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Redescription of the Tadpole of *Phyllomedusa bicolor* (Anura: Hylidae) from Central Amazonia

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Abstract. The tadpole of *Phyllomedusa bicolor* is redescribed based on 147 individuals from 16 developmental stages collected in three areas of Central Amazonia. We compare them with other tadpoles of the genus found in the Amazon and provide comments on development sites. The tadpole of *P. bicolor* (stage 36) has a triangular body in lateral view and elongate body in dorsal view. The snout is rounded, the nostrils small and ovoid and the eyes are positioned laterally. Tail length is 61% of total length. The larva has a single, sinistral, almost ventral spiracle. The short vent tube is dextral and attached to the ventral fin. There is a unique cord on the dorsal fin, visible at all stages, originating at body terminus and extending almost to the tip of the tail. The anteroventral oral disc has marginal and submarginal papillae and a labial tooth row formula of 2(2)/3(1) at Gosner stages above 24. Tadpoles inhabit streamside ponds or ponds formed in streams of terra firme forests.

Keywords. Breeding site; Ontogenetic variation; Larval morphology.

Resumo. Neste estudo, nós redescrevemos os girinos de *Phyllomedusa bicolor* utilizando 147 indivíduos em 16 estádios de desenvolvimento, coletados em três áreas na Amazônia Central. Nós comparamos com os girinos de outras espécies de *Phyllomedusa* que ocorrem na região Amazônica e também fornecemos informações sobre os sítios de desenvolvimento dos girinos. O girino de *P. bicolor* (estádio 36) é caracterizado por um corpo triangular em vista lateral e alongado em vista dorsal. O focinho é arredondado, as narinas são pequenas e ovoides e os olhos laterais. A cauda corresponde a 61% do comprimento total. O espiráculo é único, sinistro, aproximadamente ventral. O tubo anal é curto, destro e aderido à nadadeira ventral. Na nadadeira dorsal há um “cordão”, visível em todos os estádios, se originando no final do corpo e se estendendo até, aproximadamente, o final da cauda. O disco oral é anteroventral, com papilas marginais e submarginais; fórmula dentária 2(2)/3(1) a partir do estádio 24. Os girinos se desenvolvem em poças nas margens de riachos ou poças formadas dentro de riachos de floresta de terra firme.

INTRODUCTION

The Neotropical genus *Phyllomedusa* consists of 30 species distributed from Panama, the Pacific slopes of Colombia, and South America east of the Andes, including Trinidad, and southward to northern Argentina and Uruguay (Frost, 2013). *Phyllomedusa* comprises two major and well-supported clades (Faivovich *et al.*, 2010): one clade includes the *P. tarsius* and *P. burmeisteri* species groups, plus *P. bicolor*, *P. boliviana*, *P. camba*, *P. sauvagii*, and *P. vaillanti*, and the other clade is formed by the *P. perinesos* and *P. hypochondrialis* species groups plus *P. tomopterna* and *P. atelopoides*. The larvae of 24 species have been described (Provete *et al.*, 2012) or figured, of which 12 belong to the first clade of Faivovich *et al.* (2010): *P. bahiana* (Silva-Filho and Juncá, 2006), *P. bicolor* (Rada-de-Martinez, 1990), *P. boliviana* (Lavilla, 1983; Cannatella, 1983), *P. burmeisteri* (Cruz, 1982), *P. camba* (Duellman, 2005), *P. distincta* (Cruz, 1982), *P. iheringi* (de Sá and Gerhau, 1983), *P. tarsius* (Duellman, 1978), *P. tetraploidea* (Pombal and Haddad, 1992), *P. trinitatis* (Kenny, 1969), *P. vaillanti* (Duellman, 1978, 2005; Caramaschi and Jim, 1983), and *P. venusta* (Lynch, 2006).

Phyllomedusa bicolor is widely distributed in northern South America, occurring in the Amazon basin of Brazil, Colombia, Bolivia, and Peru, and the Guianan region of Venezuela and the Guianas (Frost, 2013). This species is currently not assigned to any species group (Faivovich *et al.*, 2005); however, *P. bicolor* and *P. vaillanti* were recovered as monophyletic (Faivovich *et al.*, 2010). A description of *P. bicolor* from Venezuela provided information on external morphological characters but no morphometric or ontogenetic variation data (Rada-de-Martinez, 1990). In addition, the species was included in an identification key of tadpoles of the Brazilian central Amazon (Hero, 1990) and an illustration and information on coloration and oral apparatus for specimens from French Guiana (Lescure *et al.*, 1995).

Herein, we redescribe the larva of *Phyllomedusa bicolor* based on individuals from three localities in central Amazonia, Brazil, and compare them to the known tadpoles of closely related species (Faivovich *et al.*, 2010) and other species that occur in the Amazon (*i.e.*, *P. atelopoides*, *P. hypochondrialis*, *P. palliata*, and *P. tomopterna*). We also provide data on the spawning sites.

MATERIALS AND METHODS

We collected 119 tadpoles of *Phyllomedusa bicolor* on 13 November 2008 in a pond in a temporary stream at the Universidade Federal do Amazonas (campus UFAM: 02°55' and 03°01'S, 59°53' and 59°59'W), Manaus, Amazonas, Brazil. The forest fragment has an area of about 600 ha of *terra-firme* forest (a non-seasonally flooded forest), secondary forest, “campinarana” sites (a low, sparse, forest with thin trees 10–20 m tall) and deforested areas (Tsuji-Nishikido and Menin, 2011). Three tadpoles were raised in plastic containers (40 × 40 × 10 cm) in the laboratory until individuals reached metamorphosis to confirm the species identity (CZPB-UFAM 278). Tadpoles were fed with commercial rabbit food. Tadpoles were preserved at different stages in 10% formalin. Sixteen additional larvae were collected on 28 January 2012 and 18–20 June 2012 at the Reserva Biológica do Uatumã (Rebio Uatumã: 00°50'–01°55'S; 58°50'–60°10'W) and 12 larvae were collected on 12 and 21 March 2012 at the Reserva Florestal Adolpho Ducke (RFAD: 02°55' and 03°01'S, 59°53' and 59°59'W); all were fixed immediately after collection and used in measurement analyses. Rebio Uatumã covers 942.779 ha of *terra firme* rainforest in the municipalities of Presidente Figueiredo, São Sebastião do Uatumã and Urucará, Amazonas. RFAD covers 10,000 ha of *terra firme* rainforest at Manaus, Amazonas.

Tadpole stages follow Gosner (1960). Descriptive terminology and morphometric variables follow Altig and McDiarmid (1999). Measurements were taken with an eyepiece reticle and digital calipers to the nearest 0.1 mm. Voucher specimens were deposited in the Coleção Zoológica Paulo Bührnheim of the Universidade Federal do Amazonas (Tadpole lot: CZPB-UFAM 155, 170, 264–277, 280–284).

RESULTS

Tadpole description

External morphology

The tadpoles of *Phyllomedusa bicolor* are extrotopic, lentic, and suspension-rasper (Altig and McDiarmid, 1999). At stage 36 (CZPB-UFAM 274) body triangular in lateral view (Fig. 1A) and elongated in dorsal view (Fig. 1B). Body 39.1% (38.6–40.0%) of total length and tail 60.1% (60.0–61.8%) of total length. Snout truncated in lateral and dorsal views. Eyes large, laterally positioned and directed laterally. Nostrils small, ovoid, anterolaterally positioned and near to snout. Internarial distance about 30% (28.6–31.4%) larger than eye diameter. Spiracle single and almost ventral, not forming a free tube (inner wall absent), posteriorly directed; spiracular opening large and below the mid-level of body; not visible in dorsal

view. Vent tube short and completely attached to the right side of the ventral fin. Maximum tail height about 2X greater than maximum height of tail musculature. Caudal musculature gradually tapering to a pointed tip; broader than dorsal fin along the tail. Dorsal fin originating at the tail-body junction, shallow throughout its length; highest posteriorly. Ventral fin originating at body terminus, slightly arched, and of constant height along its anterior two-thirds, gradually tapering towards the tip. Dorsal fin with a unique cord (thickening on the edge of the fin), visible at all stages, originating at body terminus and extending almost to the end of the tail (Fig. 1A).

Oral disc small (Fig. 1C), anteroventral, directed anteriorly and ventrally emarginate. Marginal papillae uniseriate, elongate, about 10 papillae per linear millimeter, with wide gap on anterior labium; gap between papillae about two-thirds of the of the A-1 labial tooth row. Submarginal papillae present laterally on anterior and posterior labium, smaller than marginal papillae. Upper jaw sheath wide, M-shaped with a medial point; lower jaw sheath wide, V-shaped; both finely serrated; serrations small, triangular-shaped, and oriented downwards. There are about 27 serrations per millimeter (estimated on lower jaw sheath). Labial tooth row formula (LTRF) 2(2)/3(1). There are about 45 labial teeth per millimeter (estimated on P-1). Rows A-1 and A-2 of same length; P-1 slightly longer than P-2; P-3 of about half the length of P-2; gap in A-2 wide, gap in P-1 very small of less than five keratodonts (Fig. 1C).

Measurements of tadpoles provided in Table 1. Metamorphosed froglets (stage 46) SVL = 22.62 ± 0.80 mm

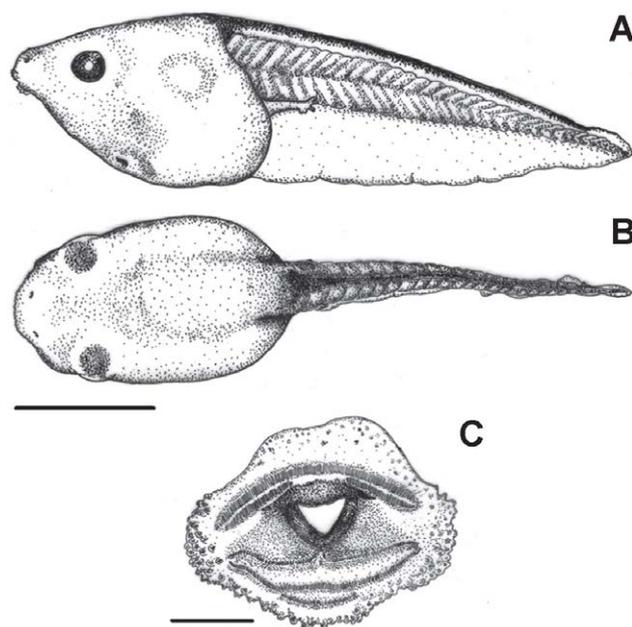


Figure 1. *Phyllomedusa bicolor* tadpole (CZPB-UFAM 274) at stage 36. (A) Lateral view, (B) dorsal view (scale = 10 mm), and (C) oral disc (scale = 1 mm).



Figure 2. Live tadpole of *Phyllomedusa bicolor* at stage 27. Reserva Florestal Adolpho Ducke, Manaus, Brazil (Photo: Domingos J. Rodrigues).

(21.34–22.81; $n = 3$). Froglets were green and had a body shape similar to adults, with the presence of sparse white spots with dark outlines on the chest and hind legs.

Laval coloration

In life, dorsum and anterior part of the body orange, belly silver, tail musculature and unique cord pale orange, fins translucent orange, iris silver (Fig. 2). In preservative, body color light yellow, dorsum brownish gray, lateral side of body and belly gray, tail musculature and unique cord pale brown, dorsal part of caudal musculature brown and fins translucent; intestines not visible through skin.

Ontogenetic variation

At stage 24 LTRF: 1(1)/2(1); stages 26, 27, 29, and 34 LTRF: 2(2)/3(1) or 2(2)/3(1-2) (Table 1). After stage 24 the LTRF with two A-rows and three P-rows was stable and only the P-gaps varied at advanced developmental stages. The vent tube was not visible at stages 24 and 25. Individuals in early developmental stages (24 and 25) were slender and less pigmented (tail muscle lighter than in other stages). Individuals of stages 36, 37, 38, and 40 had a grainy texture on lateral surfaces of the body, from the postorbital region to body terminus; grainy texture is scarce on the ventral region. Maximum total length at stage 40 (49.09 mm). Specimens from ReBio Uatumã (16 individuals) have P-3 of about half to 2/3 of the length of P-2.

Natural history

At campus UFAM, breeding adults and clutches were observed on vegetation above a pond formed as a channel of a temporary stream. *Phyllomedusa bicolor* is the only known species of the genus at campus UFAM

(Tsuji-Nishikido and Menin, 2011) and the tadpoles develop exclusively in this habitat. Tadpoles were observed at midwater and the surface, with their bodies inclined upwards at approximately 45°. The pond was approximately 47 cm deep and 12 × 17 m wide (approximately 204 m²); the bottom was sandy with dead leaves; the pond lasted about six months before drying. At Rebio Uatumã, tadpoles were found in two habitats: a) a small temporary pond (11 × 3.2 m wide, 15 cm deep) with dead leaves on the bottom, along the edge of a stream, and b) a pond formed in the channel of a stream that was 58 cm deep and 2 m wide; the bottom was sandy with dead leaves. At RFAD, *P. bicolor* is sympatric with *P. tarsius*, *P. tomopterna*, and *P. vaillanti*. The tadpoles were collected in a pond located in clay soil, isolated (> 200 m) from the nearest stream and approximately 50 cm deep and 5 × 2 m wide (about 10 m²).

DISCUSSION

Most characteristics of *Phyllomedusa bicolor* tadpoles are similar to those reported for other species in the genus, including its triangular body, small nostrils near the snout, anteroventral mouth, heavy caudal musculature, shallow dorsal fin, ventral fin deeper than dorsal fin, and sinistral, almost ventral spiracle. Overall, morphological characteristics agree with those reported for *P. bicolor* tadpoles from Venezuela (Rada-de-Martinez, 1990), except for the presence of submarginal papillae and the color of live tadpoles. However, submarginal papillae are visible in Rada-de-Martinez's (1990: fig. 9) illustration of the oral disc of *P. bicolor*. The color pattern also differs from that reported for specimens from French Guiana as grayish brown with pearl belly (Lescure *et al.*, 1995). The variation in the color pattern could be related to any number of factors, ranging from genetics to environmental

Table 1. Measurements (in mm) of 147 *Phyllomedusa bicolor* tadpoles in Gosner (1960) stages 24–38 and 40. Values are means ± standard deviation and range for stages with three or more individuals. For stages with one or two individuals, the values are presented for each individual. LTRF = labial tooth row formula.

| Characters | Stages | | | | | | | | | | | | | | | | |
|-----------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|--------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | 24 N = 10 | 25 N = 5 | 26 N = 32 | 27 N = 33 | 28 N = 23 | 29 N = 5 | 30 N = 4 | 31 N = 6 | 32 N = 1 | 33 N = 1 | 34 N = 6 | 35 N = 2 | 36 N = 4 | 37 N = 5 | 38 N = 1 | 40 N = 9 | |
| Total length | 10.80 ± 1.08 8.80 – 12.80 | 14.31 ± 2.88 11.20 – 17.61 | 22.39 ± 5.06 12.86 – 34.16 | 27.23 ± 2.12 21.82 – 30.90 | 29.78 ± 2.41 25.14 – 35.04 | 33.10 ± 1.24 31.79 – 34.59 | 35.73 ± 1.87 33.06 – 37.03 | 34.56 ± 1.23 32.58 – 36.09 | 41.52 ± 2.57 34.53 – 41.87 | 37.89 ± 2.57 34.53 – 41.87 | 42.15 ± 2.57 34.53 – 41.87 | 37.89 ± 2.57 34.53 – 41.87 | 27.94 ± 2.13 42.21 | 42.46 ± 2.13 41.32 – 46.17 | 44.61 ± 1.39 42.31 – 45.57 | 42.55 ± 1.77 43.53 – 49.09 | 45.52 ± 1.77 43.53 – 49.09 |
| Body length | 3.60 ± 0.43 3.04 – 4.64 | 5.23 ± 1.38 3.68 – 7.20 | 8.42 ± 2.06 5.02 – 12.48 | 11.40 ± 0.73 9.81 – 13.22 | 12.10 ± 0.57 10.77 – 13.02 | 12.90 ± 0.51 12.23 – 13.66 | 13.20 ± 0.11 13.12 – 13.38 | 13.73 ± 0.76 12.54 – 14.57 | 15.33 ± 0.65 14.05 – 15.62 | 14.75 ± 0.65 14.05 – 15.62 | 15.07 ± 0.65 14.05 – 15.62 | 14.75 ± 0.65 14.05 – 15.62 | 14.52 ± 0.65 16.57 | 16.85 ± 0.85 15.76 – 17.86 | 17.41 ± 0.75 16.7 – 18.59 | 16.25 ± 0.75 16.89 – 18.29 | 17.77 ± 0.56 16.89 – 18.29 |
| Tail length | 7.36 ± 0.85 5.76 – 8.80 | 9.07 ± 1.70 7.52 – 11.31 | 13.96 ± 3.20 7.77 – 20.36 | 15.91 ± 1.64 12.01 – 18.58 | 17.68 ± 2.03 13.11 – 22.59 | 20.20 ± 1.02 19.18 – 21.81 | 22.53 ± 1.88 19.89 – 23.91 | 20.85 ± 0.78 20.02 – 21.98 | 26.19 ± 1.98 20.48 – 26.25 | 27.08 ± 1.98 20.48 – 26.25 | 27.08 ± 1.98 20.48 – 26.25 | 22.91 ± 1.98 20.48 – 26.25 | 13.42 ± 25.64 25.27 – 28.31 | 25.75 ± 1.38 25.27 – 28.31 | 26.02 ± 1.39 25.61 – 28.78 | 26.3 ± 1.39 25.61 – 28.78 | 27.80 ± 1.71 25.38 – 31.01 |
| Maximum tail height | 1.68 ± 0.24 1.26 – 1.98 | 2.51 ± 0.70 1.98 – 3.68 | 4.41 ± 1.16 2.60 – 6.72 | 6.24 ± 0.41 5.60 – 7.20 | 6.45 ± 0.48 5.28 – 7.20 | 6.72 ± 0.61 6.08 – 7.52 | 6.76 ± 0.80 5.60 – 7.36 | 7.60 ± 0.50 7.20 – 8.64 | 7.84 ± 0.24 7.36 – 8.00 | 7.84 ± 0.24 7.36 – 8.00 | 7.84 ± 0.24 7.36 – 8.00 | 7.68 ± 0.24 7.36 – 8.00 | 9.28 ± 9.44 9.44 | 8.56 ± 0.75 8.00 – 9.44 | 9.92 ± 0.62 8.96 – 10.72 | 9.60 ± 0.62 8.96 – 10.72 | 8.48 ± 0.64 7.84 – 9.92 |
| Tail muscle height | 1.25 ± 0.14 0.93 – 1.32 | 1.50 ± 0.27 1.26 – 1.92 | 1.97 ± 0.45 1.04 – 2.52 | 2.64 ± 0.18 2.40 – 3.00 | 2.91 ± 0.14 2.64 – 3.24 | 2.93 ± 0.18 2.64 – 3.12 | 2.79 ± 0.21 3.00 | 3.48 ± 0.22 3.24 – 3.84 | 3.12 ± 0.19 3.00 – 3.48 | 3.48 ± 0.19 3.00 – 3.48 | 3.48 ± 0.19 3.00 – 3.48 | 3.36 ± 0.19 3.00 – 3.48 | 3.60 ± 0.20 3.60 – 3.72 | 3.60 ± 0.20 3.60 – 3.72 | 3.72 ± 0.22 3.60 – 4.08 | 3.96 ± 0.22 3.60 – 4.08 | 3.84 ± 0.18 4.08 |
| Tail muscle width | 0.81 ± 0.08 0.66 – 0.93 | 1.22 ± 0.27 0.93 – 1.60 | 1.82 ± 0.42 1.12 – 2.88 | 2.40 ± 0.14 2.08 – 2.56 | 2.39 ± 0.16 2.08 – 2.72 | 2.56 ± 0.11 2.40 – 2.72 | 2.8 ± 0.09 2.72 – 2.88 | 3.04 ± 0.14 2.88 – 3.20 | 3.20 ± 0.14 2.88 – 3.20 | 3.20 ± 0.14 2.88 – 3.20 | 3.20 ± 0.14 2.88 – 3.20 | 3.12 ± 0.13 2.88 – 3.20 | 3.20 ± 0.13 2.88 – 3.20 | 3.48 ± 0.22 3.68 – 3.84 | 3.68 ± 0.18 3.68 – 3.84 | 3.36 ± 0.18 3.68 – 4.32 | 4.00 ± 0.24 4.32 |
| Internarial distance | - | 1.78 ± 0.20 1.62 – 2.00 | 2.06 ± 0.41 1.40 – 2.75 | 2.55 ± 0.16 2.25 – 3.00 | 2.62 ± 0.17 2.40 – 3.00 | 2.86 ± 0.16 2.70 – 3.05 | 2.78 ± 0.05 2.75 – 2.85 | 3.00 ± 0.11 2.95 – 3.25 | 3.00 ± 0.06 3.10 – 3.30 | 3.00 ± 0.06 3.10 – 3.30 | 3.00 ± 0.06 3.10 – 3.30 | 3.25 ± 0.06 3.30 | 3.30 ± 0.13 3.40 | 3.38 ± 0.13 3.20 – 3.50 | 3.50 ± 0.14 3.35 – 3.75 | 3.10 ± 0.14 3.35 – 3.75 | 3.36 ± 0.22 3.48 |
| Interorbital distance | 1.75 ± 0.17 1.48 – 2.00 | 2.56 ± 0.59 1.83 – 3.20 | 3.72 ± 0.85 2.40 – 6.00 | 4.70 ± 0.24 4.30 – 5.30 | 5.08 ± 0.33 4.50 – 6.10 | 5.46 ± 0.34 5.20 – 5.80 | 5.68 ± 0.42 6.00 | 5.75 ± 0.29 6.20 | 6.80 ± 0.08 6.50 | 6.50 ± 0.08 6.50 | 6.50 ± 0.08 6.50 | 6.50 ± 0.08 6.50 | 6.10 ± 6.50 6.50 | 7.05 ± 0.38 6.80 – 7.70 | 5.60 ± 0.32 7.20 – 8.10 | 7.10 ± 0.42 7.40 – 8.70 | 8.20 ± 0.42 7.40 – 8.70 |
| Eye diameter | 0.75 ± 0.11 0.6 – 0.98 | 0.92 ± 0.20 0.68 – 1.20 | 1.32 ± 0.26 0.92 – 1.86 | 1.62 ± 0.08 1.50 – 1.86 | 1.65 ± 0.10 1.5 – 1.92 | 1.84 ± 0.12 1.74 – 2.04 | 1.89 ± 0.10 1.74 – 1.98 | 1.94 ± 0.04 1.94 – 2.04 | 2.10 ± 0.04 1.86 – 2.04 | 2.16 ± 0.09 1.86 – 2.04 | 2.16 ± 0.09 1.86 – 2.04 | 1.98 ± 0.09 2.04 | 2.16 ± 0.28 2.16 – 2.46 | 2.34 ± 0.09 2.28 – 2.46 | 2.40 ± 0.08 2.34 – 2.52 | 2.28 ± 0.08 2.34 – 2.52 | 2.46 ± 0.98 2.58 |
| Oral disc width | 0.96 ± 0.14 0.40 – 0.84 | 1.30 ± 0.42 0.82 – 1.90 | 6.68 ± 0.80 4.00 | 2.80 ± 0.17 2.40 – 3.10 | 3.00 ± 0.23 2.70 – 3.50 | 3.36 ± 0.25 3.20 – 3.60 | 3.55 ± 0.26 3.20 – 3.80 | 3.55 ± 0.26 3.10 – 3.80 | 4.00 ± 0.26 3.00 – 4.00 | 4.00 ± 0.38 3.00 – 4.00 | 4.30 ± 0.38 3.00 – 4.00 | 3.90 ± 0.38 3.00 – 4.00 | 3.70 ± 4.00 4.50 | 4.25 ± 0.23 4.00 – 4.50 | 4.10 ± 0.49 3.90 – 4.90 | 4.00 ± 0.49 3.90 – 4.90 | 4.50 ± 0.19 4.00 – 4.60 |
| LTRF | 1(1)/2(1) | 2(2)/3(1) | 2(2)/3(1-2) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1-2) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) | 2(2)/3(1) |

differences and intraspecific interactions (Thibaudeau and Altig, 2012). Our description differs from the Hero's (1990) illustration of *P. bicolor* from Central Amazonia that did not show a ventrally emarginate oral disc and lacks submarginal papillae on lateral parts of anterior and posterior labium; consequently we conclude that this description does not correspond to *P. bicolor* larvae.

Tadpoles of *Phyllomedusa bicolor* are easily distinguishable from all other closely related species (Faivovich *et al.*, 2010 clade) and another species from Amazonian, with the exception of *P. vaillanti* (Caramaschi and Jim, 1983; Hero, 1990), by the presence of a unique cord, visible at all stages, originating at body terminus and extending almost to the tip of the tail. This is also found in tadpoles of *P. vaillanti*, which further supports the close relationship between the two species (Faivovich *et al.*, 2010).

The tadpoles of *Phyllomedusa bicolor* are smaller than those of *P. bahiana* (total length 37.6–55.0 mm in stages 34–36; Silva-Filho and Juncá, 2006), *P. boliviana* (36.6–44.0 mm in stages 31–35; Cannatella, 1983; Lavilla 1983), *P. camba* (45.7 mm in stage 27; Duellman, 2005), *P. tarsius* (46.2 mm in stage 33 and 50 mm in stage 36; Duellman, 1978; Hero 1990), *P. tetraploidea* (54.7 mm in stage 37; Pombal and Haddad, 1992), *P. tomopterna* (32.2 mm in stage 28 and 64.0 mm in stage 38; Duellman, 1978, 2005; Hero 1990), *P. trinitatis* (maximum length 65 mm; Kenny, 1969), and *P. vaillanti* (51.0–69.3 mm in stage 37; Duellman, 1978, 2005; Caramaschi and Jim, 1983; Hero, 1990); they are also larger than *P. atelopoides* (22.5–25.5 mm in stage 27; Duellman, 2005) and *P. iheringi* (14.5 mm in stage 33; de Sá and Gerhau, 1983). The total length is similar to that of tadpoles of *P. burmeisteri* (42.0 mm in stage 35; Cruz, 1982), *P. distincta* (46.0 mm in stage 36; Cruz, 1982), and *P. palliata* (41.5–44.0 in stages 36 and 37; Duellman, 1978, 2005).

The tadpole of *Phyllomedusa bicolor* can also be distinguished from *P. atelopoides* by vent tube size, vent tube position and coloration (vent tube moderately long and sinistral to the ventral fin; body brownish black, belly silvery blue and snout pale lime green in live *P. atelopoides* tadpoles; Duellman, 2005), from *P. bahiana* by papillae disposition and coloration in life (marginal and sub-marginal papillae disposed regularly on the lateral sides and dorsolateral portions of the oral disc, in double rows on the lateral portions; body and musculature of the tail pale beige, dorsal and lateral surfaces with very dark brown punctuations giving a dark appearance; Silva-Filho and Juncá, 2006), from *P. boliviana* by coloration (dorsum transparent with gold and black pigments, lateral surfaces gold, belly transparent in live *P. boliviana* tadpoles; Cannatella, 1983; Lavilla, 1983), from *P. burmeisteri* and *P. distincta* by the size of labial tooth row (P-3 lesser than half of the length of P-2 in both species; Cruz, 1982), from *P. camba* by depth of fins, LTRF and coloration (ventral and dorsal fins slightly similar in depth; LTRF 2(2)/3; body black

dorsally, changing to dark bluish gray ventrally in live *P. camba* tadpoles; Duellman, 2005), from *P. hypochondrialis* by LTRF and distribution of marginal papillae (LTRF 2(2)/3 in *P. hypochondrialis* from Venezuela; gap in marginal papillae of posterior labium; Pyburn and Glidewell, 1971; Rada-de-Martinez, 1990), from *P. iheringi* by distribution of submarginal papillae and coloration (absence of submarginal papillae; presence of four dark spots and trapezoidal blotch on the head; de Sá and Gerhau, 1983), from *P. palliata* by LTRF and coloration (LTRF 2(2)/3; body and tail bluish gray with an iridescent bluish green sheen on the belly in live *P. palliata* tadpole; Duellman, 1978, 2005), from *P. tarsius* by coloration (body transparent olive or whitish with a silver belly or pale metallic green in live *P. tarsius* tadpoles; Duellman, 1978; Hero, 1990), from *P. tetraploidea* by coloration (presence of rectangular dark spot between the eyes; Pombal and Haddad, 1992), from *P. tomopterna* by coloration (body transparent olive, whitish with a silver abdomen or yellow to yellowish tan, tail transparent or whitish with a diffuse orange patch midway along the lower fin in live *P. tomopterna* tadpoles; Duellman, 1978, 2005; Hero, 1990; Lescure *et al.*, 1995), from *P. trinitatis* by coloration (ventral fin with prominent cluster of black spots which expand in the dark to form a black bar across the tail; Kenny, 1969), from *P. vaillanti* by LTRF, size of labial tooth row, and coloration (LTRF 2(2)/3 or 2(2)/3(1); P-3 slightly lesser than the length of P-2; in life, body and tail gray-greenish, belly whitish in tadpoles from eastern Brazilian Amazon; dorsum dull green, caudal musculature pale green, belly white in tadpoles from Peru; presence of a black spot between the eyes in *P. vaillanti*; Duellman, 1978, 2005; Caramaschi and Jim, 1983; Hero, 1990; Lescure *et al.*, 1995), and from *P. venusta* by the size of papillae gap (gap between papillae about one-third of the A-1 labial tooth row; Lynch, 2006).

The spawning sites where tadpoles of *Phyllomedusa bicolor* developed were in lentic water bodies (Hero, 1990; Venâncio and Melo-Sampaio, 2010; Lima *et al.*, 2012; present study), near or isolated from streams, or in still water in streams (present study), all in *terra-firme* forests. The use of lentic water bodies for reproduction was observed in the majority of species of *Phyllomedusa* (see Faivovich *et al.* 2010 to the evolution of this and other characters associated with reproduction and larval development), including all species of the clade defined by Faivovich *et al.* (2010) composed by *P. tarsius* and *P. burmeisteri* groups, plus *P. bicolor*, *P. boliviana*, *P. camba*, *P. sauvagii*, and *P. vaillanti*, and other species occurring in the Amazon. However, greater plasticity in the site of tadpole development was observed in the sister species *P. bicolor* (Venâncio and Melo-Sampaio, 2010; Lima *et al.*, 2012; present study) and *P. vaillanti* (Duellman, 1978, 2005; Caramaschi and Jim, 1983; Hero, 1990; Lima *et al.*, 2012) which reproduce in temporary or permanent ponds isolated from or on the edges of streams or in backwater in streams.

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