A new species of Pristimantis (Anura, Craugastoridae) from the Cajas Massif, southern Ecuador

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Abstract

A new species of Pristimantis is described from the highland paramos on the eastern slopes of the Cajas Massif, southern Andes of Ecuador, at 3400 m. This new species is characterized by having a distinctive reddish color, cutaneous macroglands in suprascapular region and surfaces of arm and legs, and by lacking dentigerous processes of vomers. The cutaneous macroglands are similar to those exhibited by several species of the Pristimantis orcesi group, and may suggest a close phylogenetic relationship. The new species could be a latitudinal substitution of Pristimantis orcesi in the southern Andes of Ecuador.

Keywords

Andes, glandular frog, paramo, Pristimantis erythros sp. n., taxonomy, Terraran

Resúmen

Describimos una nueva especie de Pristimantis desde las laderas orientales del macizo El Cajas en los páramos andinos del sur de Ecuador a 3400 m.s.n.m. Esta nueva especie tiene un color rojizo distintivo y se caracteriza por tener macroglándulas cutáneas en varias regiones del cuerpo, de la siguiente manera: la región supraescapular, las superficies del antebrazo, parte superior del brazo, las manos y el borde de
las piernas. Además, carece de procesos dentígeros en los vomerinos. Las macroglándulas cutáneas son similares a las presentes en el grupo de *Pristimantis orcesi*, y podrían representar una posición filogenética cercana. La nueva especie puede constituir una sustitución latitudinal de *Pristimantis orcesi* en los Andes sur de Ecuador.

**Palabras clave**
Andes, rana glandular, páramo, *Pristimantis erythros* sp. n., taxonomía, Terrarana

**Introduction**

The Andes are one of the major physiographic features on our planet. A heterogeneous mountain system, three geographical separations have been identified in the Andes, based on their different geological, geographical, climatic, and ecosystemic characteristics: northern, central, and southern Andes (Graham 2009). The paramo ecosystem is one of the most distinctive features on the northern Andes, showing remarkable and complex high-altitude flora and fauna communities (Luteyn 1999). Paramos occur on mountain tops above continuous forest line (ca. >3000 m) and below perpetual snow line, mainly in the Andes of Venezuela, Colombia and Ecuador, with outliers on the Andes of northern Peru, and the Central American Cordillera of Costa Rica and Panama. Different vegetation communities are found in paramos, but its general physiognomy is characterized by bush-grasses, rosette and cushion plants, myrophyllous and dwarf shrubs, and geophytes, with trees usually absent (except for members of the genus *Polylepis*; Luteyn 1999).

Evolution of paramo biodiversity is strongly linked to orogeny and geomorphology, and complex and rich biotas are known to occur across the northern Andes due to their heterogeneous history and topography (Luteyn 1999, Mena and Josse 2000, Sklenář et al. 2011). Paramos show discontinuous distribution, being biogeographic continental islands—isolated one from another by lower areas with different ecologic and physiographic characteristics (Mena and Josse 2000; Mena-Vásconez 2010). Due to their insularity, paramo biota shows important levels of speciation and endemism (Vuilleumier 1970; Fjeldsa 1992; Luteyn 1999; Sklenář et al. 2011; Llambí and Cuesta 2014).

Although amphibian species richness decreases with higher altitude (Navas 2006; Wiens 2007), anurans seem to be more diverse than other ectothermic tetrapods in paramos (Navas 1997, 2006). Due to their low dispersion capacity and high ecophysiological adaptations, anurans are strongly influenced by the insularity of paramos, thus showing high levels of endemism and speciation (Duellman 1979, Lynch 1987). Anuran fauna of the Andes of Ecuador is extraordinarily rich (Duellman 1988), but most collection efforts in the paramo ecosystem have focused on its northern portion. Herein, we describe a distinctive new species of *Pristimantis* from the paramos of the Cajas massif, on the southern section of the Cordillera Occidental, Andes of Ecuador.
Materials and methods

Collections were made at Chanlud hydroelectric project (Fig. 1), managed by the CELEC hydroelectric company (near ETAPA protected area), northeast of the Macizo del Cajas, province of Azuay, Ecuador. Field work as part of amphibian inventory in the Azuay paramos, and was done across transects methodology (Heyer et al. 1994, Angulo et al. 2006), the sampling were conducted in diurnal (7:00 to 11:00 a.m.) and nocturnal periods (7:00 to 11:00 p.m.). The area has a greater coverage of paramo grassland between 3430 and 3883 meters, with small scattered fragments of forest and shrub. At lower elevation (between 3076 and 3430) the vegetation changes to montane forest, here, have great pressure for deforestation and change land use for agricultural land. Photographs of both living and preserved individuals and their habitat were taken by Juan Carlos Sánchez Nivicela (JCSN). Coordinates and elevations of localities were taken with a GPS data Garmin Etrex 10.

Definitions and terminology follows proposals by Lynch and Duellman (1997) and Duellman and Lehr (2009), except for glandular descriptions that follow Toledo and Jared (1995). Specimens were euthanized with 10% roxicaine, fixed in 10% formalin, and preserved in 75% ethanol. Measurements were taken with digital calipers and rounded to the nearest 0.1 mm, following recommendations by Watters et al (2016).

Figure 1. Map of Ecuador showing the type locality of *Pristimantis erythros*, Chanlud (white square), Cajas Massif, province of Azuay, southern Andes of Ecuador. White arrow indicates the direction of Cuenca city, in austral Ecuador.
Fingers and toes are numbered preaxially to postaxially from I to IV and I to V, respectively. Comparative lengths of Toes III and V were determined when both were adpressed against Toe IV; lengths of Fingers I and II were compared when adpressed against each other. Sex was determined by gonadal inspection. Coloration patterns in life, activity patterns, and habitat characteristics were taken from collectors’ field notes and digital photographs. Ecuadorian classification of ecosystems follows the proposal by Ministerio del Ambiente del Ecuador (2013). Examined specimens are deposited at the herpetological collections of Instituto Nacional de Biodiversidad, Quito (DHMECN) and Museo de Zoología, Universidad del Azuay, Cuenca (MZUA).

Systematic account

_Pristimantis erythros_ sp. n.
http://zoobank.org/DE8E6EBB-37C8-4342-A5F9-5F9A00C2EAC9

**Common name.** English: Blood Rain Frog. Spanish: Cutín de Sangre

**Holotype.** DHMECN 12103 (field series JCS.317); (Figs 2–4), an adult female collected at Chanlud, (02°40’57.30"S, 79°1’59.21"W, 3449 m), parroquia Chiquintad, cantón Cuenca, provincial de Azuay, República del Ecuador by JCSN, Verónica Urgilés, Elvis Celi, Valentina Posse and Cristian Nieves, in October 2014.

**Paratopotypes (11 specimens).** DHMECN 12102, MZUA.AN.1355 adult male; MZUA.AN.1347, MZUA.AN.1348, MZUA.AN.1351, adult females; MZUA.AN.1350, subadult male; MZUA.AN.1349, MZUA.AN.1352, MZUA.AN.1353, subadult females; MZUA.AN.1342, MZUA.AN.1343 juveniles, collected between October and November 2014 at the type locality.

**Diagnosis.** _Pristimantis erythros_ differs from other species of the genus by the combination of the following characters: (1) Skin on head and dorsum granular, flanks and venter areolate with low warts; dorsolateral folds absent; discoidal fold weakly defined; (2) tympanic membrane and annulus present and visible, rounded, ca. 50% of eye diameter, upper half covered by parotoid macrogland; (3) snout short, rounded in dorsal and lateral views; (4) upper eyelid without tubercles, interorbital distance wider than width of upper eyelid (40%); cranial crests absent; (5) dentigerous process of vomers absent; (6) vocal slits and sacs present in males, nuptial pads absent; (7) Finger I shorter than II; discs laterally expanded with dilated pads and narrow fringes, (8) fingers with coarse lateral cutaneous fringes; (9) low ulnar warts in ventral view; radioulnar macroglands covering the upper surfaces of forearm; (10) heel and tarsus lacking tubercles; paracnemid macroglands on upper surfaces of legs, tarsi, and Toes IV and V; (11) inner metatarsal tubercle oval, not prominent, twice as large as outer metatarsal tubercle, outer metatarsal tubercle rounded and low, supernumerary tubercles low and indistinct; Toe V longer than III, disc of Toe III reaches distal border of penultimate subarticular tubercle on Toe IV, disc on Toe V reaches distal border of distal subarticular tubercle on Toe IV; (12) toes with conspicuous lateral fringes,
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Figure 2. Dorsal, ventral and lateral views of holotype of Pristimantis erythros sp. n. (adult female, DH-MECN 12103, SVL 39.1 mm) in preservative.

extend to base of fingers, webbing absent; toe pads as large as or slight larger than those on fingers; (13) in life, dorsum uniformly burgundy, red to orange-red (reddish brown to burgundy in preserved); flanks, posterior surfaces of legs, groin, throat and venter crimson (dark reddish brown in preserved); iris dark brown with thin golden reticulations; ventral surfaces of hands and feet pinkish cream; (14) SVL in adult females 38.8–42.6 mm ($\bar{x} = 40.3$, $n = 4$), in adult males 36.8–37.1 mm ($\bar{x} = 36.7$, $n = 2$).

Comparisons. (Fig. 5) Pristimantis erythros differs from all other Pristimantis by its conspicuous red coloration in life (reddish brown in preservative), areolate flanks and belly with low warts, cutaneous macroglands: parotoid, paracnemid, and radioulnar; and absence of dentigerous processes of vomers. The distinctive macroglands are also known to be present in P. orcesi (Lynch), P. pycnodermis (Lynch), and P. loujosti Yánez-Muñoz, Cisneros-Heredia & Reyes-Puig. It has a similar external appearance. Pristimantis orcesi differs from P. erythros by its uniform black to dark brown dorsum in life, areolate skin on dorsum and flanks, low parotoid macrogland and thin paracnemid and radioulnar macroglands on arm and thigh respectively, also P. orcesi inhabits paramos on the northern section of Cordillera Occidental and inter-Andean depression of the Andes of Ecuador. Pristimantis pycnodermis differs by having low cranial crests, the
presence of dentigerous processes of vomer, dark canthal, tympanic marks, and green or brown color with large black spots on the flanks; it inhabits paramos in the southern section of Cordillera Oriental of the Andes of Ecuador. *Pristimantis loujosti* differs by its subacuminate snout in dorsal view, large dentigerous processes of vomers, light orange dorsum, black spots on hidden surfaces of limbs, and light iris with dark reticulation.

**Description of holotype.** Adult female (Fig. 2), head as wide as the body, slightly wider than long, 8% of SVL; snout short, rounded in dorsal and lateral views, *canthus rostralis* rounded, loreal region concave, nostrils laterally protruding, interorbital area flat, wider than upper eyelid, upper eyelid 15% of interorbital distance; cranial crests absent; parotoid macroglands covering 65% suprascapular dorsal muscle; tympanic membrane differentiated from surrounding skin, evident and rounded ¾ tympanic annulus, laterally directed, upper quarter covered by parotoid macrogland on *cucularis* muscle, tympanum diameter 52% of eye diameter; choanae large and rounded, not covered by palatal floor or maxillary arch; dentigerous processes of vomers absent; tongue broader than long, wider in posterior region, 25% attached to mouth floor.

Skin of dorsum granular without tubercles; dorsolateral folds absent; ventral surface areolate. Discoidal fold weakly defined in ventral view; cloacal region short, and
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Figure 4. Lateral, dorsal and ventral views of living specimens of *Pristimantis erythros*. Left: Male paratype (DHMECN 12102, SVL: 37.1 mm); right: Female holotype (DHMECN 12103, SVL: 39.1 mm).

dcovered by small and pronounced warts (Fig. 2). Ulnar warts slow, radioulnar macrogland covering dorsal surface of arm, forearm and hand; palmar tubercles large, external palmar tubercle, slightly larger than inner, inner palmar tubercle oval; super-
numerary tubercles pronounced; subarticular tubercles expanded in dorsal and lateral view; fingers with lateral cutaneous fringes, without interdigital membranes; Finger I shorter than Finger II, discs expanded laterally, all fingers with well-defined circumferential grooves (Fig. 3).

Hind limbs robust, tibia length 44% SVL; heel and external border of tarsus without tubercles, covered dorsally and ventrally by paracnemid macroglands; inner tarsal fold absent; inner metatarsal tubercles oval, twice as larger than the external metatarsal tubercle; supernumerary tubercles present, rounded and flattened; toes with lateral cutaneous fringes; basal membrane absent between toes; foot disks same size as those of hand, laterally expanded from fingers I–IV; relative length of toes 1<2<3<4>5; Toe IV larger than Toe III (Fig. 3).

Measurements of holotype (in mm). Snout-vent length 39.1; head length 10.8; head width 13.8; eye diameter 3.4; eye-nostril distance 3.5; interorbital distance 5.8; internarial distance 3.5; tympanum diameter 1.9; upper eyelid width 2.8; tibia length 17.5; foot length 20.7; hand length 14.5.

Coloration of holotype in life. Dorsum dark red with slightly lighter shades on head and limbs; dark red on venter. Tips of fingers and toes pinkish cream in dorsal view; ventral surfaces of hands and feet, creamy pink. Iris homogeneously dark brown, with thin golden reticulations (Fig. 4).

Coloration of the holotype in alcohol. Dorsum reddish brown, flanks, posterior surfaces of thighs, venter, and throat dark reddish brown. Dorsal surfaces of fingers pinkish cream; ventral surfaces of hands and feet, creamy pink (Fig. 2).

Variation. Morphometric variations of the type series are presented in Table 1. The color variation is the change of tonality that goes from dark red to clear (Fig. 4).

Etymology. The specific epithet *erythros* is derived from the Greek word for red, in allusion to the distinctive coloration of this species.

Distribution, natural history, and extinction risk. *Pristimantis erythros* is only known from its type locality in the Cajas Massif. The area is covered by paramos dominated by grassland and shrubs, between 3450 and 3500 m (Fig. 6). Specimens were collected mainly in terrestrial bromeliads (*Puya hamata*) and grasses (*Neurolepis villosa*), near to small streams. Vocalizations were heard (but unrecorded) during daytime hours from 08h00 to 11h00 and from 17h00 to 19h00. Active individuals were observed from dusk until approximately 21h00, afterwards activity decreased. The new species was recorded in sympatry with *Pristimantis* aff. *cryophilius*, *P. aff. orestes* and *P. aff. riveti*.

The Paramos on the Cajas Massif (221000 h. approx.) appear well preserved. Part of its extension includes the Cajas National Park (28544 h). However, the continued changes on land cover and land use occurring in several areas over the massif on the buffer area of the national park and not protected nearest regions are leading to habitat loss (Hofstede et al. 2002). During a period of four (4) years (2014–2017), twenty six (26) localities in suitable regions (2500–3500 m) on the Cajas Massif were surveyed, no additional records of this new *Pristimantis* were added during these excursions mentioned above. It is probable that *P. erythros* inhabit only a single locality in an area of
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Figure 5. Comparison of Pristimantis erythros (top right) with Pristimantis orcesi (top left), Pristimantis pycnoderms (below left), and Pristimantis loujosti (below right).

Figure 6. Habitat of Pristimantis erythros in type locality.
Table 1. Measurements (in mm) of the type series of *Pristimantis erythros* sp. n. All specimens are adults, range is followed by mean ± standard deviation in parentheses. Abbreviations: SVL = snout vent length, HL = head length, HW = head width, ED = eye diameter, EN = eye-nostril distance, IOD = interorbital distance, IND = internarial distance, UEW = upper eyelid width; TD = tympanum diameter, HAL = hand length, Finger IV disk width = Fin4DW, TL = tibia length, FL = foot length, Toe IV disk width = Toe4DW.

| Measurement | Adult Female | Adult Male |
|-------------|--------------|------------|
|             | *N* = 4      | *N* = 2    |
| SVL         | 38.8–42.6 (40.2 ± 1.7) | 36.7–37.0 (36.9 ± 0.2) |
| EN          | 2.7–3.5 (3.2 ± 0.3) | 3.1–3.4 (3.3 ± 0.2) |
| HL          | 10.6–13.7 (11.5 ± 1.4) | 11.5–11.8 (3.3 ± 0.2) |
| HW          | 13.2–14.7 (13.7 ± 0.6) | 12.6–13.3 (12.9 ± 0.5) |
| IOD         | 4.7–5.8 (5.1 ± 0.5) | 4.2–5.4 (4.8 ± 0.9) |
| IND         | 3.1–3.5 (3.3 ± 0.9) | 3.3–3.4 (3.3 ± 0.1) |
| TL          | 16.8–17.5 (17.1 ± 0.3) | 15.9–16.6 (16.3 ± 0.5) |
| FL          | 19.5–21.1 (20.2 ± 0.8) | 18.4–18.5 (18.4 ± 0.1) |
| HAL         | 13.0–14.4 (13.8 ± 0.6) | 12.3–12.8 (12.5 ± 0.4) |
| TD          | 1.7–1.9 (1.8 ± 0.1) | 1.7–1.8 (1.8 ± 0.1) |
| ED          | 3.4–4.2 (3.7 ± 0.4) | 2.9–3.8 (3.3 ± 0.7) |
| UEW         | 2.6–3.5 (3.0 ± 0.4) | 3.1–3.3 (3.2 ± 0.1) |
| Fin4DW      | 2.3–3.5 (2.6 ± 0.3) | 2.2–2.4 (2.3 ± 0.2) |
| Toe4DW      | 2.2–2.7 (2.5 ± 0.2) | 2.1–2.3 (2.2 ± 0.1) |

less than 1 km². Finally, based on the small area of occupancy that might be restricted to the type locality which it is not under conservation in a protected area, we suggest that, it should be classified as Critically Endangered (CR) under the UICN criteria B1,B2ab(i,ii,iii,iv) (IUCN 2001).

**Discussion**

At least 50 species of anurans, including *Pristimantis erythros*, are currently known to inhabit the paramos of Ecuador (Table 2). The distribution of these species is fairly even along Andes, with 34 species recorded on the paramos of Cordillera Occidental (21 spp. on the northern part, 17 spp. southern part), and 36 species on the paramos of Cordillera Oriental (19 spp. on the northern section, 21 spp. southern section). Our data show that terrestrial frogs of the genus *Pristimantis* make a significant proportion of the amphibian fauna in Ecuadorian paramos (50–58% on each mountain range; slightly higher than calculations by Navarrete et al. 2016). The lowest species richness of *Pristimantis* occurs in the southern paramos (7 spp. on Cordillera Occidental and 10 spp. on Cordillera Oriental), probably referred as collection bias since several species from this section remain undescribed.

The Cajas Massif has one of the most particular landscapes in the Ecuadorian Andes. The massif was glaciated during the Pleistocene (Hastenrath 1981, Clapperton 1993), and its current physiography includes more than two hundred glacial lakes,
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Table 2. Amphibians of the paramos from the Andes of Ecuador (above 3000 m). Abbreviations: N = northern section, S = southern section (sections are approximately divided by 1.5°S latitude). Nominal species that may be complexes (including more than one cryptic species) are marked with an asterisk.

| Species                  | Cordillera Occidental | Cordillera Oriental | Source                                |
|--------------------------|-----------------------|---------------------|---------------------------------------|
|                          | N         | S     | N         | S     |                                  |
| Atelopus bomolochos      |           |       |           |       | Peters (1973)                     |
| A. exiguus               |           |       |           |       | Coloma et al. (2000)              |
| A. ignescens             |           |       |           |       | Coloma et al. (2000)              |
| A. nanay                 |           |       |           |       | Coloma (2002)                     |
| A. pastuso               |           |       |           |       | Coloma et al. (2010)              |
| A. petersi               |           |       |           |       | Coloma et al. (2007)              |
| A. podocarpus            |           |       |           |       | Coloma et al. (2010)              |
| Osornophryne angel       |           |       |           |       | Yáñez-Muñoz et al. (2010)         |
| O. antiana               |           |       |           |       | Hoogmoed (1987)                   |
| O. talipes               |           |       |           |       | Cannatella (1986)                 |
| Centrolene buckleyi      |           |       |           |       | Lynch and Duellman 1973           |
| Hypodactylus brunneus    |           |       |           |       | Lynch (1975)                      |
| H. penaccai              |           |       |           |       | Lynch (1975)                      |
| Lynchia flavomaculatus   |           |       |           |       | Lynch (1975)                      |
| Pristimantis buckleyi    |           |       |           |       | Lynch (1981)                      |
| P. cajamarcensis         |           |       |           |       | Lynch and Duellman (1997)         |
| P. cryophilus            |           |       |           |       | Lynch (1979)                      |
| P. cryptomelas           |           |       |           |       | Lynch (1979)                      |
| P. curtipes              |           |       |           |       | Lynch (1981)                      |
| P. devillei              |           |       |           |       | Lynch and Duellman (1980)         |
| P. erythros              |           |       |           |       | This work                          |
| P. festae                |           |       |           |       | Lynch and Duellman (1980)         |
| P. gentryi               |           |       |           |       | Lynch and Duellman (1997)         |
| P. gualaceo              |           |       |           |       | Úrgilés et al. (2014)             |
| P. huicundo              |           |       |           |       | Guayasamin et al. (2004)          |
| P. leoni                 |           |       |           |       | Lynch and Duellman (1997)         |
| P. lymani                |           |       |           |       | Lynch and Duellman (1997)         |
| P. mazar                 |           |       |           |       | Guayasamin and Arteaga (2013)      |
| P. modipeplus            |           |       |           |       | Lynch (1981)                      |
| P. myersi                |           |       |           |       | Lynch (1981)                      |
| P. ocreatus              |           |       |           |       | Lynch (1981)                      |
| P. orcesi                |           |       |           |       | Lynch (1981)                      |
| P. ortizi                |           |       |           |       | Lynch and Duellman (1997)         |
| P. philippi              |           |       |           |       | Lynch and Duellman (1995)         |
| P. phoxocephalus         |           |       |           |       | Lynch and Duellman (1997)         |
| P. pichincha             |           |       |           |       | Reyes-Puig and Páez-Rosas (2016)  |
| P. pygodermis            |           |       |           |       | Lynch and Duellman (1980)         |
| P. riveti                |           |       |           |       | Lynch (1979)                      |
| P. thymelensis           |           |       |           |       | Lynch (1981)                      |
| P. unistrigatus          |           |       |           |       | Lynch (1981)                      |
| Hyloxalus anthracinus    |           |       |           |       | Coloma (1995)                     |
| H. jacobuspetersi        |           |       |           |       | Coloma (1995)                     |
| H. vertebralis           |           |       |           |       | Coloma (1995)                     |
| Gastrotheca epeletia     |           |       |           |       | Duellman (2015)                   |
| G. litonedi              |           |       |           |       | Duellman (2015)                   |
| G. puebes              |           |       |           |       | Duellman (2015)                   |
| Hylocyrtus larinopygion  |           |       |           |       | Duellman and Hillis (1990)        |
| Telmatobius nigerr        |           |       |           |       | Trueb (1979)                      |
| T. vellardi              |           |       |           |       | Trueb (1979)                      |
interconnected ridges and peaks, and numerous broad hanging valleys (Coblentz and Keating 2008). The Cajas Massif holds the largest continuous paramos on the Cordillera Occidental of Ecuador. These paramos are separated from all surrounding highlands by the River Cañar basin (north), the River Jubones basin (south), and the intra-Andean basin of Paute (east). At least four species of anurans are endemic to the paramos of the Cajas Massif: *Atelopus exiguus*, *A. nanay*, *Pristimantis erythros*, and *P. philipi*. In fact, the Cajas Massif seems to be an important endemic area for biodiversity (Barnett 1997), with several endemic species of plants (incl. at last nine species of the genus *Valeriana*, Sklenář and Jørgensen 1999), birds (incl. *Metallura baroni* and *Xenodacnis* sp., Astudillo et al. 2015, and mammals (incl. *Chibchanomys orcesi*, Jenkins and Barnett 1997).

*Pristimantis erythros* share conspicuous cutaneous macroglands on its body and extremities with *P. orcesi*, *P. pycnodermis*, and *P. loujosti*. *Pristimantis erythros* is most similar to *P. orcesi*, from which it differs by its coloration and morphology, and has a significant biogeographic separation due to the isolation of the Cajas Massif from other paramos. Phylogenetic relationships of *P. erythros* are still uncertain, and due to the lack of additional evidence (e.g., molecular data), we refrain to assign *P. erythros* to any species group. Although *P. erythros* and *P. orcesi* may be related, the *Pristimantis orcesi* species-group is not a monophyletic group (Hedges et al. 2008, Padial et al. 2014). We do not discard the possibility that *P. erythros* replaces latitudinally *P. orcesi*.

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**References**

Angulo A, Rueda-Almonacid JV, Rodríguez-Mahecha JV, La Marca E (Eds) (2006) Técnicas de inventario y monitoreo para los anfibios de la región tropical andina. Conservación
A new species of Pristimantis (Anura, Craugastoridae) from the Cajas Massif...

Internacional. Serie Manuales de Campo No 2. Panamericana Formas e Impresos S.A., Bogotá DC, 298 pp.

Astudillo PX, Tinoco BA, Siddons DC (2015) The avifauna of Cajas National Park and Mazán Reserve, southern Ecuador, with notes on new records. Cotinga 37: 1–11.

Barnett AA (1997) The ecology and natural history of a fishing mouse Chibchanomys spec. nov. (Ichthyomyini: Muridae) from the Andes of Southern Ecuador. Zeitschrift fur Saugetierkunde 62(1): 43–52.

Cannatella DC (1986) A new species of Osornophryne (Anura: Bufonidae) from the Andes of Ecuador. Copeia 198(3): 618–622. https://doi.org/10.2307/1444942

Clapperton CM (1993) The glaciation of the Andes. Quaternary Science Reviews 2: 83–155. https://doi.org/10.1016/0277-3791(83)90005-7

Coblentz D, Keating PL (2008) Topographic controls on the distribution of tree islands in the high Andes of south-western Ecuador. Journal of Biogeography 35(11): 2026–2038. https://doi.org/10.1111/j.1365-2699.2008.01956.x

Coloma LA (1995) Ecuadorian frogs of the genus Colostethus (Anura: Dendrobatidae). Miscellaneous Publications of the Museum of Natural History (University of Kansas) 87: 1–72.

Coloma LA, Salas A, Lötters S (2000) Taxonomy of the Atelopus ignescens complex (Anura: Bufonidae): designation of a neotype of Atelopus ignescens and recognition of Atelopus exiguus. Herpetologica 56: 303–324.

Coloma LA (2002) Two species of Atelopus (Anura: Bufonidae) from Ecuador. Herpetologica 58(2): 229–252. https://doi.org/10.1655/0018-0831(2002)058[0229:TSAOAP]2.0.CO;2

Coloma LA, Miranda-Leiva A, Lötters S, Duellman WE (2007) A taxonomic revision of Atelopus pachydermus, and description of two new (extinct?) species of Atelopus from Ecuador (Anura: Bufonidae). Zootaxa 1557: 1–32.

Coloma LA, Duellman WE, Almendáriz A, Ron SR (2010) Five new (extinct?) species of Atelopus (Anura: Bufonidae) from Andean Colombia, Ecuador, and Peru. Zootaxa 2574: 1–54.

Duellman WE (1979) The herpetofauna of the Andes: patterns of distribution, origin, differentiation, and present communities. In: Duellman EW (Ed.) The South American Herpetofauna: its Origin, Evolution, and Dispersal. University of Kansas Press, Lawrence, Museum of Natural History, Monograph 7: 371–459.

Duellman WE (1988) Patterns of species diversity in anuran amphibians in the American tropics. Annals of the Missouri Botanical Garden, 79–104. https://doi.org/10.2307/2399467

Duellman WE (2015) Marsupial Frogs: Gastrotheca & Allied Genera. Johns Hopkins University Press, Baltimore, 407 pp.

Duellman WE, Hillis DM (1990) Systematics of frogs of the Hyla larinopygion group. Occasional Papers of the Museum of Natural History (The University of Kansas, Lawrence, Kansas) 134: 1–23.

Duellman WE, Lehr E (2009) Terrestrial-Breeding Frogs (Strabomantidae) in Peru. Natur und – Verlag, Naturwissenschaft, Münster, 386 pp.

Fjeldsa J (1992) Biogeographic patterns and evolution of the avifauna of the relict high-altitude woodlands of the Andes. Steenstrupia 18: 9–62.
Graham A (2009) The Andes: a geological overview from a biological perspective. Annals of the Missouri Botanical Garden 96(3): 371–385. https://doi.org/10.3417/2007146

Guayasamin JM (2004) The Eleutherodactylus orcesi species group (Anura: Leptodactylidae): comparative osteology and comment on its monophyly. Herpetological Monograph 18: 142–174. https://doi.org/10.1655/0733-1347(2004)018[0142:TEOSGA]2.0.CO;2

Guayasamin JM, Almeida-Reinoso DP, Nogales-Sornosa F (2004) Two new species of frogs (Leptodactylidae: Eleutherodactylus) from the high Andes of northern Ecuador. Herpetological Monographs 18: 127–141. https://doi.org/10.1655/0733-1347(2004)018[0127:TNSOFL]2.0.CO;2

Guayasamin JM, Arteaga AF (2013) A new species of the Pristimantis orestes group (Amphibia: Strabomantidae) from the high Andes of Ecuador, Reserva Mazar. Zootaxa 3616: 345–346. https://doi.org/10.11646/zootaxa.3616.4.3

Hastenrath S (1981) The glaciation of the Ecuadorian Andes. A.A. Balkema, Rotterdam, 173 pp.

Hedges SB, Duellman WE, Heinicke MP (2008) New World direct-developing frogs (Anura, Terrarana), molecular phylogeny, classification, biogeography, and conservation. Zootaxa 1737: 1–182.

Heyer WR, Donnelly MA, McDiarmid RW, Hayek LC, Foster MS (1994) Traducción Lavilla, E. O. 2001. Medición y Monitoreo de la Diversidad Biológica: Métodos Estandarizados para Anfibios. Smithsonian Institution Press, Washington/London, 349 pp.

Hořšteď R, Coppus R, Vásconez PM, Segarra P, Wolf J, Sevink J (2002) El estado de conservación de los páramos de pajonal en el Ecuador. Ecotropicos 15(1): 3–18.

Hoogmoed MS (1987) New Osornophyene (Amphibia: Anura: Bufonidae) from the atlantic versant of the Andes in Ecuador. Zoologische Mededelingen 61(16): 209–242.

IUCN (2001) Red List Categories: version 3.1. UICN Species Survival Commission, Gland.

Jenkins PD, Barnett AA (1997) A new species of water mouse, of the genus Chibchanomys (Rodentia, Muridae, Sigmodontinae) from Ecuador. Bulletin of the Natural History Museum of London (Zoology) 63(2): 123–128.

Llambí LD, Cuesta F (2014) La diversidad de los páramos andinos en el espacio y en el tiempo. In: Cuesta F, Sevink J, Llambí LD, De Bièvre B, Posner J, Editores (Eds) Avances en investigación para la conservación de los páramos andinos, CONDESAN.

Luteyn JL (1999) Paramos: A checklist of plant diversity, geographical distribution and botanical literature. The New York Botanical Garden, Bronx, New York, 278 pp.

Lynch JD (1972) Two new species of frogs (Eleutherodactylus: Leptodactylidae) from the paramos of northern Ecuador. Herpetologica 28:141–147.

Lynch JD (1975) A review of the Andean leptodactylid frog genus Phrynopus. Occasional Papers of the Museum of Natural History (The University of Kansas, Lawrence, Kansas) 35: 1–51.

Lynch JD (1979) Leptodactylid frogs of the genus Eleutherodactylus from the Andes of Southern Ecuador. University of Kansas, Museum of Natural History, Miscellaneous Publication 66: 1–62.

Lynch JD (1981) Leptodactylid frogs of the genus Eleutherodactylus in the Andes of Northern Ecuador and adjacent Colombia. The University of Kansas, Museum of Natural History, Miscellaneous Publications 72: 1–46. https://doi.org/10.5962/bhl.title.16289
A new species of Pristimantis (Anura, Craugastoridae) from the Cajas Massif...

Lynch JD (1987) Origins of the high Andean herpetological fauna. In: Vuilleumier F, Monasterio M (Eds) High Altitude Tropical Biogeography. Oxford University Press, Oxford, 478–499.

Lynch JD, Duellman WE (1973) A review of the Centrolenid frogs of Ecuador, with descriptions of new species. Occasional Papers of the Museum of Natural History, The University of Kansas 16: 1–66.

Lynch JD, Duellman WE (1980) The Eleutherodactylus of the Amazonian slopes of the Ecuadorian Andes (Anura: Leptodactylidae). The University of Kansas, Museum of Natural History, Miscellaneous Publications 69: 1–86.

Lynch JD, WE Duellman (1995) A new fat little frog (Leptodactylidae: Eleutherodactylus) from lofty Andean grasslands of southern Ecuador. Occasional Papers of the Museum of Natural History, University of Kansas 173: 1–7.

Lynch JD, WE Duellman (1997) Frogs of the genus Eleutherodactylus (Leptodactylidae) in western Ecuador: Systematics, Ecology, and Biogeography. University of Kansas, Museum of Natural History, Special Publication 23: 1–236.

Mena P, Josse C (2000) La biodiversidad de los páramos. GTP/Abya Yala, Quito, 99 pp.

Mena-Vásconez P (2010) Los páramos ecuatorianos: Paisajes diversos, frágiles y estratégicos. AFESE, Quito, 97–122.

Ministerio del Ambiente del Ecuador (2013) Sistema de Clasificación de los Ecosistemas del Ecuador Continental. Ministerio del Ambiente del Ecuador, Quito.

Navarrete MJ, Venegas PJ, Ron SR (2016) Two new species of frogs of the genus Pristimantis from Llanganates National Park in Ecuador with comments on the regional diversity of Ecuadorian Pristimantis (Anura, Craugastoridae). ZooKeys 593: 139–162. https://doi.org/10.3897/zookeys.593.8063

Navas CA (1997) Thermal extremes at high elevations in the Andes: Physiological ecology of frogs. Journal of Thermal Biology 22(6): 467–477. https://doi.org/10.1016/S0306-4565(97)00065-X

Navas CA (2006) Patterns of distribution of anurans in high Andean tropical elevations: insights from integrating biogeography and evolutionary physiology. Integrative and Comparative Biology 46: 82–91. https://doi.org/10.1093/icb/icj001

Padial JM, Grant T, Frost DR (2014) Molecular systematics of terraranas (Anura: Brachycephaloidea) with an assessment of the effects of alignment and optimality criteria. Zootaxa 3825: 1–132. https://doi.org/10.11646/zootaxa.3825.1.1

Peters JA (1973) The frog genus Atelopus in Ecuador (Anura: Bufonidae). Smithsonian Contributions to Zoology 145: 1–49. https://doi.org/10.5479/si.00810282.145

Reyes-Puig C, Páez-Rosales N (2016) Pristimantis pichincha. In: Ron SR, Guayasamin JM, Yanez-Muñoz MH, Merino-Viteri A, Ortiz DA, Nicolalde DA (Eds) AmphibiaWebEcuador. Version 2016.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. http://zoologia.puce.edu.ec/vertebrados/anfibios/FichaEspecie.aspx?id=48476 [accessed on 30 July 2017]

Ron SR, Yanez-Muñoz MH, Merino-Viteri A, Ortiz DA (2018) Anfibios del Ecuador. Version 2018.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/amphibiaweb [accessed on 15 January 2018]
Sklenář P, Dušková E, Balslev H (2011) Tropical and temperate: evolutionary history of páramo flora. The Botanical Review 77(2): 71–108. https://doi.org/10.1007/s12229-010-9061-9

Sklenář P, Jørgensen PM (1999) Distribution patterns of páramo plants in Ecuador. Journal of Biogeography 26(4): 681–691. https://doi.org/10.1046/j.1365-2699.1999.00324.x

Toledo RC, Jared C (1995) Cutaneous granular glands and amphibian venoms. Comparative Biochemistry and Physiology 111A(1): 1–29. https://doi.org/10.1016/0300-9629(95)98515-1

Trueb L (1979) Leptodactylid frogs of the genus Telmatobius in Ecuador with the description of a new species. Copeia 4: 714–733. https://doi.org/10.2307/1443882

Urgilés VL, Sánchez-Nivicela JC, Nieves C, Yánez-Muñoz MH (2014) Ranas terrestres en los ecosistemas surandinos de Ecuador I: Dos nuevas especies de Pristimantis (Anura: Craugastoridae) de la ladera oriental. Avances en Ciencias e Ingenierías 6: 51–59. https://doi.org/10.18272/aci.v6i1.159

Vuilleumier F (1970) Insular biogeography in continental regions. I. The Northern Andes of South America. The American Naturalist 104(938): 373–388. https://doi.org/10.1086/282671

Watters JL, Cummings ST, Flanagan RL, Siler CD (2016) Review of morphometric measurements used in anuran species descriptions and recommendations for a standardized approach. Zootaxa 4072(4): 477–495. https://doi.org/10.11646/zootaxa.4072.4.6

Wiens JJ (2007) Global patterns of species richness and diversification in amphibians. American Naturalist 170: 86–106. https://doi.org/10.1086/519396

Yánez-Muñoz MH, Altamirano-Benavides M, Cisneros-Heredia DF, Gluesenkamp AG (2010) Nueva especie de sapo andino del género Osornophryne (Amphibia: Bufonidae) del norte de Ecuador, con notas sobre la diversidad del género en Colombia. ACI Avances en Ciencias e Ingenierías 2(3): 46–53.

Yánez-Muñoz MH, Cisneros-Heredia DF, Reyes-Puig JP (2010) Una nueva especie de rana terrestre Pristimantis (Anura: Terrarana: Strabomantidae) de la cuenca alta del Río Pastaza, Ecuador. Avances en Ciencias e Ingenierías 3: 28–32.