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A new species of small tree frog, genus *Dendropsophus* (Anura: Hylidae) from the eastern Amazon lowlands of Ecuador

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Abstract

We describe a new species of the hylid frog genus *Dendropsophus* from Amazonian Ecuador. The new species, *Dendropsophus shiwiarum* sp. nov., appears to be part of the *D. microcephalus* species group. *Dendropsophus shiwiarum* differs from its congeners by a combination of: (1) tympanic membrane non-differentiated and annulus evident only ventrally, (2) disc of Finger III and Toe IV with pointed tip, (3) dorsal surfaces of digital discs with a conical tubercle as result of projection of distal phalanx, and (4) small size (SVL < 19 mm). The new species is morphologically most similar to *Dendropsophus riveroi*. Examination of the type material of the latter suggests that some Ecuadorian populations reported as *D. riveroi* were misidentified and in fact belong to *D. shiwiarum* sp. nov.

Key words: Anura, Hylidae, *Dendropsophus shiwiarum* sp. nov., *Dendropsophus riveroi*, *Dendropsophus microcephalus* group, Upper Amazon Basin, Ecuador

Introduction

The “Central Amazonian lowlands of Ecuador” (CAE) is a poorly studied and relatively small area that holds a species-rich amphibian fauna (Ortega-Andrade 2010). Collections from previously unexplored areas in the Amazon Basin usually result in the documentation of significant range extensions and the discovery of new species (Cisneros-Heredia *et al.* 2009; Duellman & Mendelson 1995; Elmer & Cannatella 2008; Funk *et al.* 2011; Guayasamin *et al.* 2006; Ortega-Andrade 2009; Ortega-Andrade & Valencia 2010; Motta *et al.* 2012).

Neotropical species formerly placed in the genus *Hyla* (Family Hylidae), were recently matter of wide phylogenetic analyses (*e.g.* Faivovich *et al.* 2005; Wiens *et al.* 2010; Pyron & Wiens 2011), with at least 40 genera being recognized under subfamily Hylinae Rafinesque 1815 (Frost 2013). Among them, the genus *Dendropsophus* was resurrected to name a clade of small frogs with a putative diploid number of 30 chromosomes (Faivovich *et al.* 2005). Fieldwork in 2007 by the senior author in the Shiwiar territories, in Ecuadorian lowland forests of Pastaza province revealed several species unknown for the area (Ortega-Andrade 2010). Among them, we found an unnamed species of small *Dendropsophus* which we describe herein.

Material and methods

Notes on color, ecology, and color photographs of specimens were taken in field. Measurements on call parameters were obtained from two individuals (DHMECN 4431 and QCAZ 48101) recorded in choruses. Recordings were made with Sony microcassette- M-670V (DHMECN 4431) and Olympus™ LS10 recorders (QCAZ 48101) and

analyzed with Raven Pro 1.4 ® (Charif et al. 2010). Distance between the microphone and frogs were variable, up to 5 m. Five parameters were measured to describe the call, as follows (Cocroft & Ryan 1995; Angulo 2006): (1) Call length= time from beginning to end of one call, measured from waveform in milliseconds; (2) dominant frequency= frequency in call containing the greatest amount of energy determined from the entire call; (3) call rise time = time from beginning of the call to point of maximum amplitude; (4) interval between notes = time from ending of a call and beginning of next call; and (5) call rate = total number of calls-1/time from beginning of first call to beginning of last call, all relativized to 60 seconds. Recordings are deposited in the Sound Archive of the Museo Ecuatoriano de Ciencias Naturales and Museo de Zoología of Pontificia Universidad Católica del Ecuador and will be available at AmphibiaWebEcuador (<http://zoologia.puce.edu.ec/vertebrados/anfibios/>).

Nine morphological measurements were taken with dial calipers (nearest 0.1 mm precision), as follows (modified from Ortega-Andrade & Valencia 2012): (1) snout–vent length (SVL) = distance from tip snout to posterior margin of vent; (2) head width (HW) = greatest width of head measured at level of jaw articulation; (3) head length (HL) = distance from the tip of snout to posterior angle of jaw articulation, touch the landmarks with caliper tips; (4) horizontal eye diameter (ED) = distance between anterior and posterior borders of eye; (5) eye-nostiril distance (EN) = distance from posterior margin of nostril to anterior margin of eye; (6) tympanic diameter (TD) = distance between external anterior and posterior margins of tympanic annulus; (7) femur length (FL) = length of femur from vent to knee; (8) tibia length (TL) = length of flexed leg from knee to heel; and (9) foot length (FoL) = distance from heel to tip of toe IV, including in the measurement the length of tarsus and foot. Upper eyelid width and inter-orbital distance were not measured because of its limited utility due to preservation artifacts. Bones coloration was accessed by direct inspection in preserved and living specimens. We follow Duellman & Lehr (2009) to describe tympanum shape and exposure.

Webbing formulae are based on Savage & Heyer (1967; 1997); terminology for digital disc features follows Savage (1997; 2002). Diagnostic characters and terminology follows Duellman (2001). We determined the sex of all specimens by direct inspection of the gonads. Geographic coordinates of type series were taken with GPS Garmin e-trex, and are provided in decimal degrees, based on the WGS 84 datum; other coordinates were directly assessed from Museum databases. Assessment of the extinction risk category of the new species is based on the IUCN Red List criteria (International Union for Conservation of Nature, IUCN 2001).

To describe the new species, we reviewed two paratypes and two topotypes of *D. riveroi* [AMNH 72552–72553, (=CJG 2331–2332, in Cochran & Goin 1970), USNM 152609, 152610; all males], four specimens collected from nearby areas at type locality of *D. riveroi* in Leticia, Amazonas, Colombia (ICN 50611, 50613, 50615, 50617) and the holotype and allotype of *D. leali* (MZUSP 74210, 74211; Appendix I). Other specimens assigned to both species, from Museum collections or literature (e.g., De la Riva & Duellman 1997; De la Riva et al. 1997; Köhler et al. 2005; Köhler & Lötters 2001b; Marquez et al. 1993) are considered herein as *confer* (*cf.*) populations, until a comprehensive systematic review with additional material is available. Additional specimens reviewed herein (listed in the type-series and Appendix I) are housed at Fundación Herpetológica Gustavo Orcés in Quito, Ecuador (FHGO); Museo Ecuatoriano de Ciencias Naturales in Quito, Ecuador (DHMECN); Museo de Zoología – Pontificia Universidad Católica del Ecuador in Quito, Ecuador (QCAZ); Museu de Zoologia, Universidade de São Paulo, Brazil (MZUSP); American Museum of Natural History in New York, USA (AMNH), National Museum of Natural History in Washington DC, USA (USNM), and Instituto de Ciencias Naturales, Universidad Nacional de Bogotá, Colombia (ICN).

Systematic account

Dendropsophus shiwiarum sp. nov.

(Figs. 1–4, Table 1)

“*Hyla riveroi*”.—Duellman (1978); Almendáriz (1989); Duellman & Mendelson (1995).

“*Dendropsophus* sp.”.—Ortega-Andrade (2010).

Holotype: DHMECN 4393, an adult female collected at Kurintza, 2.060° S, 76.780° W, 354-m elevation, Pastaza province, Republic of Ecuador, between 26–28 April 2007 by H. Mauricio Ortega-Andrade, Miguel Cachay, Jorge Santi and Tseremp Timias.

Paratotypes: Two adult males (DHMECN 4394, 4399), with same collection data as holotype.

Paratypes: ECUADOR: Nineteen adult males (DHMECN 4430–32, QCAZ 8250, 8252, 8253, 8308, 21936–937, 22885, 27045–046, 28086), two juvenile females (QCAZ 11544, 27791) and one adult female (QCAZ 11542). Napo province: QCAZ 27045, 27046 were collected at Ahuano, Runa Huasi, 1.060° S, 77.550° W, 394 m a.s.l, on 25 May 2005 by E. Carrillo and M. Read. Orellana province: QCAZ 8250, 8252, 8253, 8308 were collected at 42 km carretera Pompeya-Iro, Parque Nacional Yasuní, 0.650° S, 76.450° W, 236 m a.s.l; QCAZ 11542, 27791, collected at Apaika, Parque Nacional Yasuní, 0.870° S, 75.860° W, 209 m a.s.l.; QCAZ 22752 collected at Estación Científica Yasuni de la Pontificia Universidad Católica del Ecuador, Parque Nacional Yasuní, 0.680° S, 76.410° W, 241-m a.s.l. Pastaza province: DHMECN 4430–32, were collected at Juyuintza, 2.110° S, 76.190° W, 200 m a.s.l, between 26–28 April 2007 by H. M. Ortega-Andrade, M. Cachay, J. Santi and T. Timias. Sucumbíos province: QCAZ 21936, 21937, 22885 were collected at 2.5 km N de Lago Agrio, 0.120° N, 76.880° W, 302 m a.s.l, on 17 March 2003 by S. Valdiviezo, D. Tirira, J. Wiens and L. Coloma; QCAZ 11544, collected at Hostería La Selva, 0.450° S, 76.280° W, 232 m a.s.l; QCAZ 28086, collected at Reserva de Producción Faunística Cuyabeno, 0.320° S, 75.770° W, 223 m a.s.l; QCAZ 52969, 52970 collected at Limoncocha, 0.40688° S, 76.62063° S, 256 m a.s.l., on 13 March 2012 by H. Mauricio Ortega-Andrade.

Diagnosis. A small species of *Dendropsophus* distinguished by the following combination of traits: (1) females similar in size (up to 18.8 mm SVL, N = 2) to males (up to 18.5 mm, N = 19); (2) snout short, truncate in both dorsal and lateral profiles; (3) canthus rostralis rounded in cross-section, loreal region slightly concave; (4) tympanic membrane non-differentiated and annulus evident only ventrally, supratympanic fold weakly developed; (5) vomerine odontophores small, oblique, separated medially between choanae, bearing 1–5 teeth; (6) skin on dorsum, head and dorsal surfaces of limbs finely shagreen; skin on belly and proximal surfaces of thighs coarsely granular, skin on other surfaces smooth; (7) ulnar fold and tubercles absent, tarsal fold and tubercles on outer edge of tarsus absent, inner metatarsal tubercle distinct and oval, outer metatarsal tubercle absent; (8) axillary membrane developed, reaching a half or three-fourths of arm length; (9) fingers about one-third webbed, webbing formulae I2½–2II2–3III2–2IV; toes about four-fifths webbed, webbing formulae I1½–2II1–2III1–2IV2–1V; (10) disc of Finger III and Toe IV with pointed tip, conical tubercle on dorsal surface of each disc which represents the projection of distal phalanx, distal subarticular tubercle of fourth finger bifid in all specimens; (11) in life, dorsum coppery tan, with or without dark reddish brown spots or an inverted triangular blotch on scapular area; (12) belly immaculate white, ventral and hidden surfaces of thighs translucent fleshy white, vocal sac bright yellow; (14) iris coloration varies from silvery copper to reddish pale yellow with a copper ring around pupil; (15) bones white.

Comparisons with other species. Among other small species of *Dendropsophus* in the Amazon Basin, the new species is most similar to *Dendropsophus riveroi*. Both species have similar body size, but the latter have rounded discs on tips of Finger III and Toe IV. The type material of *Dendropsophus riveroi* and specimens from the type locality (e.g., ICN 50611, 50613, 50615, 50617) can be distinguished from *D. shiwiaram* (whose traits are given in parenthesis, Figs. 2, 4) by having: (1) smooth skin on the dorsum (finely shagreen); (2) tympanic membrane and tympanic annulus prominent (tympanic membrane non-differentiated and annulus evident only ventrally); (3) snout rounded in both dorsal and lateral views and in profile (both truncated); and (4) dorsal surfaces of digital discs lacking a conical tubercle as result of projection of distal phalanx (tubercle present).

Amazonian species of the *Dendropsophus microcephalus* group (Duellman & Fouquette 1968) [*D. coffeus* (Köhler, Jungfer & Reichle, 2005), *D. joannae* (Köhler & Lötters, 2001a, 2001b), *D. leali* (Bokermann, 1964), *D. walfordi* (Bokermann, 1962)] are distinguished by their larger body size, iris and dorsal coloration and rounded discs. The Cerrado dweller *D. cruzi* (Pombal & Bastos, 1998) differs in having elliptic discs on digits. The holotype and allotype of *Dendropsophus leali* (MZUSP 74210, 74211) differ from the new species by its larger size (males up to 22 mm in *D. leali*; 18.85 mm in *D. shiwiaram*), prominent tympanic membrane and annulus, rounded tips of digits, and commonly with “X” or “—” shaped dark marks in the scapular region (holotype), or uniform reddish tan dorsum with a narrow, barely visible, dark brown interorbital mark (allotype). *Dendropsophus coffeus*, an inhabitant of southwest Amazonian ecoregion, Departamento La Paz, Bolivia, is similar to *D. shiwiaram* in snout shape, dorsal color pattern and the presence of a dark brown lateral stripe, but is distinguished by its larger size (SVL up to 21.2 mm in males, 26.0 mm in females), prominent tympanic membrane and annulus, smooth dorsal skin with minute scattered tubercles. *Dendropsophus joannae* has protuberant eyes, tuberculate dorsal skin, a red inner iris in life, whereas *D. juliani* Moravec, Aparicio & Köhler (2006) differs by exhibiting a greenish ventral

surfaces and vocal sac in life; as well both species present differences in advertisement call (Köhler & Lötters 2001a; Moravec *et al.* 2006).



FIGURE 1. Living specimens of *Dendropsophus shiwiarum* sp. nov. in dorsal view. Holotype female DHMECN 4393 (A) and paratype male DHMECM 4394 (B). Note the dark reddish canthus rostralis, interorbital and post-orbital bars, and white subocular stripe/blotch in both specimens. Photographs were digitalized from film camera by HMO-A.

Dendropsophus aperomeus (Duellman 1982), is an inhabitant of Amazonian slopes of Andes in northern and central Peru, distinguished from *D. shiwiarum* by its larger size (males up to 21.3 mm of SVL, females up to 25.0 mm), having a single distal subarticular tubercle on the fourth finger, a white supra-anal stripe, and rounded tips of digits. *Dendropsophus minimus* (Ahl, 1933) is only known from the type locality at Rio Amazonas region in central Brazil, and is distinguished from the new species by having a concealed tympanum, rounded tips of digits and pale dorsolateral stripes which extend to the groin (dorsolateral stripes in *D. shiwiarum* only extend to the mid-flank). *Dendropsophus miyatai* (Vigle & Goderdhan-Vigle 1990) is an inhabitant of upper Amazon Basin of Ecuador and northeastern Peru, distinguished by having rounded tip of digits, concealed tympanum, and dorsal color pattern with bright red and yellow blotches.

Members of the *Dendropsophus minutus* group [*Dendropsophus delarivai* (Köhler & Lötters 2001b), *D. minutus* (Peters, 1872), *D. xapuriensis* (Martins & Cardoso, 1987)] differ from *D. shiwiarum* in having a white supra-anal stripe and a longer cloacal sheaths.

Description of holotype. Head about as wide as body, wide as long, widest below eyes; snout short (30% of HL), truncate in both dorsal and lateral profiles (Fig. 2); distance from nostril to corner of eye shorter than diameter of eye (80% of ED); canthus rostralis rounded and distinct; loreal region slightly concave; lips not flared; internarial area not depressed, nostrils barely protuberant, directed anterolaterally, at about three-quarters the distance from eyes to tip of snout; interorbital area flat, in about 36% of head width; eye large, protuberant, its diameter about two times the distance from upper lip to orbit and about 30% of head length. Tympanic membrane is concealed under skin; thin supratympanic fold extends laterally from posterior corner of eye to point above arm insertion; fold hides upper edge of tympanic annulus. Ventral border of the tympanic annulus barely evident, round, located behind mid-orbit, its diameter about two-thirds of eye length, separated from eye by a distance of about half its diameter. Arm not hypertrophied; dorsal surfaces of arms shagreen; axillary membrane extends to mid-length of upper arm; ulnar folds and tubercles absent; fingers short and broad, relative length of fingers I < II < IV < III; large discs, diameter of disc on third finger about as wide of tympanic membrane; disc pointed at tip on Finger III, and nearly round on other fingers (Figs. 3–4); conical tubercle on dorsal surface of each disc; subarticular tubercles small, round; distal tubercle of fourth finger prominent, bifid; supernumerary tubercles small, round, and flat; barely evident supernumerary tubercles form a row along the proximal one third of each finger; palmar tubercle small, ovoid; prepollical tubercle large, flat, ovoid; webbing of hand I $2\frac{1}{2}$ –II $2\frac{1}{2}$ –III $2\frac{1}{2}$ –IV. Legs slender and long (FL+TL+FoL= 1.7 times the SVL); tarsal fold and tarsal tubercles absent. Toes moderately large; discs about the same size than those of fingers; disc pointed on Toe IV, nearly round in other toes (Figs. 3–4); conical tubercle

present in dorsal surface of each disc; relative length of toes I < II < III = V < IV; outer metatarsal tubercle absent; inner metatarsal tubercle moderately small, elliptical; subarticular tubercles small, round; supernumerary tubercles absent; webbing on foot $I\frac{1}{2}$ – $2II1^+–2III1^+–2IV2^+–1^+V$. Skin of dorsum, head and dorsal surfaces of limbs finely shagreen to tuberculate; skin on flanks shagreen; skin on venter areolate; skin on chest and throat smooth. Cloacal opening directed posteriorly at upper level of thighs; cloacal sheath very short, covering 1/6 upper edge of cloacal opening; cloacal folds and tubercles absent. Tongue cordiform, posterior fourth not attached to mouth floor, vomerine odontophores small, but prominent, about half the diameter of choanae, each bearing five vomerine teeth; choanae moderately sized, ovoid, medially separated, not covered by palatal shelf.

Color of holotype in life. Dorsal surfaces pinkish tan, paler toward posterior third of body; blurred brown transversal stripe on sacrum; dark brown interorbital, canthal, and post-orbital stripes extending to mid-flank; white bar bordered with brown below each eye. Three pale brown narrow stripes on dorsal surfaces of shanks; dorsal surfaces of arms uniform tan. Outer edge of venter, chest, throat, webbing, hidden surfaces, ventral surfaces of forearms and limbs flesh-colored and unpigmented; belly immaculate, whitish-cream. Iris silvery copper with a dark red ring around pupil.

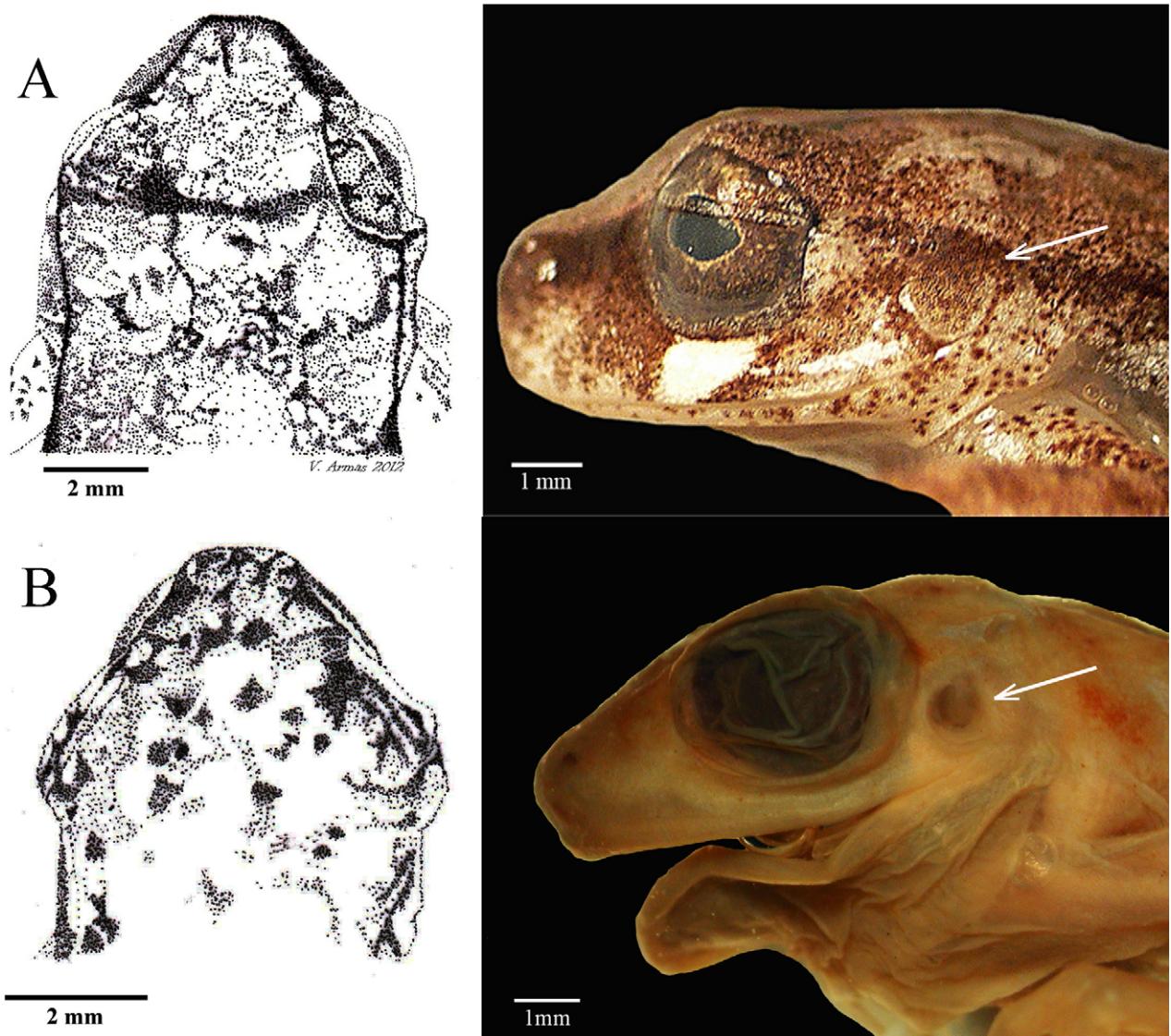


FIGURE 2. Schematic drawing of the head (dorsal view) and photograph of lateral profile of paratype male *Dendropsophus shiwiarum* sp. nov. (A, DHMECN 4394) and the paratype of *D. riveroi* (B, AMNH 72552). Note the snout shape, truncated in dorsal view and lateral profile in *D. shiwiarum*, and compare the tympanum shape and exposure (indicated by the arrows) among both species.

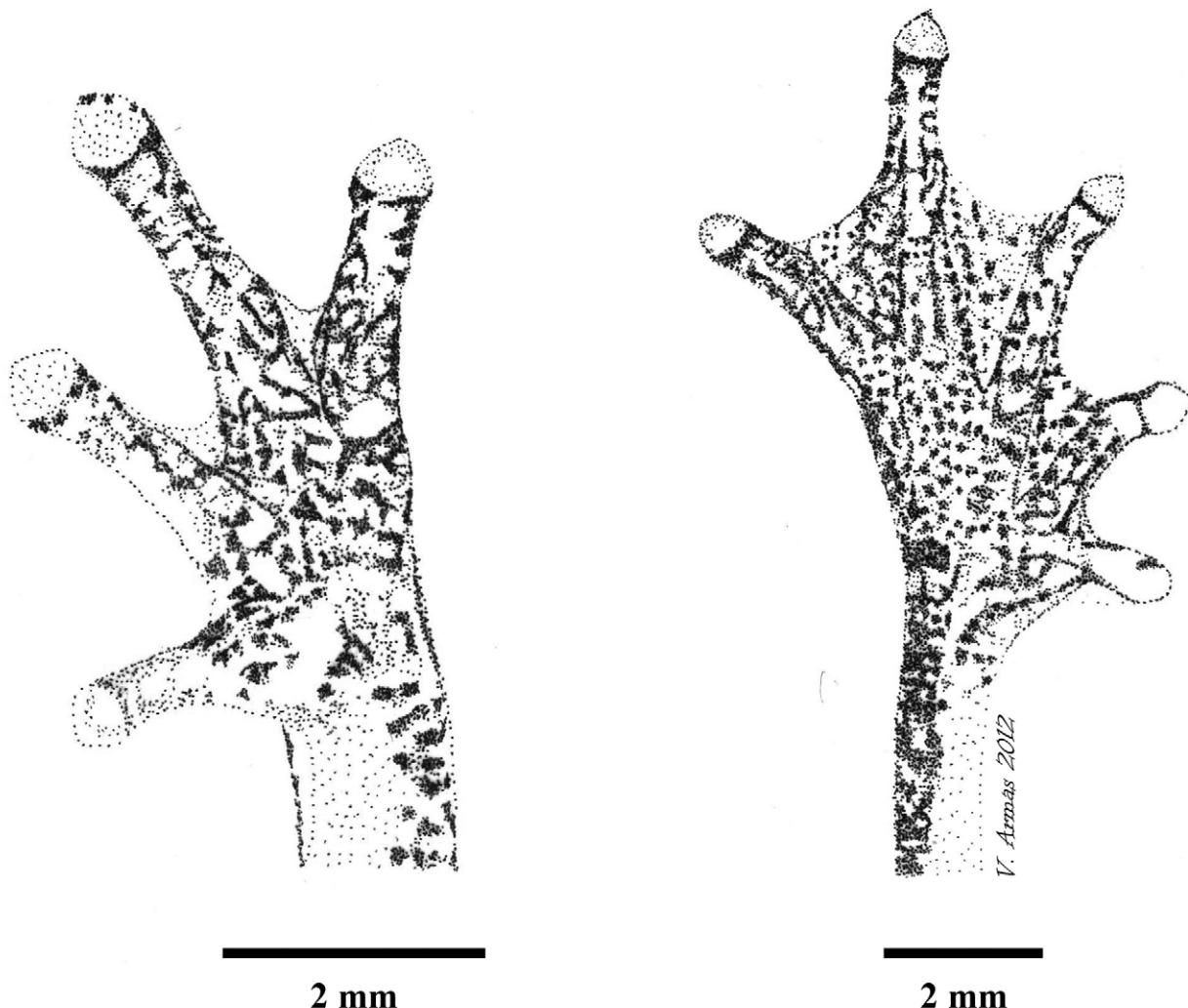


FIGURE 3. Hand and foot in ventral view of the paratype of *Dendropsophus shiwiarum* sp. nov. (DHMECN 4394). Note the distinctive, pointed tip on discs of fingers and toes. These characters may be barely visible in Toes I and V on preserved specimens.

Measurements of holotype (in mm). Specimen DHMECN 4393 is a gravid female. SVL = 18.8; HW = 6.4; HL = 6.8; ED = 2.1; EN = 1.7; TD = 1.4; FL = 9.5; TL = 9.7; FoL = 13.5. Proportions: HL/SVL = 0.36; HW/HL = 0.94; FL/SVL = 0.51; ED/HL = 0.31; EN/HL = 0.25; EN/ED = 0.81; TL/SVL = 0.52; FoL/SVL = 0.72; TD/ED = 0.67.

Variation. *Dendropsophus shiwiarum* exhibits considerable variation in coloration and pattern, even among individuals of the same population (Fig. 5). In preservative, the dorsum of most specimens is reddish with irregular small marks (e.g. DHMECN 4394, 4430) or pinkish tan with blotches or large marks (DHMECN 4393); some specimens also have a reddish inverted triangular mark on the scapular region (QCAZ 21936, DHMECN 4432) or a wide interorbital bar and an inverted triangular reddish mark on the sacral region (QCAZ 11542). Most specimens also have a narrow dark brown interorbital bar, which can be complete (e.g. DHMECN 4394), or barely visible (DHMECN 5020), wider than the horizontal canthal bar (QCAZ 11542), or incomplete (DHMECN 4393). At night, males are pale reddish brown with a dark brown dorsolateral stripe and a yellow vocal sac (Fig. 5 E–F); by day, the dorsum is creamy tan with or without reddish brown markings. Iris coloration varies from silvery copper (e.g. DHMECN 4393) to reddish pale yellow (e.g. DHMECN 4432) with a copper ring around pupil. Stripes, unpigmented spots or bars below the eye are variable in number, even between sides in the same individual: 3–4 in about 30%, 2–3 in about 6%, 1–2 in about 7%, 1 in about 30%, lacking in about 7%. Males have long vocal slits,

extending from the first quarter of the mandible to the angles of the jaws; vocal sac large, single, median, subgular and greatly distensible. The condition of pointed discs in *D. shiwiarum* is variable, from prominent as occur in most specimens (~90%, e.g. QCAZ 48105) to less evident in other specimens (e.g. QCAZ 51162). Anyway, the evidence suggests that it is not an artifact of preservation given live individuals present such pointed discs (see living specimens of *D. shiwiarum* in http://zoologia.puce.edu.ec/gallery/main.php?g2_itemId=3646&g2_page=1). Variation in measurements and proportions of specimens from the type series is summarized in Table 1.

TABLE 1. Variation of measurements (in mm) of the type series of *Dendropsophus shiwiarum* sp. nov. (range, average \pm SD and proportions by sex of adult specimens). Abbreviations for characters are SVL, snout–vent length; HW, head width; HL, head length; ED, horizontal eye diameter; EN, eye to nostril distance; TD, tympanic annulus diameter; FL, femur length; TL, tibia length; and FoL, foot length.

Character	Females ($N= 2$)	Males ($N= 19$)
SVL	18.2–18.8	16.1–18.85 (17.31 \pm 0.89)
HL	6.2–6.8	5.2–7.22 (6.04 \pm 0.63)
HL/SVL	0.34–0.36	0.3–0.43
HW	6.4–6.5	5.4–7.2 (6.35 \pm 0.49)
HW/HL	0.94–1.05	0.9–1.25
FL	9.5–9.6	7.2–9.8 (8.44 \pm 0.6)
FL/SVL	0.51–0.53	0.42–0.58
TL	9.7–10	8.1–10 (9.06 \pm 0.55)
TL/SVL	0.52–0.55	0.47–0.59
FoL	13.5–14.7	11.2–13.24 (12.3 \pm 0.53)
FoL/SVL	0.72–0.81	0.67–0.78
EN	1.5–1.7	1.2–1.8 (1.55 \pm 0.19)
EN/HL	0.24–0.25	0.19–0.33
ED	2.1–2.3	1.7–2.7 (2.26 \pm 0.25)
ED/HL	0.31–0.37	0.26–0.47
TD	1.4–1.5	0.4–1.5 (0.82 \pm 0.25)
TD/ED	0.65–0.67	0.19–0.71

Color in life. Background dorsal coloration varies from bright yellow, to yellowish tan, pinkish tan or coppery red (Figs. 1, 5). Irregular triangular marks or blotches or dark brown to pale red flecks are always present. Vocal sac in males and tips of digits are bright yellow.

Color in preservative. In alcohol, all bright yellow dorsal surfaces turn into cream; coppery red and pinkish tan areas become paler than in life; dark flecks in reddish brown individuals (e.g. DHMECN 4430) become barely visible. Ventral surfaces of forearms and limbs, outer edge of venter, chest, throat and webbing are transparent; belly immaculate cream.

Advertisement call (Fig. 6). A total of 35 calls were analyzed from two males recorded from Ecuador. Specimen DHMECN 4431 was recorded at 21:06 h on 17 May 2007 (air temperature ca. 22 °C) at Juyintza, Pastaza province. Specimen QCAZ 48101 was recorded at 21:08 h on 3 April 2010 (air temperature ca. 24.2 °C), at km 93 on Pompeya – Iro road, Yasuni National Park, Orellana province. Both males were part of a small chorus (approximately six to eight calling males, not collected), calling from shrubs, 0.5 – 1.5 m above the water, on a swamp dominated by the palm *Mauritia flexuosa*. The call consists of one high pitched pulsed note, with length 52.83 ± 31.87 ms, dominant frequency range 3983.6–5254.1 Hz (4714.5 \pm 353.1 Hz), call rise time 23.1 ± 7.8 ms, interval between notes 1946.15 ± 587.24 ms (range 814.0–2966.9) and a call rate ~32.9 calls/minute.

Natural history and distribution. *Dendropsophus shiwiarum* is known from 22 localities in eastern Ecuador, provinces of Napo, Orellana, Pastaza and Sucumbíos, up to 550 m a.s.l (Fig. 7). This species occurs in about 34,861 km² along the evergreen lowland rainforest, but it is expected to be more widely distributed along the upper Amazon basin. Duellman & Mendelson (1995) describe nine specimens of “*D. riveroi*” from the Amazon Basin of

northern Loreto, Peru (ca. 108 km E from the type locality of *D. shiwiarum* and ca. 50 km E from Juyintza) that, based on their morphological similarity, may correspond to *D. shiwiarum*.

Dendropsophus shiwiarum is an opportunistic breeder at temporary ponds and swamps on secondary forest, flooded and open areas, being very rare through dry seasons. Males were calling from leaves of bushes, trees and *Heliconia* at secondary forest, 0.05–1.5 m above the water, in the border of a temporary swamp at Kurintza on 26 and 28 April 2007, and from leaves of bushes and low vegetation at flooded areas dominated by the palm *Mauritia flexuosa* (vegetation type locally known as *moretal*) in Juyintza, on 17 May 2007. The holotype is a gravid female which, after capture, deposited a clutch of 121 unpigmented eggs in a single layer of clear gelatin inside a plastic bag; it was captured in amplexus with DHMECN 4394 (16.8 mm in SVL) perched on a *Heliconia* leaf at 18:33 h at Kurintza. Two days after the collection of the holotype, the rain stopped, the swamp dried-out and *D. shiwiarum* was not found anymore.

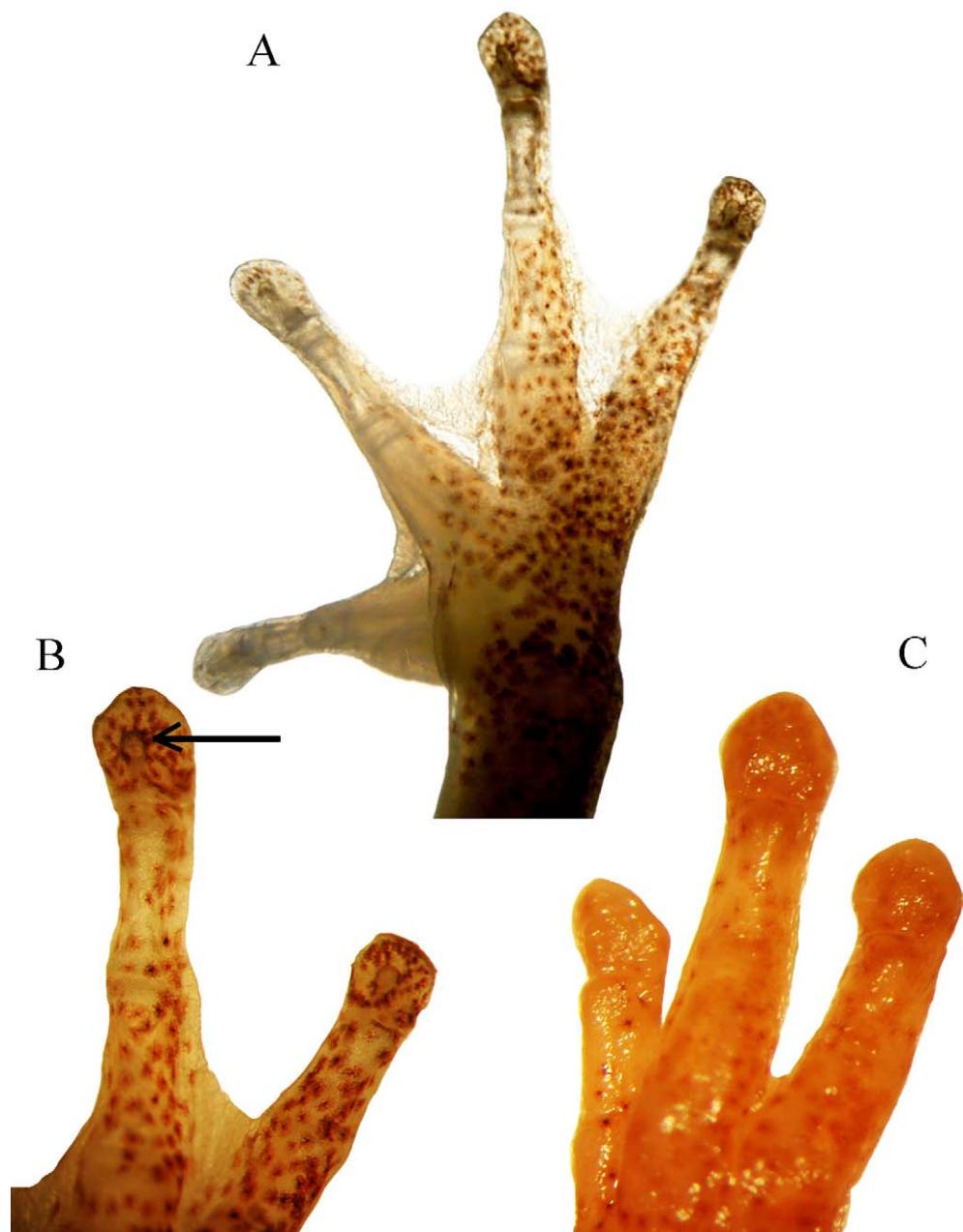


FIGURE 4. Hand and fingers in dorsal view of the holotype of *Dendropsophus shiwiarum* sp. nov. (A–B, DHMECN 4393) and the paratype of *D. riveroi* (C, AMNH 72553). Note the presence of a well-defined tubercle on dorsal view of discs of *Dendropsophus shiwiarum* sp. nov. as result of projection of last phalanx (indicated by the arrow) and distinctive pointed tips on fingers III.

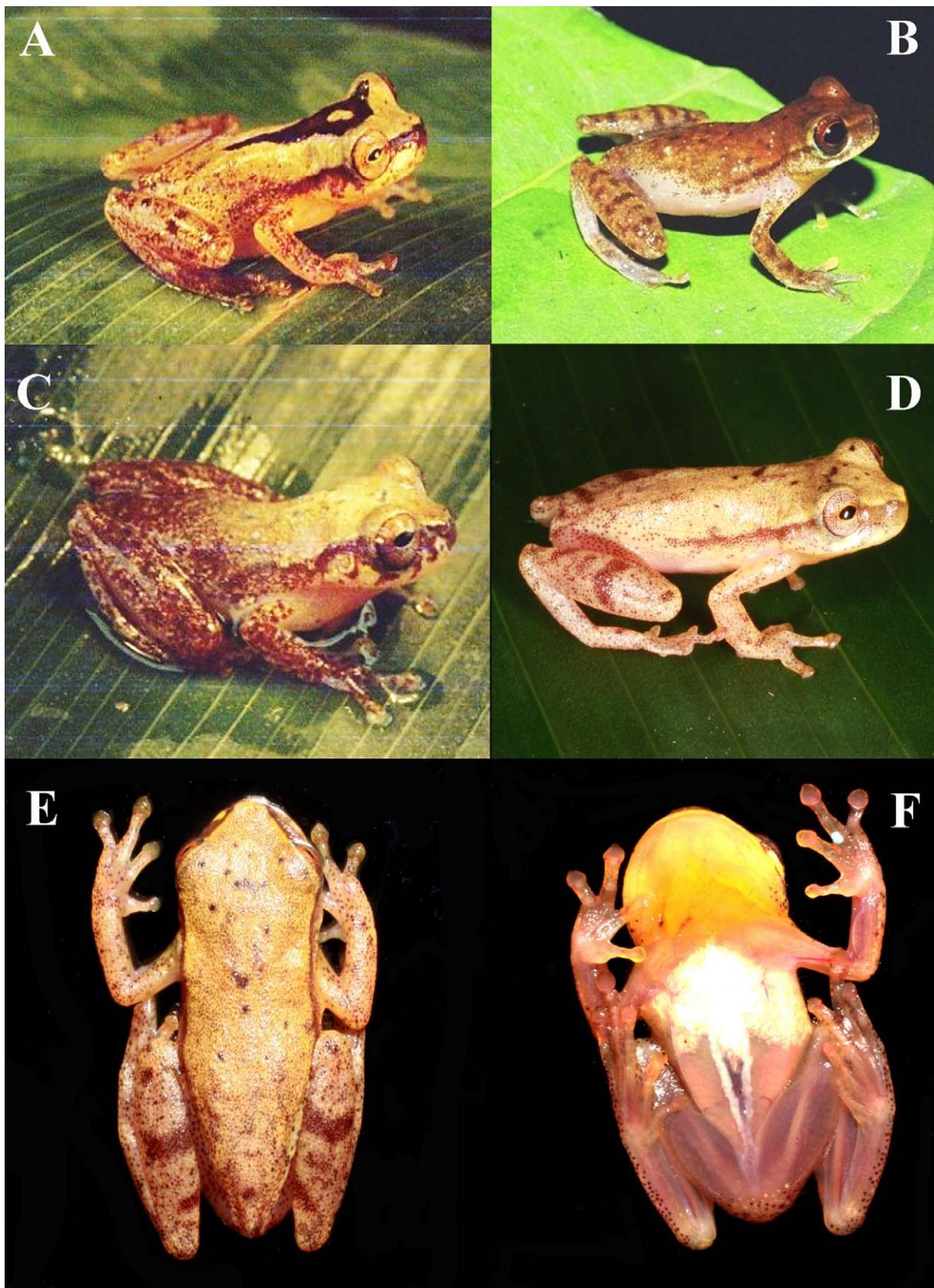


FIGURE 5. Extreme color patterns in *Dendropsophus shiwiarum* sp. nov. (A) adult male, DHMECN 443, SVL 16.5 mm, (B) Adult male DHMECN 4399, SVL 16.4 mm, (C) adult female, not collected, SVL 18.2 mm, and (D–F) adult male, QCAZ 52970, SVL 18.5 mm. Photographs of A–C were digitalized from film camera by HMO-A. Note the shagreen texture of skin of dorsum (E) and pointed tips of digits III and IV on hands (E–F).

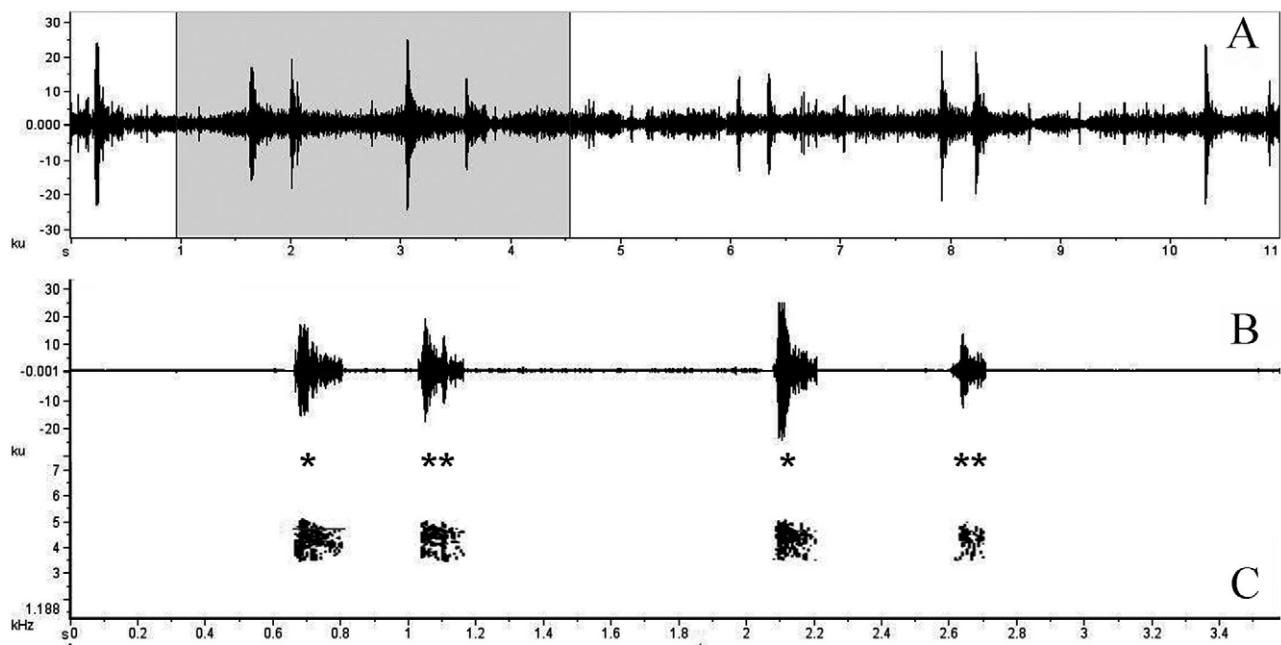


FIGURE 6. Advertisement call of *Dendropsophus shiwiarum* sp. nov. (A) Oscillogram of the section of a chorus, (B) oscillogram and (C) audiospectrogram of the specimen DHMECN 4431 (*SVL = 16.6 mm), seconded by other male (**not collected) in the chorus (shaded area in A). Dominant frequency is about 4352 Hz. Recording obtained on 17 May 2007, at Juyuintza, Pastaza province, Ecuador. Air temperature ~22 °C.



FIGURE 7. Distribution map of *Dendropsophus shiwiarum* sp. nov. (circles) in eastern Ecuador. Red symbols indicate the type localities for *D. shiwiarum*, *D. riveroi* (triangle) and *D. leali* (square) in the Amazon Basin. Localities are based on specimens listed in Appendix I. Dark shaded colors represent areas up to 1000 m above sea level.

Other hylid frogs found at these swamps were *Dendropsophus brevifrons* (Duellman & Crump 1974), *D. parviceps* (Boulenger 1882), *D. rhodopeplus* (Günther 1858), *D. sarayacuensis* (Shreve 1935), *Hypsiboas calcaratus* (Troschel 1848), *H. cinerascens* (Spix 1824), *H. geographicus* (Spix 1824), *H. lanciformis* (Cope 1869), *Osteocephalus deridens* (Jungfer, Ron, Seipp & Almendariz 2000), *O. fuscifacies* (Jungfer, Ron, Seipp & Almendariz 2000), *O. taurinus* (Steindachner 1862) and *Scinax funereus* (Cope 1874). The aquatic snake *Helicops angulatus* (Linnaeus 1758) was also recorded at one of the swamps. The new species is sympatric with *Dendropsophus bifurcus* (Andersson 1945), *D. bokermanni* (Goin 1959), *D. aff. leali*, *D. marmoratus* (Laurenti 1768) *D. miyatai*, *D. parviceps*, *D. rhodopeplus*, *D. sarayacuensis*, and *D. triangulum* (Günther 1868) along its distributional range in eastern Ecuador.

Etymology. The new species is named for the Shiwiari indigenous nation of the Pastaza Trench in the upper Amazon Basin of Ecuador, as recognition for sharing their invaluable knowledge about biodiversity and rich culture, maintaining through the generations a close relationship with nature. Moreover, they generously granted permission to HMO?A to sample frogs from their ancestral territories. The epithet is a genitive noun in apposition.

Discussion

Dendropsophus shiwiarum appears to be morphologically more closely related to *Dendropsophus riveroi*, a species assigned to the *Dendropsophus microcephalus* group (Wiens et al. 2010, Fouquet et al. 2011). *Dendropsophus riveroi* has been commonly described as having white flecks or bars below the eye, a short head with a relatively sharp *canthus rostralis*, and a loreal region darker than the dorsum (e.g. Duellman 1978; Duellman & Mendelson 1995; Rodríguez & Duellman 1994). After its description by Cochran & Goin (1970) based on specimens from Leticia, Colombia, and surrounding areas in the north-central Amazon Basin, this species was commonly confused with *D. leali* and *D. rossalleni* (see Duellman 2005; Köhler et al. 2005 for discussion).

Our review of specimens reported as *Dendropsophus riveroi* from throughout its distribution range lead us to a conclusion similar to the one reached by Köhler et al. (2005), who remarked that the holotype and the type series lack some diagnostic characters that have been attributed to *D. riveroi* in the literature. For example, one to three white bars or blotches below the eye are frequently described for populations in western and southern Amazonia (e.g., De la Riva et al. 2000; Duellman 1978). The bars are absent in the type material of *D. riveroi*, but that could be a preservation artifact. White bars are present in some specimens collected from nearby areas at Leticia, Amazonas, Colombia (e.g. ICN 50615, 50617). The presence of an outer metatarsal tubercle is barely visible in type series of *D. riveroi* [prominent in holotype, according to Köhler et al. (2005)], but absent in *D. shiwiarum*. These tubercles were barely visible in paratypes of *D. riveroi* preserved in ethanol, however, it is necessary to highlight that these traits are difficult to detect due to dehydration.

Diagnostic characters used to separate *D. shiwiarum* from *D. riveroi* are based on the presence of a conical tubercle on dorsal surfaces of discs, the condition of the tympanic membrane and annulus, snout shape and skin texture. The presence of a prominent and well defined tympanic membrane and annulus in *D. riveroi* is considered an important character to delimitate both species (Fig. 2). The presence of a conical tubercle on dorsal surfaces of discs in *D. shiwiarum*, as result of projection of distal phalanx, and pointed tip of discs are useful characters to separate both species, even in living specimens (Figs. 4, 5). Our revision of Ecuadorian specimens identified as *D. riveroi* revealed that they were in fact *D. shiwiarum* (see Appendix I). Photographs and specimens reported as *D. riveroi* from Ecuador and northern Loreto, Peru (e.g., Almendáriz 1987; Duellman & Mendelson 1995), suggest that they may correspond to *D. shiwiarum*. In these cases, a wider survey of museum collections is required to determine the status of Ecuadorian and Peruvian populations ascribed to *D. riveroi* in the literature. Specimens from Rondônia, Nova Brasilia, Brazil (USNM 304058–074, 304174–186) have intermediate characters between *D. riveroi* and *D. shiwiarum* and, thus, their taxonomic status needs to be clarified. These specimens have an “X”-mark on the scapular region, an interorbital brown bar, round discs, obscured sides of snout and a cream or brown canthal stripe, but are larger in size than the type series of *D. riveroi* from Leticia, Colombia. As described by Cochran & Goin (1970), the holotype and topotypes of *D. riveroi* lack a distinctive dorsal pattern, except for the presence of some brown dots and chevrons on the head and back.

Conservation status. The upper Amazon Basin, located at eastern lowlands of Colombia, Ecuador, Peru and the Juruá valley in Brazil, holds the highest richness, diverse and complex amphibian assemblies known from any

area on Earth (Dixon & Soini 1975; Duellman 1978; Duellman & Mendelson 1995; Lynch 2005; Lynch *et al.* 1997; Vigle 2008). The increase of human activities resulted in a rapid conversion of forest types, especially in the southern and eastern parts of the basin, even in tropical forest along the Ecuadorian frontiers with Peru and Colombia, on the upper part of the basin (Bohórquez 2006; Potapov *et al.* 2008). In this context, about 1,8 million ha per year of primary forest has been lost since 1980, resulting in fragmentation of previously continuous forest into smaller islands of remaining habitat (Laurance *et al.* 2004; Myers *et al.* 2000), with a marked reduction in about 9% of forest coverage throughout the past decade in South America (FAO 2011).

In spite that *Dendropsophus shiwiarum* sp. nov. seems to be abundant within its relatively small known distribution range (~35,000 km²), is expected to have a larger distribution in the region. However, four localities (18%), including the type locality, are not included in the National System of Protected Areas of Ecuador. Therefore, the extent and quality of its habitats are probably declining by human disturbances. For these reasons, we consider *D. shiwiarum* to be Near Threatened, thus making the species close to qualifying for Vulnerable in the future, under the criteria A3cE.

Comments on other minute *Dendropsophus* frogs in Amazonia of Ecuador. De la Riva & Duellman (1997) clarified the status of *Dendropsophus rossalleni*, which belongs to the *D. leucophyllatus* group, and commented that specimens reported by Duellman (1978) as *D. rossalleni* from Santa Cecilia, Ecuador, were in fact *D. leali*. According to Duellman (2005), *D. leali* is distributed from eastern Ecuador, Rondônia (Brazil) and Amazonas (Colombia) to southeastern Peru and northern Bolivia. Köhler & Lötters (2005) noted that populations of *D. leali* in southeastern Peru and northern Bolivia are intermediate in some aspects with southern populations of *D. cf. riveroi*. Ecuadorian specimens tentatively assigned to *D. leali* by De la Riva & Duellman (1997) differ in coloration from the holotype and allotype (Duellman 1978). Based on the absence of confirmed records of *D. rossalleni* and *D. leali* from Amazonian Ecuador, their occurrence is still doubtful.

Conclusions

Among the existing species of *Dendropsophus*, *D. shiwiarum* sp. nov. appears morphologically most similar to *D. riveroi*, then it should be placed in the *D. microcephalus* species group (Wiens *et al.* 2010; Fouquet *et al.* 2011). A deeper and comprehensive systematic review of Amazonian *Dendropsophus* is necessary to evaluate the status of populations of *D. riveroi*, *D. leali* and *D. shiwiarum*, along their geographical range and relationships within the *D. microcephalus* species group.

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APPENDIX I. Referred specimens and photographs (*) examined.

- Dendropsophus bifurcus.**—ECUADOR: MORONA SANTIAGO: 2.3 km E de Santiago, QCAZ 27400–402, Cusuimi, Río Cusuime (=Cusime), AMNH 94197, Santiago de Méndez, QCAZ 13941, 23813, 40980, 16984, 16992, 17021, 17027, 1715. PASTAZA: 5.7 Km SE de Bobonaza, QCAZ 32547–551, 900m SE de Bobonaza, QCAZ 32499–501, Canelos, QCAZ 15429–431, 15436, 15443–15446, 16078–083, Finca km 6 vía San Ramón–El Triunfo. Cooperativa La Mariscal Sucre. Entrando por la trocha hecha por el tractor 500 mt antes del Río Pucayaku, QCAZ 36955, Tigüino, Bataburo Lodge, QCAZ 39439, 39514, Vía Tuculí, Bobonaza, QCAZ 32527–537, 32545, Villano, FHGO 612, 620. SUCUMBÍOS: Santa Cecilia, AMNH 93177, 93178–180.
- Dendropsophus bokermanni.**—ECUADOR: PASTAZA: Canelos, QCAZ 16026. SUCUMBÍOS: Santa Cecilia, QCAZ 4467.
- Dendropsophus brevifrons.**—ECUADOR: MORONA SANTIAGO: Sawastian, FHGO 541. PASTAZA: 900m SE de Bobonaza, QCAZ 32489, 32491, Canelos, QCAZ 14990, Vía Tuculí, Bobonaza, QCAZ 32543, 32544.
- Dendropsophus cf. leali.**—COLOMBIA: AMAZONAS: Leticia, AMNH 82088–093. ECUADOR: MORONA SANTIAGO: Tiink, Río Zamora, QCAZ 17026. ORELLANA: Santa Teresita, 4 km NW from Nuevo Rocafuerte, north bank of Río Napo, QCAZ 44643. PASTAZA: Pozo Misión, EPN 9856. SUCUMBÍOS: Lago Agrio, QCAZ 27621, Laguna Grande, Estación Científica PUCE, Reserva de Producción Faunística Cuyabeno, QCAZ 5869, 5870, Santa Cecilia, AMNH 93197. Pozo Tarapoa 2, DHMECN 3600.
- Dendropsophus leali***. MZUSP 74210 (holotype), MZUSP 74211 (allotype), Forte Príncipe da Beira, Territorio Federal de Rondônia, Brazil.
- Dendropsophus marmoratus.**—ECUADOR: MORONA SANTIAGO: Kapawi Jungle Lodge, QCAZ 9026. PASTAZA: Canelos, QCAZ 14982, 20131–136, Lorocachi, QCAZ 8904, Mazaramu, FHGO 4321, 4323, Pandenuque, FHGO 3708, 3829, 3834, Pozo Danta, FHGO 1187, 1292, Pozo Garza 1, FHGO 1252. SUCUMBÍOS: 5 km W Santa Cecilia, AMNH 93212, 93213.
- Dendropsophus microcephalus.**—MEXICO: CHIAPAS: Juárez, QCAZ 7378, 7379. PANAMA: PANAMÁ: Unión Emberá, Rio Majé, Sur del Lago Bayano, QCAZ 30672.
- Dendropsophus miyatai.**—ECUADOR: ORELLANA: Yuturi, QCAZ 10121. SUCUMBÍOS: Hostería La Selva, QCAZ 11543, 12000, 35505, Reserva de Producción Faunística Cuyabeno, QCAZ 4920, 4925, Zancudococha, QCAZ 4521.
- Dendropsophus parviceps.**—ECUADOR: MORONA SANTIAGO: Sawastian, FHGO 5412. ORELLANA: 10 Km al suroeste del Pozo Yampuna, QCAZ 23097. PASTAZA: Pozo Danta, FHGO 1283, Tigüino, Bataburo Lodge, QCAZ 39431, 39515, Vía Tuculí, Bobonaza, QCAZ 32555.
- Dendropsophus rhodopeplus.**—ECUADOR: MORONA SANTIAGO: Méndez, Santiago de, QCAZ 23814, Peñas, alrededores, QCAZ 27381–388, Río Yunganza, QCAZ 17157. PASTAZA: 900m SE de Bobonaza, QCAZ 32490, Canelos, QCAZ 16065–070, 17478–483, 17488, Finca km 6 vía San Ramón–El Triunfo. Cooperativa La Mariscal Sucre. Entrando por la trocha echa por el tractor 500 mt antes del Río Pucayaku, QCAZ 37888, 37890, 40969, 40970.
- Dendropsophus riveroi.**—COLOMBIA: AMAZONAS: Leticia, AMNH 72552, 72553, USNM 146256, 146257, 152609, 152610; Leticia, 2 km vía Tarapacá, ICN 50611, 50613, 50615, 50617.
- Dendropsophus cf. riveroi.**—BRAZIL: RODÔNIA: Nova Brasilia, USNM 304058–074, 304174–186. COLOMBIA: META: Quebrada Honda, tributary to Upper Rio Guejar, USNM 152201, 152202.
- Dendropsophus shiwiarum sp. nov.**—ECUADOR: Napo: Tena, QCAZ 2739; Ahuano, QCAZ 27045–46. Orellana: Northern Production Facilities, Empresa Petrolera Maxus, QCAZ 8250–53, 8308; Aporika, QCAZ 20737, 20739; Estación Científica Yasuní, QCAZ 22752; Km 93 vía Pompeya-Iro, a 93 km de Pompeya, por la carretera, QCAZ 48101–05; Pantano Mauritia cerca NPF, QCAZ 49204; Bloque 16, Sitio 25, vía Tivacuno cerca NPF, QCAZ 49742; Km 96 vía Pompeya - Iro, QCAZ 51162; Parque Nacional Yasuní, 78–79 Km Vía Pompeya-Iro, QCAZ 53363–65, 53373. Sucumbíos: Reserva de Producción Faunística Cuyabeno, Estación Científica de la Pontificia Universidad Católica del Ecuador, QCAZ 5955; Hostería La Selva, QCAZ 11542, 11544; 2.5 km Norte de Lago Agrio, QCAZ 21936–37, 22885; Rey de los Andes, QCAZ 28086. Specimen DHMECN 5020 from “Amazonia of Ecuador”, lacks specific location.
- Dendropsophus sarayacuensis.**—ECUADOR: PASTAZA: Finca km 6 vía San Ramón–El Triunfo. Cooperativa La Mariscal Sucre. Entrando por la trocha hecha por el tractor 500 mt antes del Río Pucayaku, QCAZ 37885, 37889, 40248, Nueve de Octubre, QCAZ 32637, 27046, 8252, 8253, 8308, 27791, 4431, 4432, 4393, 4394, 4399, 5020, 21937, 22885.
- Dendropsophus triangulum.**—ECUADOR: PASTAZA: Canelos, QCAZ 16003, 17410, 17411, 17414–423, Conambo, DHMECN 4744, 4745, Finca km 6 vía San Ramón–El Triunfo. Cooperativa La Mariscal Sucre. Entrando por la trocha echa por el tractor 500 mt antes del Río Pucayaku, QCAZ 37887, Montalvo, AMNH 86512, Pandenuque, FHGO 3828. SUCUMBÍOS: Limoncocha, AMNH 98097, 98098, Santa Cecilia, AMNH 93207–211.