



A new species of *Pristimantis* (Anura: Strabomantidae) from Andean cloud forests of northern Peru

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Abstract

We describe a new species of *Pristimantis* from cloud forests of the eastern versant of the Andes in northern Peru. The type locality lies in Quebrada del Vino, Provincia San Ignacio, Departamento Cajamarca, Peru. The new species is most similar to *P. crucifer*, *P. eriphus*, *P. flavobracatus*, *P. leucorrhinus*, *P. lucasi*, and *P. vilcabambae*, with which it shares the presence of large conical eyelid tubercles, ulnar tubercles, and heel and tarsal tubercles as well as flash colours on the groin surrounded by bold black stripes and white stripes. The new species can nonetheless be distinguished from all of them by, having tympanic membrane and annulus, by males having nuptial pads and vocal slits, and by having finger discs scarcely enlarged and truncated with ungual flap not indented.

Key words: Andes, new species, *Pristimantis crucifer*, *Pristimantis eriphus*, *Pristimantis flavobracatus*, *Pristimantis leucorrhinus*, *Pristimantis lucasi*, Terrarana

Introduction

The eastern versant of the Andes is one of the most diverse areas of the world (Myers *et al.* 2000), and it houses one of the more diverse vertebrate groups, if not the most diverse one: the genus *Pristimantis*. *Pristimantis* designate a clade of frogs (Hedges *et al.* 2008) of over 440 species, ranging from Honduras to Bolivia, that constitutes the largest clade of amphibians named as a genus, containing 7% all frog species and ca. 25% of those in the Neotropics (Frost 2011). Most species in the genus have been described from Andean Colombia, Ecuador, and northern Peru (Frost 2011), and many new species are still being described from the Andes or elsewhere (e.g. Duellman & Chaparro 2008; Guayasamín & Funk 2009; Padial & De la Riva 2009; Lehr *et al.* 2009; Terán-Valdez & Guayasamín 2010; Arteaga-Navarro & Guayasamín 2011; Kok *et al.* 2011).

In Peru, *Pristimantis* are found from the Amazon or the Pacific Coast to the páramos above 3500 masl (Duellman & Lehr 2009). The cloud forests of Cordillera Oriental in Central Peru, although largely unexplored, houses a large number of endemic species of *Pristimantis* and related species in the family Strabomantidae (Duellman & Lehr 2009). Here, three distinct, conspicuous, and probably related *Pristimantis* species were described recently: *Pristimantis flavobracatus* (Lehr *et al.* 2006), *Pristimantis leucorrhinus* (Boano *et al.* 2008), and *Pristimantis lucasi* (Duellman & Chaparro 2008). These three species are characterized by their tuberculate skin, and by having large and conspicuous conical tubercles on the eyelids, forearms, heels, and tarsus. Also, all the three species were described from cloud forests around Oxapampa (Departamento Pasco). *Pristimantis flavobracatus* is only known from the type locality in the Selva Alta Ecoregion at elevations around 1770 masl; *P. leucorrhinus* occurs at higher elevations, in cloud forests around 2500 masl; and *P. lucasi* inhabits the elfin forests of the

same area at elevations of ca. 3000 masl. These three species are similar to *Pristimantis eriphus* (Lynch & Duellman 1980), an inhabitant of montane forests in northern Ecuador and adjacent Colombia, occurring at elevations between 2160–2630 masl (Lynch & Duellman 1980; Mueses-Cisneros 2005; Guayasamin & Funk 2009), and to *Pristimantis crucifer*, which occurs in the Western versant of the Andes of Ecuador (Lynch & Duellman 1997). Another putatively related species is *Pristimantis vilcabambae* (Lehr 2007), only known from elevations around 2000 masl in the northern part of Cordillera Vilcabamba. Here, we describe an additional species putatively belonging to this small assemblage of possibly related frogs, from cloud forests in Cordillera Huancabamba, on the eastern versant of the Andes in northern Peru.

Material and methods

Specimens were collected by hand and euthanized using Nembutal. A piece of tissue was removed from the feet in most specimens and preserved in 95–100% ethanol (tissues are deposited at Museo de Historia Natural, Universidad Nacional de San Antonio Abad del Cusco and at the DNA and at the tissue collection from the National Museum of Natural History in Madrid). Whole individuals were fixed in 10% formalin and later transferred to 70% ethanol for permanent storage. Specimens have been deposited in the herpetological collection of Museo de Historia Natural, Universidad Nacional de San Antonio Abad, Cusco, Peru.

Colour pattern in life was taken from field notes and colour digital photographs. Sex and maturity were determined by the presence or absence of nuptial pads (once it was established that adult males of the new species had nuptial pads) or by dissection and direct examination of gonads. Comparisons of external character states are based both on original descriptions and examination of museum specimens (see Appendix I for material examined).

Terminology for morphological characters follows Duellman and Lehr (2009). For morphometrics, a single person (APM) took measurements with a digital calliper to the nearest 0.01 mm but for avoiding pseudo precision, all measurements were rounded to only one decimal. Abbreviations are as follows: snout-vent length, SVL; head length (from posterior margin of lower jaw to tip of snout), HL; head width (measured at level of rictus), HW; eye length (measured horizontally), EL; eye to nostril distance, EN; internarial distance, IND; eye-eye distance, EE; tympanic membrane height, TYH; tympanic membrane length, TYL; width of disc of Finger III, F3; width of disc of Finger IV, F4; arm length (from posterior margin of thenar tubercle to elbow), FA; tibia length, TL; thigh length, TH (from vent to knee); foot length (from proximal border of inner metatarsal tubercle to tip of fourth toe), FL; width of disc of Toe IV, T4. We do not include values of interorbital distance (IOD) and upper eyelid width (EW).

To date, there is no identifiable morphological synapomorphy supporting the genus *Pristimantis* (Hedges *et al.* 2008). We assign the new taxon to the genus *Pristimantis* based on geography and overall similarity to the majority of species of *Pristimantis* described. Other direct-developing frogs inhabiting the Andes in Peru are members of the genera *Bryophryne*, *Lynchi*, *Noblella*, and *Phrynos*, and all of these are compact, round-shaped, short-legged frogs, while the new species is an slender arboreal species, as most other species of *Pristimantis*. Also, we assign the new species to the largely polyphyletic *P. unistrigatus* species group for being slender, with narrow head, short snout, having Finger I shorter than Finger II, toe V much longer than Toe III and extending to the distal edge of the distal subarticular tubercle on Toe IV, and for having expanded digital discs (Hedges *et al.* 2008).

Pristimantis bustamante sp. nov

(Figs. 1–2, 4)

Holotype. MHNC 8638 (field number SNTN 11), an adult female (Fig. 1A–B, Fig. 2) from Quebrada del Vino, 2745 m, Peru (Coordinates: 5° 9'40.06"S, 79° 12'2.04"W), Distrito Namballe, Provincia San Ignacio, Departamento Cajamarca, collected on 16 November 2009 by Juan Carlos Chaparro (Fig. 3).

Paratypes. Eight paratopotypes collected at similar coordinates between 2745–3016 m, on 15–17 November 2009 by Juan Carlos Chaparro. Two adult males: MHNC 8641 (field number SNTN 14) (Fig. 1E–F), and MHNC 8651 (field number SNTN 24); three immature males: MHNC 8640 (field number SNTN 13) (Fig. 1C–D), MHNC 8642 (field number SNTN 15), MHNC 8643 (field number SNTN 16) (Fig. 1G–H); and three immature females: MHNC 8630 (field number SNTN 3), MHNC 8639 (field number SNTN 12), MHNC 8644 (field number SNTN 17) (Fig. 1I–J).



FIGURE 1. Living specimens of the type series of *Pristimantis bustamante* A–B), adult female holotype (MHNC 8638, SVL = 21.2); C–D), immature male paratopotype (MHNC 8640, SVL = 16.4); E–F), adult male paratopotype (MHNC 8641, SVL = 15.7); G–H), immature male paratopotype (MHNC 8643, SVL = 14.6); I–J), immature female paratopotype (MHNC 8644, SVL = 17.5).



FIGURE 2. Adult female holotype of *Pristimantis bustamante* (MHNC 8638, SVL = 21.2).

Diagnosis. A small species of *Pristimantis* characterized by: (1) dorsal skin covered with scattered to conical or flat to round low keratinized tubercles, sometimes densely, sometimes sparsely, and sometimes forming an incomplete dorsolateral fold (Fig. 2) covered with tuberculate skin; venter coarsely areolate, with some enlarged warts, lacking discoidal or thoracic folds; (2) tympanic membrane differentiated, visible, round, 45% of eye length in females and 48–53% in males; tympanic annulus present, upper margin hidden; one or two postrictal tubercles situated posteroventrally to tympanic annulus; (3) snout short, broadly rounded in dorsal view and rounded in profile, sometimes with a subconical tubercle on the tip; (4) upper eyelid bearing two larger conical tubercles and several scattered small tubercles; cranial crests absent; (5) upper and lower lips tuberculate; dentigerous process of vomers not evident; choanae not concealed by palatal shelf of maxillary; (6) males with a small subgular vocal sac; vocal slits, and a single nuptial pads on each thumb; (7) first finger shorter than second; discs on fingers moderately expanded, truncate to rounded, but disc on first finger rounded, barely expanded (Fig. 4); (8) fingers bearing narrow lateral fringes; outer palmar tubercle small and rounded, divided or partially divided distally; inner palmar tubercle small and ovoid; subarticular tubercles round in section; supernumerary palmar tubercles rounded, smaller than subarticular tubercles; (9) ulnar tubercles present, conspicuous, conical, continuous throughout forearm; (10) heel and tarsal tubercles present, conical, conspicuous; tibia bearing scattered conical and round tubercles; (11) toes

bearing narrow fringes; webbing absent; Toe V longer than Toe III; toe discs slightly expanded, rounded; (12) inner metatarsal tubercle ovoid, about two times the size of outer rounded tubercle; supernumerary plantar tubercles rounded and smaller than subarticular tubercles; (13) cloacal region bordered by tubercles; (14) iris red, dorsal coloration polymorphic, ranging from yellowish white to red, grey, brown or olive green, with polymorphic patterns; groin and posterior surfaces of flanks with bold black sinuous bars separated by white stripes, and with flash red or orange marks on hidden surfaces of groin; (15) SVL in single adult female 21.2 mm, in adult males 14.4–15.7 mm ($n = 2$).

Thirteen species of the *Pristimantis unistrigatus* group from the eastern versant of the Andes from central Peru to southern Ecuador present flash marks on the groin surrounded by bold black stripes or spots: *P. aquilonaris*, *P. ardalonychus*, *P. bellator*, *P. ceuthospilus*, *P. coronatus*, *P. cruciocularis*, *P. eriphus*, *P. flavobracatus*, *P. infraguttatus*, *P. leucorrhinus*, *P. lindae*, *P. lucasi*, and *P. vilcabambae*. Only seven of these species have large conical tubercles on the upper eyelid: *P. aquilonaris*, *P. coronatus*, *P. eriphus*, *P. flavobracatus*, *P. leucorrhinus*, *P. lucasi* and *P. vilcabambae*. *Pristimantis aquilonaris* and *P. coronatus* lack large heel and tarsal conical tubercles. The remaining are the most similar species to *Pristimantis bustamante*: *P. eriphus*, *P. flavobracatus*, *P. leucorrhinus*, *P. lucasi*, and *P. vilcabambae*. *Pristimantis eriphus* differs from the new species by having greatly enlarged and ovate finger discs with indented ungual flap, by lacking tympanic membrane, and by having just small conical tubercles on upper eyelid. *Pristimantis flavobracatus* has large and continuous yellow flash marks on shanks, tarsus, and flanks, it lacks tympanic membrane and annulus, the eyelid tubercles are small, males lack vocal sacs and nuptial pads, and it has low and round ulnar tubercles. *Pristimantis leucorrhinus* has a single, large, and expanded eyelid tubercle that projects forwards from the eyelid, lacks nuptial pads, has broadly expanded discs, the tympanic membrane and annulus are not evident, and lacks flash colours on groin other than white and black. *Pristimantis lucasi* has smooth dorsal skin with scattered tubercles; lacks a tympanic membrane, and finger discs are round to ovate and large. *Pristimantis vilcabambae* lacks tympanic membrane and annulus, males lack nuptial pads, fingers discs are rounded, the heel has only small conical tubercles, and the foot are basally webbed. In addition, one species from the Western versant of the Andes of Ecuador (*P. crucifer*) also present flash marks on the groin surrounded by bold black stripes or spots, has a red iris, and has enlarged tubercles on eyelid, heels and tarsus. *Pristimantis crucifer* nonetheless differs from *P. bustamante* by having crenelated finger and toe fringes, and by having dentigerous process of the vomers.

Description of the holotype. An adult female (Fig. 1 A–B, Fig. 2, Fig. 4) with head slightly narrower than body, as long as wide, with two prominent tubercles between eyes, and one at the region between eyes and nostril; upper eyelid bearing several scattered small tubercles and two larger conical tubercles; head width and length about 40% of SVL; snout relatively short (snout to eye distance 18% of SVL), broadly rounded in dorsal view and rounded in profile, with a subconical tubercle on its tip; tongue ovoid, longer than wide, posterior half not adherent to floor of mouth; lower and upper lips bordered by tubercles; eye diameter larger than eye-nostril distance ($EL/EN = 1.6$); nostrils not protuberant, directed laterally; canthus rostralis weakly concave in dorsal view and in profile; loreal region slightly concave; cranial crests absent; tympanic annulus distinct, round; tympanic membrane differentiated, visible; one postrictal tubercle, situated posteroventrally to tympanic annulus on each side of the head; choanae round, not concealed by palatal shelf of maxillary; dentigerous processes of vomers not evident; skin on dorsum granular, with some enlarged scattered tubercles and a dorsolateral line of subconical tubercles from eyes to the groin; a single and incomplete dorsolateral fold visible on either side of the body; skin on venter areolate with many scattered warts; cloacal sheath absent; cloacal region bordered by tubercles; ulnar tubercles present, conical, prominent, continuous throughout forearm; outer palmar tubercle small and rounded; inner palmar tubercle small and ovoid; subarticular tubercles round in section; supernumerary palmar tubercles rounded, smaller than subarticular tubercles; fingers bearing narrow lateral fringes; Finger I shorter than Finger II; disc of Finger I barely expanded; all other discs expanded, truncate; ventral pads well defined by circumferential grooves.

Tibia length 55% of SVL, presenting scattered tubercles on outer surface; foot length 46% of SVL; outer tarsal and heel tubercles present, large, conical, tarsal fold absent; inner metatarsal tubercle ovoid, about 2x the size of the outer rounded tubercle; subarticular tubercles round in section; plantar supernumerary tubercles rounded, smaller than subarticular tubercles; toes bearing narrow lateral fringes; webbing absent; discs of toes slightly expanded, rounded; toes with ventral pads well defined by circumferential grooves; relative length of toes: $I = II < III < V < IV$. For measurements see Table 1.

TABLE 1. Measurements and proportions of adult specimens of *Pristimantis bustamante*.

	Adult female (MNHC 8638)	Adult male (MNHC 8641)	Adult male (MNHC 8651)
SVL	21.2	15.7	14.4
HL	8.4	5.8	5.8
HW	8.4	5.7	5.8
EL	3.7	2.6	2.2
EN	2.3	1.7	1.6
IND	1.9	1.6	1.2
EE	4.3	3.7	3.0
TYH	1.3	1.1	1.0
TYL	1.0	1.3	1.2
F3	1.1	0.7	0.8
F4	1.1	0.7	0.8
FA	5.0	3.6	3.7
TL	11.6	8.0	7.6
TH	10.8	7.9	6.9
FL	9.8	7.3	6.4
T4	0.9	0.6	0.7
TL/SVL	0.5	0.5	0.5
FL/SVL	0.5	0.6	0.4
HW/HL	1.0	1.0	1.0
EN/EL	0.6	0.7	0.7
EL/HW	0.4	0.5	0.4
TYL/TYH	0.8	1.1	1.2

Coloration of holotype. In life, dorsal surface red, with a white and broad interocular bar; exposed surfaces of extremities pinkish white with diffuse red stripes; groin, flanks and thighs barred in bold black and yellowish white; upper lip with red bars below eyes; dark brown to black supratympanic stripe present; background colour of ventral surfaces pinkish white with scattered bold black spots; iris red. In preservative, dorsal surface, limbs and upper lip bars become greyish brown, the interocular bar gray, and the middorsal stripe pale grey.

Variation. Skin texture and some coloration traits are highly variable (Fig. 1). The degree of granulation, size of the granules, and density of granules varies inter individually. In some specimens, tubercles in the interocular region form a row reassembling and interocular fold (e.g. Fig. 1C). A broad middorsal bad can be absent (Fig. 1A) or present (Fig. 1C), and background colour varies from dirty yellow, green, brown, dark purple, or red (Fig. 1). Iris colour is also slightly variable, ranging from bronze to red. Specimens in life have well-defined rows of tubercles on top of incomplete dorsolateral folds, but tubercles and folds are difficult to appreciate in preservative. For measurements see Table1.

Etymology. The species epithet "bustamante" is used as a name in apposition, and refers to the Bustamante family (Bakersfield, California), to which we dedicate this species in recognition for their support of herpetological taxonomic research in Peru.

Distribution and natural history. *Pristimantis bustamante* is only known from the type locality, in an area between 2745–3016 masl (Fig. 5). The type locality belongs to Tabaconas Namballe National Sanctuary and is inserted into the ecotone of dwarf forest or montane evergreen forest from northern Andes (above 2700 m) and montane rainforest of the northern Andes (below 2700 m). Tree species, covered with abundant moss and epiphytes, are mainly sclerophyllous from the genera: Clethra, Clusia, Weimannia, Escallonia, Hesperomeles, Gynoxys, Hedyosmum, Oreopanax and Schefflera. All specimens were encountered at night during the rainy season, perching at night on leaves and branches from 50–250 cm above the ground.

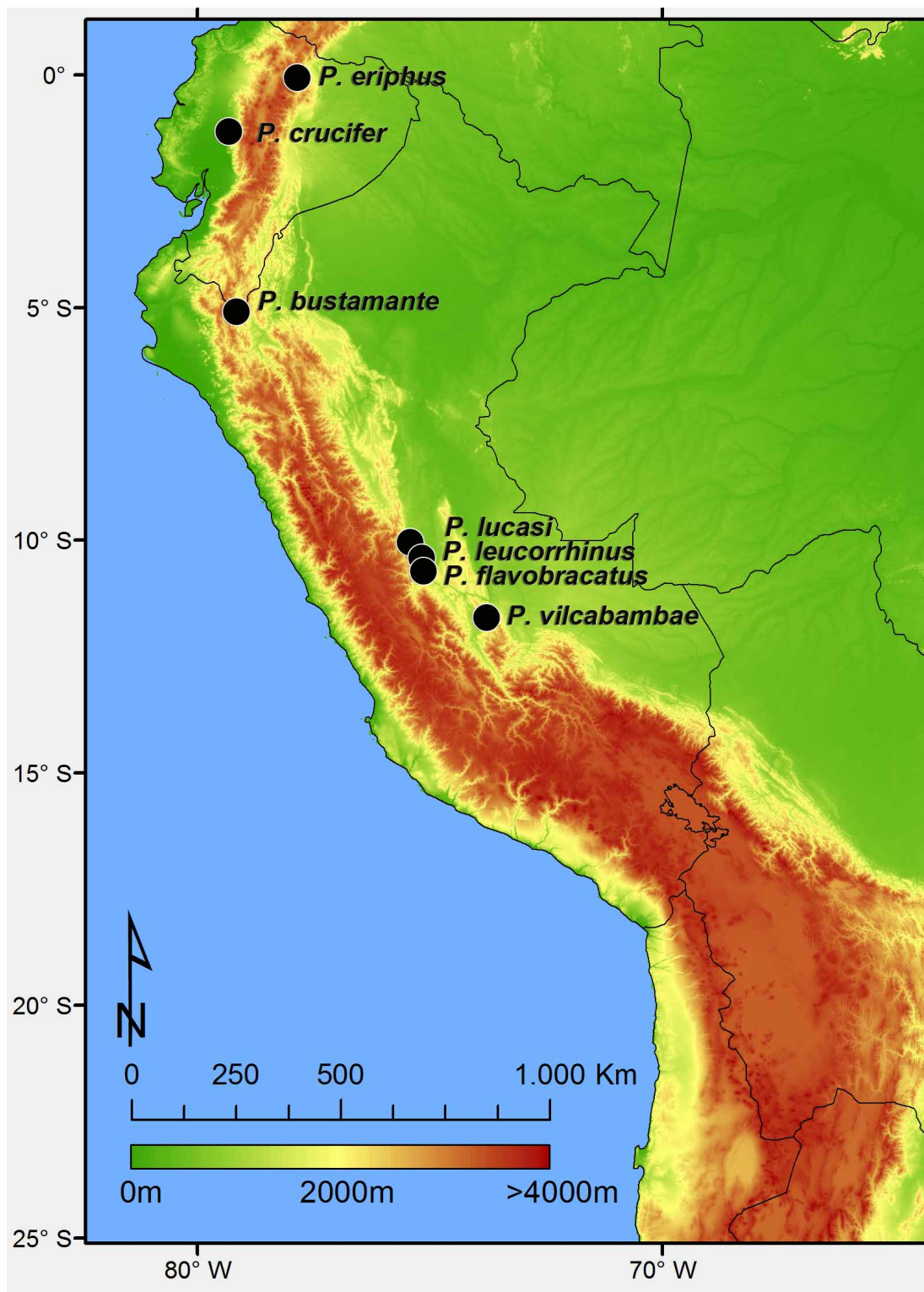


FIGURE 3. Map of Peru showing the type locality of *Pristimantis bustamante* and the type localities of putatively related species.

Discussion

Recent advances in molecular phylogenetics in Terrarana have shown that groups like *Bryophryne*, *Lynchi*, *Phrynopus*, or *Psychrophrynella* share convergent morphologies resulting from adaptation to cold paramos, which historically lead taxonomists to place most species together in paraphyletic or polyphyletic genera (e.g. Lynch

1975). The case in *Pristimantis* is considerably different. *Pristimantis* includes the most disparate arrangement of morphologies within Terrarana, with groups in which most species are adapted to paramos (e.g. *P. orestes* group and *P. curtipes* groups), groups of exclusively arboreal species (e.g. *P. lacrimosus* assemblage), or groups that include terrestrial and arboreal species from lowlands and Andean forests (e.g. the *P. peruvianus* and *P. conspicillatus* groups). Being those groups largely paraphyletic (Hedges *et al.* 2008), it might a priori seem that there are no clear patterns of particular morphologies associated to particular clades, but that perception is probably the result of the incomplete taxon sampling, erroneous grouping, and little study of the morphology. Indeed, when taxon sampling becomes more or less complete, and the morphology is thoroughly reviewed, some groups will most likely emerge as distinctive, as is the case of Yunganastes (Padial *et al.* 2007) or Hypodictyon (Hedges *et al.* 2008). We expect that in the future multiple morphologically diagnosable clades within *Pristimantis* will be discovered and named as monophyletic species groups or as taxa of higher rank.



FIGURE 4. Plantar surfaces of the holotype of *Pristimantis bustamante* (MHNC 8638, SVL = 21.2).



FIGURE 5. Habitat at the type locality of *Pristimantis bustamante* in Tabaconas Namballe National Sanctuary.

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Appendix I. Specimens examined.

- Pristimantis eriphus*—ECUADOR: NAPO: Río Jatuntinahua, 10 km SE Cuyujúa, 2160 m, KU 166031 (holotype).
- Pristimantis flavobracatus*—PERU: PASCO: Km 34 on road from Oxapampa to Yaupi, Provincia de Oxapampa, 1770 m, MUSM 19848, 19871 (holotype).
- Pristimantis leucorrhinus*—PERU: PASCO: Refugio El Cedro, 2500 m, MUSM 19996 (holotype).
- Pristimantis lucasi*—PERU: PASCO: from Abra Esperanza, 2790 m, Distrito Oxapampa, Provincia Oxapampa, MHNC 6475 (holotype), KU 311454-55, MHNC 6476, 6478, 6494, 6500, 6504-05, 6526, 6536, 6565, and 7155 (paratypes).
- Pristimantis vilcabambae*—PERU: JUNIN: Cordillera de Vilcabamba, CI/RAP Expedition Camp Two, 2050 m, AMNH 153057 (holotype), AMNH 153058-60 (paratypes).