janeiro).

Results

Adelophryne glandulata sp. nov.

Figs. 2A, B; 4A, B; 5

Holotype. Adult male (MNRJ 87077; Fig. 2) collected on 28 August 2012 in a primary forest (Trilha Roda d'água) at REBIO Augusto Ruschi in the municipality of Santa Teresa, state of Espírito Santo, Brazil (19° 54' 35.55" S, 40° 32' 31.76" W, 806 m asl).

Paratypes. Six adult males (MBML 7636–7, MNRJ 87081, MZUESC 12178, and ZUFG 7961–2), and eleven adult females (MBML 7638–9, MNRJ 87078–80, MZUESC 12179–81, and ZUFG 7963–5). These specimens were collected from August to December 2012 and June to July 2013.

Diagnosis. The new species inhabits the leaf litter of forest floor; none exceeds 20 mm in SVL; the terminal digits are either barely or not expanded; the digits are pointed apically. These features are included in the subfamily Phyzelaphryninae (see Hedges *et al.* 2008). These specimens are distinguished from the genus *Phyzelaphryne* because they possess: subdigital pads rather than subarticular tubercles (subarticular tubercles in *Phyzelaphryne*), reduction of the phalanges in the finger IV (no reduction in *Phyzelaphryne*), and indistinct tympanum (distinct in *Phyzelaphryne*). For more details see Hoogmoed & Lescure (1984), Hoogmoed *et al.* (1994) and Hedges *et al.* (2008).

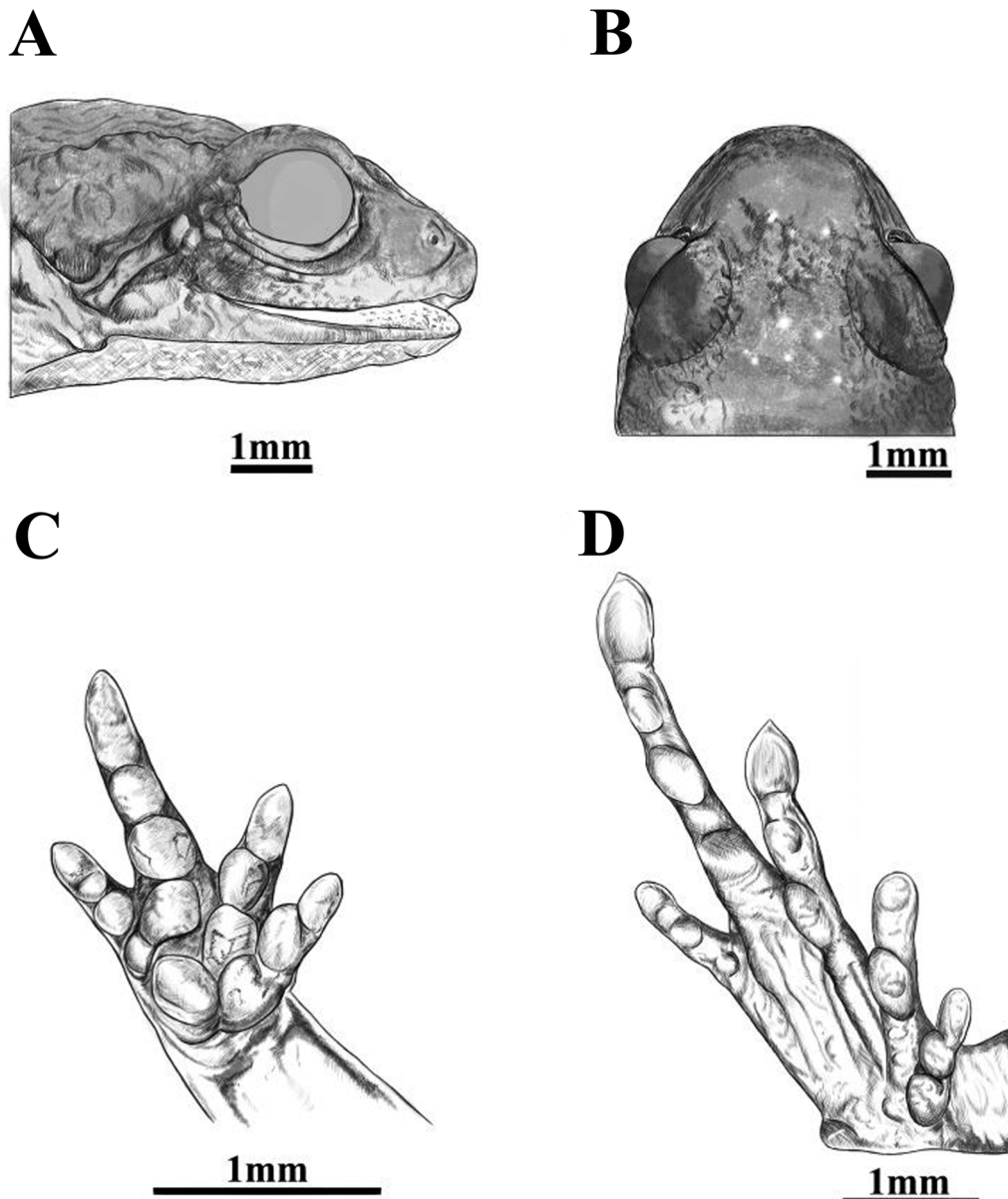


FIGURE 2. Adult male holotype of *Adelophryne glandulata* sp. nov. (MNRJ 87077). Lateral (A) and dorsal (B) views of head, ventral views of hand (C) and foot (D).

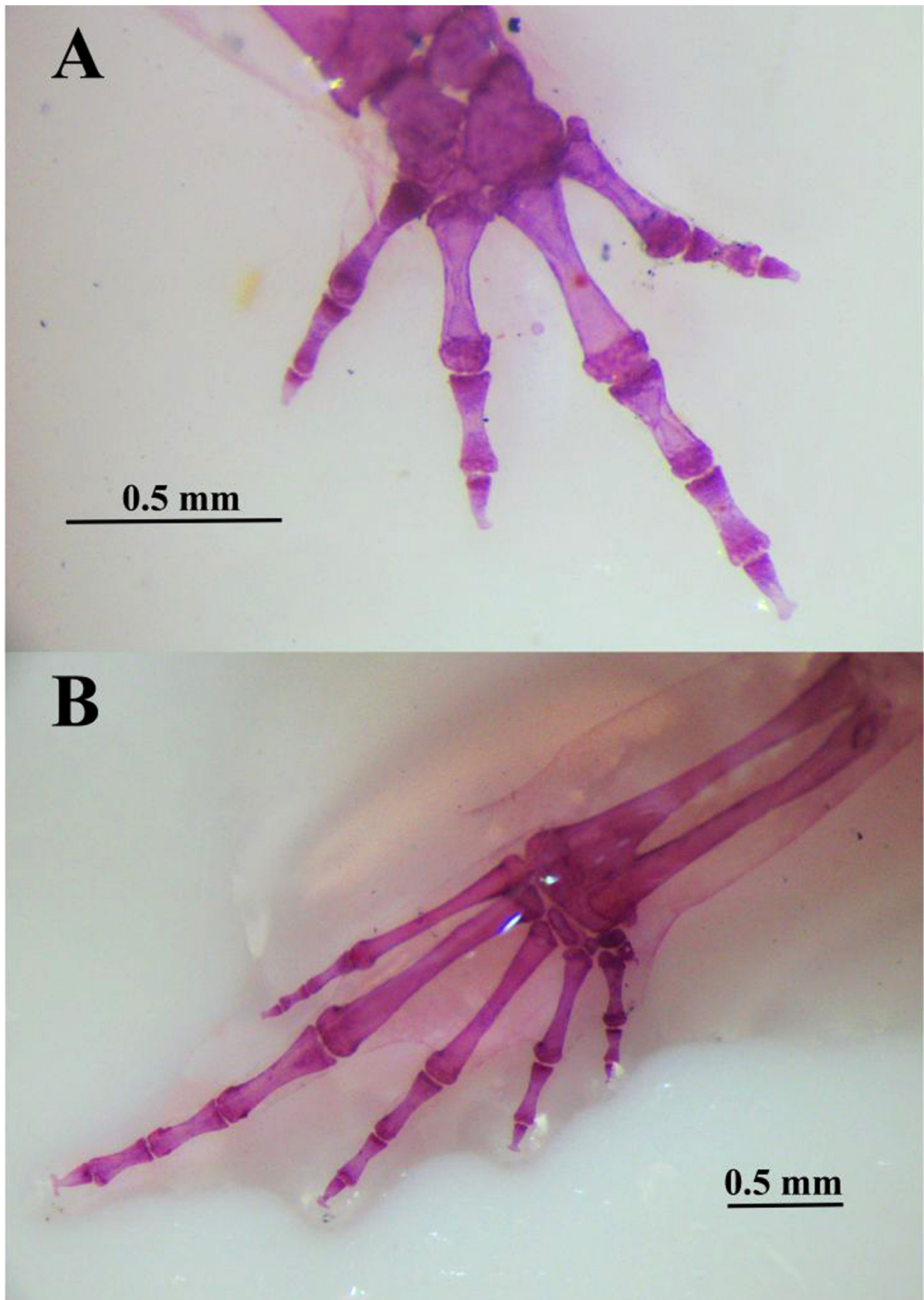


FIGURE 3. Views of hand (A) and foot (B) of a cleared and stained paratype *Adelophryne glandulata* sp. nov. (MZUESC 12181).

The generic assignment of *Adelophryne glandulata* **sp. nov.** is based on the possession of a head narrower than body, small size, cranial crests absent, finger IV with single subdigital pad and tip slightly mucronate, toes III and IV with discs and mucronate tips, and terminal phalanges of toes and fingers T-shaped.

The new taxon is diagnosed by the following combination of character states: (1) male SVL smaller than 11 mm (males 10.5±0.3; females 12.2±0.6); (2) tympanum indistinct without visible membrane; (3) tympanic annulus absent; (4) dentigerous processes of vomers absent; (5) fingers without terminal discs, tips of fingers slightly mucronate and terminal phalanges T-shaped; (6) toes with circumferential grooves and either terminal or vestigial discs, terminal tips mucronate; (7) terminal phalanges of toes T-shaped; (8) finger I shorter than finger II; (9) phalangeal formula to fingers 2–2–3–2; (10) phalangeal formula to toes 2–2–3–4–3; (11) subarticular tubercles absent (subdigital pads present); (12) belly skin smooth; (13) dorsum skin shagreened; (14) anal flap absent; (15) a glandular ridge line that runs from the posterior part of eye to the insertion of the forelimb.

Comparison with other species. *Adelophryne glandulata* **sp. nov.** is distinguished from several congeners by its smaller size (maximum SVL 16.3 mm in *A. baturitensis*, 16.0 mm in *A. gutturosa*, 17.4 mm in *A. maranguapensis*, 14.9 mm in *A. mucronatus*, and 23.0 mm in *A. patamona*, and 13.1 mm in *A. glandulata* **sp. nov.**). The new species can be distinguished from *A. baturitensis* and *A. maranguapensis* by lacking discs or circumferential grooves on fingers. It can also be distinguished from *A. baturitensis* by the absence of subarticular tubercles (subdigital pads present in *A. glandulata* **sp. nov.**). From all other congeners by subdigital pad formula (2–3–4–2 in *A. pachydactyla*, 1–1–2–2, *A. maranguapensis*, 1–1–2–1 in *A. adiastrata*, *A. gutturosa*, *A. meridionalis*, and *A. patamona*, 1–2–3–1 in *A. mucronatus*, and 1–2–2–1 in *A. glandulata* **sp. nov.**). It can also be distinguished from all other congeners but *A. gutturosa* by the presence of a distinct glandular ridge line that runs from the posterior part of the eye to the insertion of the forelimb. It is further distinguished from *A. baturitensis*, *A. gutturosa*, *A. maranguapensis*, *A. mucronatus*, and *A. patamona* by having two phalanges in finger IV (three in *A. baturitensis*, *A. gutturosa*, *A. maranguapensis*, *A. mucronatus*, and *A. patamona*). It is distinguished from *A. adiastrata*, *A. baturitensis*, *A. meridionalis*, *A. mucronatus*, *A. pachydactyla*, and *A. patamona* by skin texture of dorsum (smooth in *A. baturitensis*, *A. meridionalis*, and *A. pachydactyla*, smooth with scattered small granules in *A. mucronatus*, shagreened to granular in *A. adiastrata*, and tuberculated in *A. patamona*, shagreened with small and rounded tubercles in *A. glandulata* **sp. nov.**). It is distinguished from *A. baturitensis*, *A. adiastrata*, *A. gutturosa*, *A. maranguapensis*, *A. mucronatus*, *A. pachydactyla*, and *A. patamona* by having a indistinct tympanum (distinct in *A. baturitensis*, *A. adiastrata*, *A. gutturosa*, *A. maranguapensis*, *A. mucronatus*, *A. pachydactyla*, and *A. patamona*). It is distinguished from *A. meridionalis* by having toes II, III, IV and V with circumferential grooves or disc (*A. meridionalis* has only toe IV with circumferential grooves).

Description of the holotype. Adult male, SVL 10.5 mm (Fig. 2). Snout rounded in ventral, lateral and dorsal views (Fig. 2). ETSD slightly smaller than ED with approximately 6.2%. END smaller than IND with approximately 53.8%. Nostrils not protruding and rounded. IND smaller than IOD with approximately 72.2%. Canthus rostralis indistinct, concave in lateral view. Loreal region concave. Choanae small, round, located laterally. Dentigerous processes absent. Tongue ovoid, free except its anterior margin. Vocal sac single, subgular. Pupil horizontally oval. Upper eyelid slightly convex. Temporal region vertical, tympanum indistinct, tympanic annulus absent, and a distinct glandular ridge line that runs from the posterior part of eye to the insertion of the forelimb and two smaller-rounded glandular posterior to the eye with to 0.3 mm diameter. Skin texture of venter smooth, dorsum and limbs shagreened, rough to the touch with small and rounded tubercles, approximate equal size and very close to one another, relatively flat; flanks and ventral region of thighs areolate. Anal flap absent, cloacal opening positioned at slightly below the level of the dorsal surface of the thigh. Fingers without discs and mucronate tips; fingers thin, depressed and short, without webbing. Finger formula: I=IV<II<III (Fig. 2C). Phalangeal formula for fingers 2–2–3–2 (Fig. 3A). Fingers and palm appear to be surrounded by a narrow strip of transparent skin. Subarticular tubercles absent with subdigital pads (1–2–2–1); no pads under ultimate phalanges. Inner metacarpal tubercle ovoid, outer metacarpal tubercle round, slightly larger than inner. Toes without webbing, cylindrical but slightly flattened. Toes formula: I<V<II<III<IV; tips of toes II and V with circumferential groove and slightly mucronate, III and IV with discs and mucronate tips; tip of toe I without disc or circumferential groove, slightly mucronate (Fig. 2D). Phalangeal formula for toes 2–2–3–4–3 (Fig. 3B). Skin transparent only on the distal portion of toes. Subarticular tubercles absent with round subdigital pads present (1–1–2–3–1); no pads under ultimate phalanges and no supernumerary tubercles. Inner metatarsal tubercle oval; outer metatarsal tubercle smaller and rounded. For measurements see Table 1.

Color. Venter dark with numerous small white dots. Throat and underside of thighs and shanks black. Dorsum golden brown, dark brown or reddish brown with two dark brown lines of variable width in mid-dorsum. Loreal region dark brown; a dark brown stripe extending along the flanks and reaching the groin. Thigh and tibia with one

or two dark brown bands. Numerous tiny white dots on dorsum, flanks, and dorsal surfaces of limbs. Iris reddish brown or dark brown with black reticulations (Fig. 4A). The color pattern does not change in preservative, although colors become darker than in life.

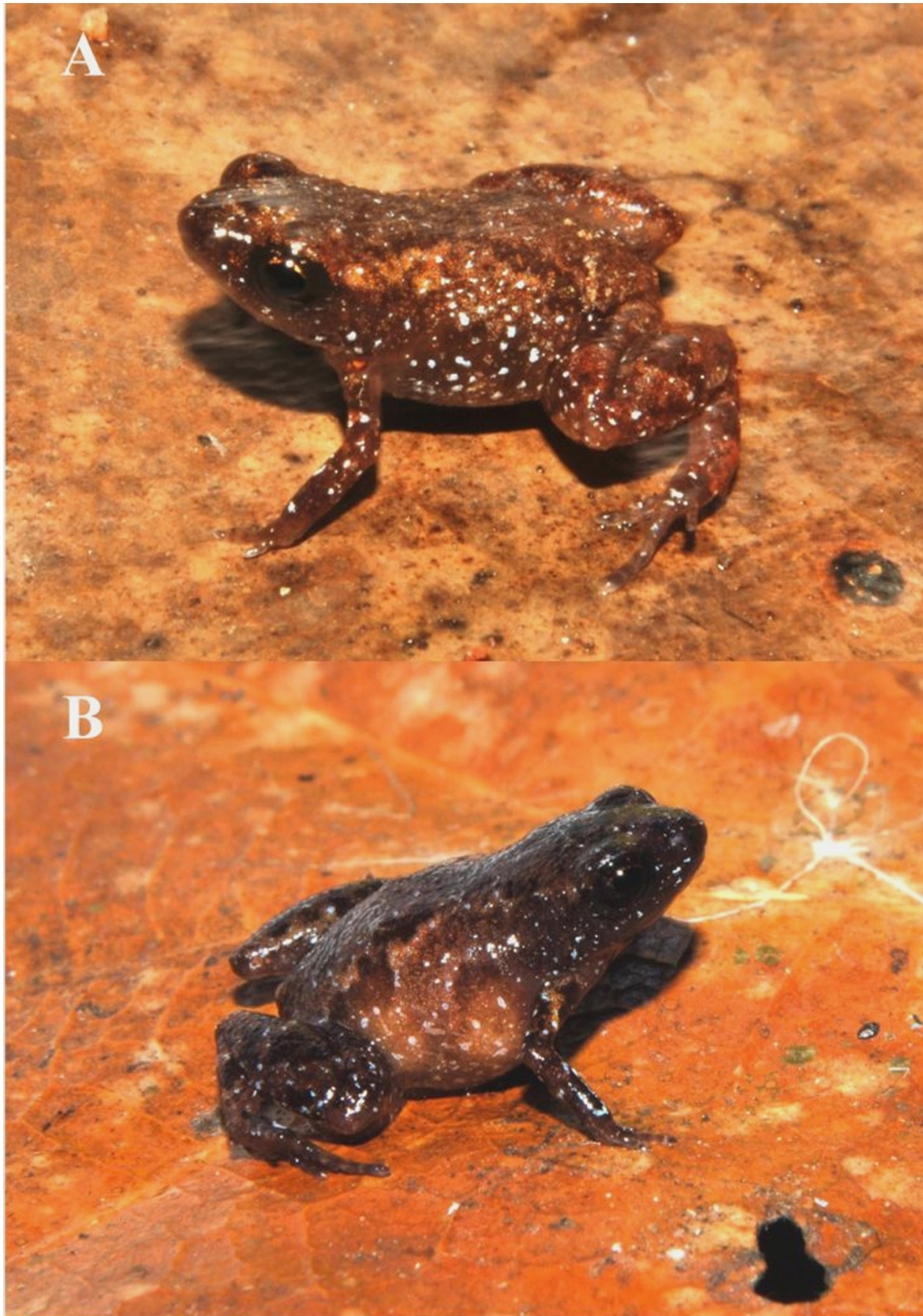


FIGURE 4. Adult individuals of *Adelophryne glandulata* sp. nov. in life: (A) male paratype (MZUESC 12180—10.2 mm), and (B) female paratype with eggs visible through flank skin (MNRJ 87080—12.8 mm).

Variation. The individuals vary greatly in dorsal coloration (not sexually dimorphic), from golden to dark brown and reddish brown. Females are larger than males (mean SVL in females 12.2±0.6 mm, males 10.5±0.3mm); males vary in THL more than females (mean in females 4.9–5.7 mm, in males 4.9–5.9 mm), TL (mean in females 5.1–5.7, in males 4.5–5.6) and FL (mean in females 8.2–10.0 mm, in males 7.0–9.2 mm); females vary more than males in HL (mean in females 3.9–4.6 mm, in males 3.5–3.9 mm) and IOD (mean females 1.6–2.6 mm, males 1.7–1.9 mm). The rounded glandular series posterior to the eye vary in size among individuals or may be absent. For morphometric variation see Table 1.

TABLE 1. Measurements of the type series of *Adelophryne glandulata* sp. nov. Values presented in millimeters as mean ± standard deviation (range).

Measurement	Holotype		Paratypes	
	Male	Males (n=6)	Females (n=6)	
SVL	10.5	10.5±0.3 (10.9–10.1)	12.2±0.6 (13.1–11.5)	
HL	3.6	3.8±0.2 (3.9–3.5)	4.2±0.3 (4.6–3.9)	
HW	3.7	3.8±0.2 (4.0–3.6)	4.1±0.1 (4.2–3.9)	
ED	1.5	1.7±0.1 (1.9–1.6)	1.8±0.1 (2.0–1.7)	
UEW	1.0	1.2±0.0 (1.2–1.1)	1.3±0.1 (1.4–1.1)	
IOD	1.8	1.8±0.1 (1.9–1.7)	2.0±0.3 (2.6–1.6)	
IND	1.3	1.5±0.1 (1.6–1.3)	1.7±0.1 (1.9–1.5)	
END	0.7	0.9±0.0 (1.0–0.9)	1.0±0.1 (1.2–0.8)	
NSD	0.8	0.9±0.1 (1.0–0.7)	0.9±0.1 (1.0–0.7)	
THL	5.0	5.2±0.3 (5.9–4.9)	5.2±0.3 (5.7–4.9)	
TL	5.0	4.9±0.4 (5.6–4.5)	5.4±0.3 (5.7–5.1)	
FL	8.3	8.3±0.8 (9.2–7.0)	9.0±0.8 (10.0–8.2)	
ETSD	1.4	1.6±0.1 (1.8–1.5)	1.8±0.1 (1.9–1.7)	

Geographic Distribution. *Adelophryne glandulata* sp. nov. is only known from the type locality, in forested areas of the municipality of Santa Teresa, Espírito Santo state, southeastern Brazil, from 675 m to 922 m elevation.

Natural History and Ecology. A total of 109 individuals of *A. glandulata* sp. nov. were captured inside the forest across 252 plots of 5 m x 5 m. If we consider detection probability = 1, the species density is 1.73/100 m². This represents the third greatest density among all frog species collected along our samplings. The most abundant species were *Haddadus binotatus* (Spix, 1824) and *Ischnocnema* sp. 1 aff. *parva* (C.A. Cruz, In Prep.). Fourteen individuals were found in plots at forest edge, 47 were in plots at 50 m inside the forest, and 44 at 200 m inside the forest. Abundance was significantly higher in plots at 50 and 200 m inside primary forest compared to plots at the forest edge (Chi-Square (χ^2) = 18.38, $P < 0.005$). Only three individuals were found in a secondary-growth forest, although 28 plots were placed in each of the three matrix-habitat types sampled across the studied landscape (coffee plantation, *Eucalyptus* plantation, and secondary-growth forest).



FIGURE 5. Mouth-gaping exhibited as defensive behavior (specimen no vouched).

We found 13 species co-occurring with *A. glandulata* **sp. nov.** in the same 5 m x 5 m plots (*Chiasmocleis schubarti* Bokermann, 1952; *Euparkerella tridaactyla* Izecksohn, 1988; *Haddadus binotatus* [Spix, 1824]; *Ischnocnema abdita* Canedo & Pimenta, 2010; *I. guentheri* [Steindachner, 1864]; *I. oea* [Heyer, 1984]; *I. verrucosa* Reinhardt & Lutken, 1862; *Ischnocnema* sp1. aff. *parva*; *Ischnocnema* sp. 2 aff. *parva*; *Physalaemus crombiei* Heyer & Wolf, 1989; *Proceratophrys boiei* [Wied-Neuwied, 1824]; *P. paviotii* Cruz, Prado & Izecksohn, 2005; and *Zachaenus carvalhoi* Izecksohn, 1983). We did not observe any interspecific aggression.

We found *A. glandulata* **sp. nov.** throughout all sampling months (September to December 2012 and June to July 2013). Despite the presence of vocal sac, no calling males were observed neither were amplexant couples. Eggs are visible through the female skin (Fig. 4B). A female containing three eggs (2.0 mm diameter) was collected on 06 November 2012, suggesting this species reproduces during the rainy season. *Adelophryne maranguapensis* also reproduces in the rainy season and has clutches with three to eight eggs (Cassiano-Lima *et al.* 2011). Due to the low number of eggs and their relatively large size, we suspect *A. glandulata* **sp. nov.** exhibits direct development with embryos metamorphosing directly as fully formed froglets as observed in *A. maranguapensis* as well as in other terraranas (Hedges *et al.* 2008).

Adelophryne glandulata **sp. nov.** is a leaf-litter inhabitant. It forages on and under the leaf-litter and commonly uses fleeing (active escaping) as defensive strategy. Because their dorsal coloration is similar to a decomposing leaf, it may act as camouflage. In laboratory, four types of defensive behaviors were exhibited by *A. glandulata*: fleeing (N= 7), immobility (N= 3), mouth-gaping (N= 3; Fig. 5), and puffing-up the body (N= 2) (see Toledo *et al.* 2011 for further description of these behaviors). Mouth-gaping behavior was also observed for *A. mucronatus* (Lourenço-de-Moraes *et al.* 2012).

We dissected seven specimens of *A. glandulata* for stomach content analysis. One specimen had two ants. The other five specimens had one beetle per stomach and one specimen had one beetle and one ant. Ants were also found in *A. gutturosa* (MacCulloch *et al.* 2008) and in *A. mucronatus* (Lourenço-de-Moraes *et al.* 2012).

Etymology. The latin epithet “*glandulata*”, meaning “glandular”, is used in refers to the glandular ridge line that runs from the posterior part of the eye to the insertion of the forelimb (Fig. 2B).

Common name. Teresensis Flea Frog or Rãzinha-Pulga Teresensis (in Portuguese).

Discussion

Species diversity of *Adelophryne* seems to be vastly underestimated as revealed by the multiple discoveries of new species in the last years. In addition, a molecular phylogeny with dense geographical sampling (Fouquet *et al.* 2012) indicates the existence of three probably new species (*Adelophryne* sp. 4, *Adelophryne* sp. 5, and *Adelophryne* sp. 6) along with *A. pachydactyla* which form the proposed Southern Atlantic Forest Clade (SAFC). *Adelophryne* sp. 6 (CFBH 23672) corresponds to *A. mucronatus* (Lourenço-de-Moraes *et al.* 2012) and *Adelophryne* sp. 5 to *A. meridionalis* (Santana *et al.* 2012). In addition to the microendemic distribution of *Adelophryne* species, the recent discovery of new species (Lourenço-de-Moraes, unpubl. data) prevent us from assigning specimens identified as *Adelophryne* sp. 4 in Fouquet *et al.* (2012) to *A. glandulata* **sp. nov.** Almeida *et al.* (2011) included *Adelophryne* cf. *pachydactyla* (MNRJ 28344) in the anuran list of Espírito Santo state based on a single specimen collected in Santa Teresa. Later, Fouquet *et al.* (2012) pointed out this specimen could represent a new species. We examined this exemplar and another (MNRJ 34932) collected from Santa Teresa, thus we assign *A. cf. pachydactyla* mentioned in Almeida *et al.* (2011) to *A. glandulata* **sp. nov.** Another specimen of *Adelophryne* from Espírito Santo state was found at a lower elevation and ca. 35 km south from Santa Teresa, at Reserva Biológica de Duas Bocas (J.F.R. Tonini, pers.comm.). We were unable to examine this specimen because it is apparently lost.

The reduction in the number of phalanges in finger IV is not a synapomorphy of the South Atlantic Forest Clade (SAFC) as proposed by Santana *et al.* (2012). *Adelophryne mucronatus* has three phalanges on the finger IV and is in the SAFC whereas *A. adiastrata* has two phalanges on the finger IV and is part of the North Amazonia Clade of Fouquet *et al.* (2012).

Because most named species within *Adelophryne* spp. are microendemics, it is likely that additional new species remain to be discovered across the multitude of isolated forest massifs that separate the few and sparse localities where *Adelophryne* species have been found so far. The new species described and named herein is an example in this respect. Therefore, we consider a priority to uncover and describe species diversity in this fragmented and endangered region where additional new species are expected to occur. We recommend the active search of leaf litter for an effective sampling because this method revealed higher density of individuals than previous studies on *Adelophryne*.

Adelophryne glandulata **sp. nov.** may be listed as Endangered (EN) under B1ab(iii) criteria of the IUCN Red List (IUCN 2001). This species has presumably a small distribution and there is continuing decline in the extent and quality of its habitat. In addition, *Adelophryne glandulata* **sp. nov.** is currently restricted to a narrow elevational range, and it is sensitive to deforestation and edge effects. The presence of this species in protected areas (*i.e.*, Estação Biológica de Santa Lúcia and Reserva Biológica Augusto Ruschi) minimizes the problem associated with deforestation that is undergoing in private properties across this region, due to expansion of ranch condominiums and *Eucalyptus* spp. plantations. Climate change may constitute another source of concern for this species because it is associated with the mild microclimate of Santa Teresa. The sensibility to anthropogenic changes actually mirrors that of most congeneric species restricted to narrow altitudinal belts of primary forests (Rodríguez & Duellman 1994; Kok & Kalamandeen 2008; Lourenço-de-Moraes *et al.* 2012).

Acknowledgments

We thank José Padiál and Roy MacCulloch for their comments on the manuscript. This manuscript is part of the Bromeligenous Project. We thank the Project's crew: Cassio Z. Zocca, Cecília Waichert, Fernanda C. F. Lirio, Francys Lacchine, Gustavo Milanezi, João F. R. Tonini, Juliano Saich, Lamara P. Barbosa, Marcio M. Mageski, Namany Lourpen, Paulo R. Jesus, and Randerson L. B. Ferreira for helping during fieldwork. Thanks to Gabriel Deprá for aid to coloring and staining six individuals, and Claudio Zawadzki, Fabricio Oda and Rosimeire Ribeiro for aid to pictures (NUPÉLIA, UEM—Universidade Estadual de Maringá). Raoni Rebouças Santos

(UFRRJ—Universidade Federal Rural do Rio de Janeiro) for the picture of the holotype. Fabio Hepp, José Pombal Jr, Mônica Cardoso, Rafael Pontes, and Thiago Silva-Soares (Museu Nacional, Universidade Federal do Rio de Janeiro) for their attempt to locate one deposited specimen (MNRJ 28344). All landowners for allowing access to their properties. To the staff of Reserva Biológica Augusto Ruschi and Museu de Biologia Mello Leitão for their support. The Bromeligenous Project was financed by The Herpetologists' League, Ecology Center at Utah State University, Dr. Dinesh and Kalpana Patel Fellowship, and Rufford Foundation. RLM (process 140710/2013-2) and RPB (process 304363/2010-3) thank CNPq for providing scholarships. RBF thanks Ecology Center at Utah State University for the PhD scholarship. Sampling permits were issued by “Sistema de Autorização e Informação em Biodiversidade” (SISBIO, 28607-3) and by Institutional Animal Care and Use Committee of Utah State University (IACUC- USU, 2002). AF has benefited from an ‘Investissement d’Avenir’ grant managed by Agence Nationale de la Recherche (CEBA, ref.ANR-10-LABX-25-01).

References

- Almeida, A.P., Gasparini, J.L. & Peloso, P.L.V. (2011) Frogs of the state of Espírito Santo, southeastern Brazil – the need for looking at the ‘coldspots’. *Check List*, 7, 542–560.
- Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., Mersey, B. & Ferrer, E.A. (2011) Has the Earth's sixth mass extinction already arrived? *Nature*, 471, 51–7. <http://dx.doi.org/10.1038/nature09678>
- Becker, C.G., Fonseca, C.R., Haddad, C.F.B., Batista, R.F. & Prado, P.I. (2007) Habitat split and the global decline of amphibians. *Science*, 318, 1775–1777. <http://dx.doi.org/10.1126/science1149374>
- Cassiano-Lima, D., Borges-Nojosa, D.M., Cascon, P. & Cechin, S.Z. (2011) The reproductive mode of *Adelophryne maranguapensis* Hoogmoed, Borges & Cascon, 1994 (Anura: Eleutherodactylidae) an endemic and threatened species from Atlantic Forest remnants in northern Brazil. *North-Western Journal of Zoology*, 7, 92–97.
- Cei, J.M. (1980) *Amphibians of Argentina*. *Monitore Zoologica Italiano, New Series Monografia*, 609 pp.
- Fouquet, A., Loebmann, D., Castroviejo-Fisher, S., Padial, J.M., Orrico, V.G.D., Lyra, M.L., Roberto, I.J., Kok, P.J.R., Haddad, C.F.B. & Rodrigues, M.T. (2012) From Amazonia to the Atlantic Forest: molecular phylogeny of Physelaphryninae frogs reveals unexpected diversity and a striking biogeographic pattern emphasizing conservation challenges. *Molecular Phylogenetics and Evolution*, 65, 547–561. <http://dx.doi.org/10.1016/j.ympev.2012.07.012>
- Frost, D.R. (2014) Amphibian Species of the World: an Online Reference. Version 6.0 American Museum of Natural History, New York. Available from: <http://research.amnh.org/herpetology/amphibia/index.html> (accessed 20 May 2014).
- Gaston, K.J. & Williams, P.H. (1996) Spatial patterns in taxonomic diversity. In: Gaston, K.J., *Biodiversity: A biology of numbers and difference*. Blackwell Science, Mississauga, Ontario, Canada, pp. 202–229.
- Giam, X., Scheffers, B.R., Sodhi, N.S., Wilcove, D.S., Ceballos, G. & Ehrlich, P.R. (2012) Reservoirs of richness: least disturbed tropical forests are centres of undescribed species diversity. *Proceedings of the Royal Society B*, 279, 67–76. <http://dx.doi.org/10.1098/rspb.2011.0433>
- Haddad, C.F.B., Toledo, L.F., Prado, C.P.A., Loebmann, D., Gasparini, J.L. & Sazima, I. (2013) *Guia dos Anfíbios da Mata Atlântica: diversidade e biologia*. Anolisbooks, São Paulo, 544 pp.
- Hedges, S.B., Duellman, W.E. & Heinicke, M.P. (2008) New world direct-developing frogs (Anura: Terrarana): molecular phylogeny, classification, biogeography, and conservation. *Zootaxa*, 1737, 1–182.
- Heyer, R.W., Rand, A.S., Cruz, C.A.G., Peixoto, O.L. & Nelson, C.E. (1990) “Frogs of Boracéia”. *Arquivos de Zoologia São Paulo*, 31, 231–410.
- Hoogmoed, M.S. & Lescure, J.L. (1984) A new genus and two new species of minute leptodactylid frogs from northern South America, with comments upon *Physelaphryne* (Amphibia: Anura: Leptodactylidae). *Zoologische Mededelingen Leiden*, 58, 85–115.
- Hoogmoed, M.S., Borges, D.M. & Cascon, P. (1994) Three new species of the genus *Adelophryne* (Amphibia: Anura: Leptodactylidae) from northeastern Brazil, with remarks on the other species of the genus. *Zoologische Mededelingen Leiden*, 68, 271–300.
- Kok, P.J.R. & Kalamandeen, M. (2008) Introduction to the taxonomy of the amphibians of Kaieteur national Park, Guyana. *Abc Taxa*, 5, 1–278.
- International Union for Conservation of Nature (2001) IUCN Red List of Threatened Species: Categories and Criteria. Version 3.1. I. S. S. Commission. Switzerland and Cambridge, UK: 30. Available from: <http://www.iucnredlist.org/> (accessed 28 May 2014).
- Lourenço-de-Moraes, R., Solé, M. & Toledo, L.F. (2012) A new species of *Adelophryne* Hoogmoed & Lescure 1984 (Amphibia: Anura: Eleutherodactylidae) from the Atlantic rainforest of southern Bahia, Brazil. *Zootaxa*, 344, 59–68.
- MacCulloch, R.D., Lathrop, A., Kok, P.J.R., Minter, L.R., Khan, S.Z. & Barrio-Amorós, C. (2008) A new species of

- Adelophryne* (Anura: Eleutherodactylidae) from Guyana, with additional data on *A. guttuosa*. *Zootaxa*, 1884, 36–50.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.
<http://dx.doi.org/10.1038/35002501>
- Peel, M.C., Finlayson, B.L. & McMahon, T.A. (2007) Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences*, 11, 1633–1644.
<http://dx.doi.org/10.5194/hess-11-1633-2007>
- Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J. & Hirota, M.M. (2009) The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for Conservation. *Biological Conservation*, 142, 1141–1153.
<http://dx.doi.org/10.1016/j.biocon.2009.02.021>
- Ripley, B., Venables, B., Bates, D.M., Hornik, K., Gebhardt, A. & Firth, D. (2014) Support Functions and Datasets for Venables and Ripley's MASS. Available from: <http://cran.r-project.org/web/packages/MASS/MASS.pdf> (accessed 18 June 2014)
- Rizzini, C.T. (1979) *Tratado de fitogeografia do Brasil. Aspectos sociológicos e florísticos*. HUCITEC of Sao Paulo, 374 pp.
- Rodriguez, L.O. & Duellman, W.E. (1994) *Guide the Frogs of the Iquitos Region, Amazonian Peru*. University of Kansas Natural History Museum Special Publication, 22, 80 pp.
- Santana, D.J., Fonseca, E.M., Neves, M.O. & Carvalho, R.M.H. (2012) A new species of *Adelophryne* (Anura: Eleutherodactylidae) from the Atlantic Forest, southeastern Brazil. *Salamandra*, 48, 187–192.
- Toledo, L.F., Sazima, I. & Haddad, C.F.B. (2011) Behavioral defenses of anurans: an overview. *Ethology Ecology & Evolution*, 23, 1–25.
<http://dx.doi.org/10.1080/03949370.2010.534321>
- Williams, C.R., Brodie Jr., E.D., Tyler, M.J. & Walker S.J. (2000) Antipredator Mechanisms of Australian Frogs. *Journal of Herpetology*, 34, 431–443.
<http://dx.doi.org/10.2307/1565367>

APPENDIX

Specimens examined:

- Adelophryne adiaastola*—Ecuador: **Pastaza**: Kurintza (División de Herpetología, Museo Ecuatoriano de Ciencias Naturales, Quito, Ecuador) DHMECN 4378.
- Adelophryne baturitensis*—Brazil: **Ceará**: Guaramiranga (Célio F.B. Haddad Collection, Universidade Estadual Paulista, Rio Claro, São Paulo, Brasil) CFBH 20469–76; Tiangua CFBH 24554–67; Viçosa do Ceará CFBH 24579–85.
- Adelophryne glandulata* (under the name *Adelophryne* cf. *pachydactyla*)—Brazil: **Espírito Santo**: Santa Teresa: Estação Biológica de Santa Lúcia, (Museu Nacional do Rio de Janeiro, Rio de Janeiro, Brasil) MNRJ 28344, 34932.
- Adelophryne maranguapensis*—Brazil: **Ceará**: Maranguape: CFBH 24515–27.
- Adelophryne meridionalis*—Brazil: **Minas Gerais**: Juiz de Fora, Parque Municipal de Lajinha, (Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil) MZUFV 12625.
- Adelophryne mucronatus*—Brazil: **Bahia**: Una CFBH 23672, RPPN Nova Angélica, (Museu de Zoologia da Universidade Estadual de Campinas “Adão José Cardoso”, Campinas, São Paulo, Brasil) ZUEC 16169,12139,16626, (Museu de Zoologia da Universidade Estadual de Santa Cruz, Ilhéus, Bahia, Brasil) MZUESC 9091–96.
- Adelophryne pachydactyla*—Brazil: **Bahia**: Itacaré (RPPN Capitão) ZUEC 18212–13 and Una (RPPN Nova Angélica) ZUEC 17825.