



# A new species of harlequin toad from the Western Cordillera of Colombia (Bufonidae: *Atelopus*), with comments on other forms

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**Abstract.** The harlequin toads (Bufonidae, *Atelopus*) from the Cordillera Occidental of Colombia are poorly understood, with several species being known only from few specimens and a single locality. Material from the Yotoco area, Departamento Valle del Cauca, has been addressed in previous studies and was allocated ambiguously to different available names. We here describe the Yotoco *Atelopus* as a species new to science as it is readily distinguished from all congeners by a combination of morphological characters (i.e., snout profile, cranial crests, skin texture, pattern and coloration). In addition, we comment on the taxonomy of three *Atelopus* populations from the Cordillera Occidental and the Cordillera Central of Colombia; two of them we tentatively assign to *A. nicefori* and *A. sonsonensis*, respectively. The third one remains of unclear status. The need for further examination of the harlequin toads from the Andes of Colombia in an integrative taxonomic framework is emphasized.

**Key words.** Amphibia, Anura, *Atelopus calima* sp. n., conservation, morphology, taxonomy.

**Resumen.** Los sapos arlequín (Bufonidae, *Atelopus*) de la Cordillera Occidental de Colombia son poco conocidos, con varias especies conocidas sólo a partir de unos pocos especímenes y una sola localidad. El material del área de Yotoco, Departamento del Valle del Cauca, ha sido abordado en estudios previos y fue asignado de manera ambigua a diferentes nombres disponibles. Aquí describimos al *Atelopus* de Yotoco como una especie nueva para la ciencia, ya que se distingue fácilmente de todos los congénicos por una combinación de características (i.e., perfil del hocico, crestas craneales, textura de la piel, patrón y coloración). Adicionalmente, comentamos la taxonomía de tres poblaciones de *Atelopus* de la Cordillera Occidental y Central de Colombia. Asignamos tentativamente dos de ellos a *A. nicefori* y *A. sonsonensis*, respectivamente. El tercero sigue sin estar claro. Se enfatiza la necesidad de realizar un examen más profundo de los sapos arlequín de los Andes de Colombia en un marco taxonómico integrador.

**Palabras clave.** Amphibia, Anura, *Atelopus calima* sp. n., conservación, morfología, taxonomía.

## Introduction

Neotropical harlequin toads of the bufonid genus *Atelopus* DUMÉRIL & BIBRON, 1841 comprise more than 130 species. Diversity is highest in the northern Andes of Colombia and Ecuador (RUEDA-ALMONACID et al. 2005, LÖTTERS et al. 2023). However, the taxonomy of many of these anurans remains poorly studied. Six species are described from montane forests of the Cordillera Occidental of Colombia at elevations above 1000 m a.s.l. (LÖTTERS 1996, RUEDA-ALMONACID et al. 2005): *A. carauta* RUÍZ-CARRANZA

& HERNÁNDEZ-CAMACHO, 1978; *A. chochoensis* LÖTTERS, 1992; *A. famelicus* RIVERO & MORALES, 1995 (with its junior synonym *A. negreti* RUÍZ-CARRANZA, VÉLEZ-RODRIGUEZ & ARDILA-ROBAYO, 1995); *A. galactogaster* RIVERO & SERNA, 1993; *A. nicefori* RIVERO, 1963; and *A. pictiventris* KATTAN, 1986 (Fig. 1). Similar harlequin toads from the western Andes of northern Ecuador are *A. longirostris* COPE, 1868 (including its junior synonyms *A. boussingaulti* THOMNOT, 1889; and *A. longirostris marmorata* WERNER, 1901); and *A. lynchi* CANNATELLA, 1981 (LÖTTERS 1996, RUEDA-ALMONACID et al. 2005). Both have been suggested to

range into Colombia (e.g. RIVERO 1963, COCHRAN & GOIN 1970, CANNATELLA 1981), but more recently, Colombian populations assigned to these names have been shown to represent distinct taxa (RIVERO & MORALES 1995, RUEDA-ALMONACID et al. 2005, CASTRO-HERRERA & BOLÍVARGARCIA 2010). An exception is a population from Reserva Natural La Planada (Departamento Nariño) that might be conspecific with *A. lynchi*. For this population and Ecuadorian material we use the name *A. lynchi* sensu stricto.

We here deal with material from the Yotoco area, Departamento Valle del Cauca (Figs 1–4), that we consider not being conspecific with any of the currently recognized

nominal species. The Yotoco *Atelopus* and *A. nicefori* are the only members of the genus inhabiting the eastern versant of the Cordillera Occidental. This also requires comparison with the harlequin toads from the northern Cordillera Central (LÖTTERS 1996, RUEDA-ALMONACID et al. 2005): *A. nocturnus* BRAVO-VALENCIA & RIVERA-CORREA, 2011; *A. quimbaya* RUÍZ-CARRANZA & OSORNO-MUÑOZ, 1994; *A. sanjosei* RIVERO & SERNA, 1989; *A. sernai* RUÍZ-CARRANZA & OSORNO-MUÑOZ, 1994; and *A. sonsonensis* VÉLEZ-RODRIGUEZ & RUÍZ-CARRANZA, 1997 (Fig. 1). *Atelopus simulatus* RUÍZ-CARRANZA & OSORNO-MUÑOZ, 1994, also reported from the northern Cordillera Central (Ruíz-

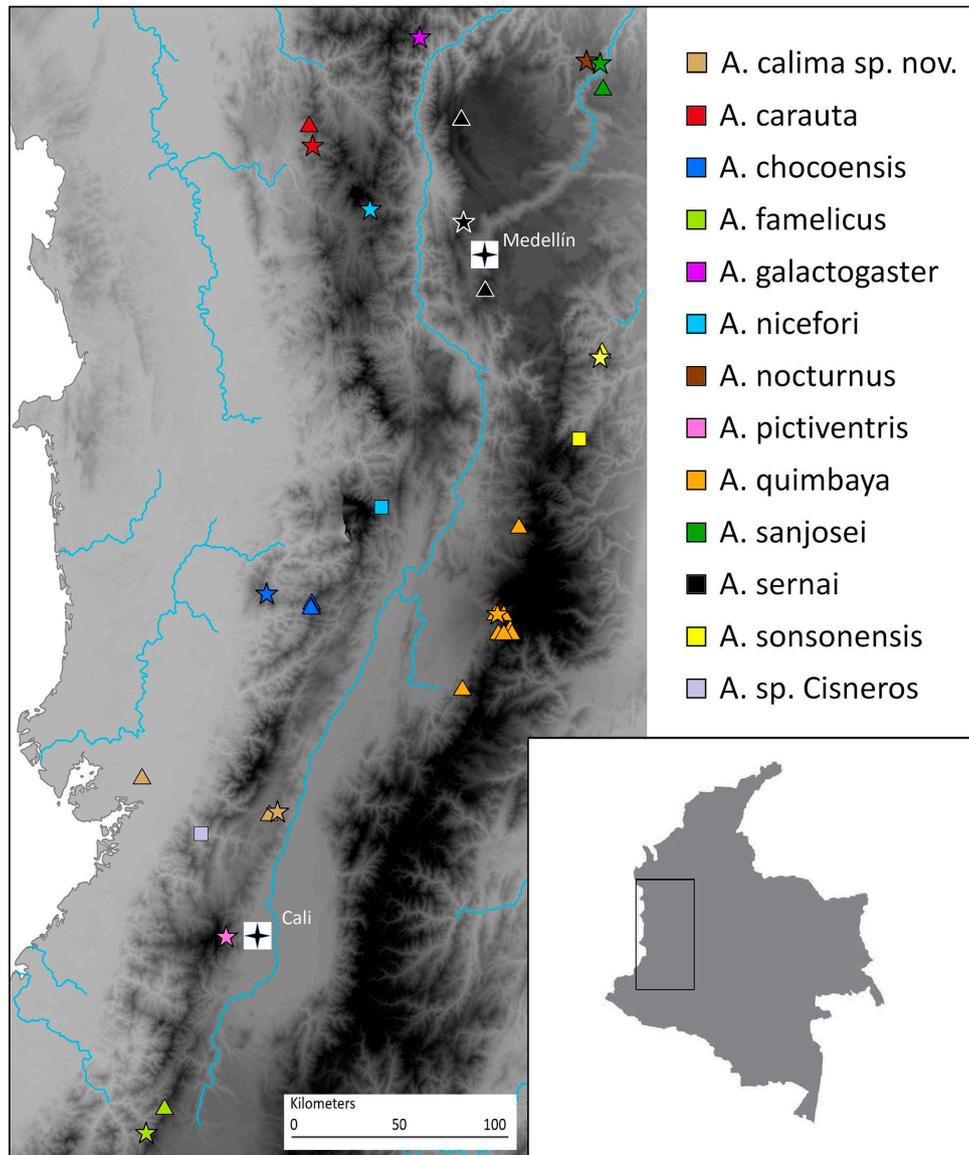


Figure 1. Map of western Colombia showing the distribution of *Atelopus* species in the Cordillera Occidental and the northern Cordillera Central of Colombia, roughly between the cities of Cali and Medellín, as discussed in the text. Type localities are indicated by stars, additional localities by triangles of the same colour, while squares refer to material assigned to available names or discussed in this paper. Higher altitudes are indicated by darker grey scale, main rivers are shown. Note that the shown lowland locality of *A. calima* sp. n. is doubtful (see Distribution).

CARRANZA & OSORNO-MUÑOZ 1994), we consider to actually represent a species restricted to the area of the type locality in the southern Andes of Colombia.

A better understanding of these amphibians and making them 'visible' by naming them are essential steps for the establishment of concrete conservation measures (MAGALHÃES et al. 2018). This is urgently needed in harlequin toads, as most species have undergone severe population declines since the late 1980s and many have not been seen for many years (LA MARCA et al. 2005, VALENCIA & MARIN DA FONTE 2022, LÖTTTERS et al. 2023). Taxonomic identity is best being studied in an integrative approach, in anurans for instance using information on larval stages and bioacoustics combined with adult morphological and molecular phylogenetic data (e.g., PADIAL et al. 2010). For the Yotoco *Atelopus* such information is largely lacking. It is only known from a limited number of specimens and it has not been recorded for 30 years. Since it can be well distinguished from its congeners on the basis of external morphology, we here describe it as a new species. With this, we hope that taxonomic action will stimulate further work to relocate the new species followed by conservation action.

### Material and methods

Specimens examined are deposited at CJ (Centro Jambatu de Investigación y Conservación de Anfibios, Quito), CSJ (Museo de Ciencias Naturales de La Salle, Medellín), FMNH (Field Museum of Natural History, Chicago), IAvH (Instituto Alexander von Humboldt, Villa de Leyva), ICN (Instituto de Ciencias Naturales, Universidad Nacional, Bogotá), KU (The University of Kansas, Museum of Natural History, Lawrence), LACM (Natural History Museum of Los Angeles County, Los Angeles), MNHNP (Muséum national d'Histoire Naturelle, Paris), NHMW (Naturhistorisches Museum Wien, Vienna), and UVC (Colección de Anfibios y Reptiles, Universidad del Valle, Cali). A detailed list of material examined in addition to the new species is provided in the Appendix.

Sex was determined as described by COLOMA et al. (2000). Measurements are provided in mm and were taken to the nearest 0.1 mm with manual callipers and are given as mean  $\pm$  SD. Abbreviations are as follows: SVL, snout-vent length; TIBL, tibia length; FOOT, foot length; HLSQ, head length from the squamosal; IOD, interorbital distance; HDWD, head width; EYDM, eye diameter; EYNO, eye to nostril distance; ITNA, internarial distance; FAL, length of flexed forearm; HAND, hand length; THBL, thumb length; SW, sacrum width. FAL and SW were measured according to BRAVO-VALENCIA & RIVERA-CORREA (2011). All other definitions of measurements follow GRAY & CANNATELLA (1985) with the exception of ITNA, defined as the distance between nostrils measured from the centre of each nostril. The foot webbing formula was taken in the manner of SAVAGE & HEYER (1997). Finger nomenclature follows FABREZI & ALBERCH (1996) and COLOMA et al. (2010). We refer to the terms conus and spiculae as defined by COLOMA et al. (2010).

### Nomenclatural act

The electronic edition of this article conforms to the requirements of the amended International Code of Zoological Nomenclature (ICZN). Hence, the new name given herein is available under the code from the electronic edition of this article. This published work and the nomenclatural act it contains have been registered in ZooBank, the online registration system for the ICZN. The LSID (Life Science Identifier) for this publication is: urn:lsid:zoobank.org:pub:F61E89A4-DAD5-4020-8F51-95BD548C3123. The electronic edition of this work was published in a journal with an ISSN, and has been archived and is available from the following digital repositories: salamandra-journal.com, zenodo.org.

### Results

#### *Atelopus calima* sp. n.

Figs 2–4

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*Atelopus famelicus* non RIVERO & MORALES – CASTRO-HERRERA et al. 2007: 23; CASTRO-HERRERA & BOLÍVAR-GARCÍA 2010: 73. *Atelopus* sp. 8 – RUEDA-ALMONACID et al. 2005: 144. *Atelopus* sp. cf. *chocoensis* Yotoco – LÖTTTERS et al. 2023: Supplementary Table 1.

Holotype: ICN 35832 (field number JDL 20276), adult male, from Colombia, Departamento del Valle del Cauca, Municipio de Yotoco, ca. km 18 on Buga–Buenaventura road, Bosque Reserva Forestal Yotoco (approximately 3°52' N, 76°25' W), 1530 m a.s.l., leg. JOHN D. LYNCH and JOAQUÍN ROMERO, 14 July 1994.

Paratypes: UVC 7543, adult male, from Colombia, Departamento del Valle del Cauca, Municipio de Yotoco, Reserva Forestal Bosque de Yotoco (3°51'36.5" N, 76°25'9.1" W), 1880 m a.s.l., leg. JORGE OREJUELA, 17 July 1977; UVC 10165, adult female, from the same locality, leg. EDUARDO FLOREZ, 15 March 1988; ICN 26106–26111, six adult males, from Colombia, Departamento del Valle del Cauca, Municipio de Yotoco, ca. km 18 on Buga–Buenaventura road at Quebrada el Guadual (approximately 3°52' N, 76°25' W), 1550–1700 m a.s.l., date and collectors unknown.

Referred material: UVC 16080–16081, two adult males, from Colombia, Departamento del Valle del Cauca, Municipio de Yotoco, Reserva Forestal Bosque de Yotoco, leg. FERNANDO CASTRO, 1977; IAvH-Am 8652–8655, 8659, 8662–8666, eight males and two females, from Colombia, Departamento Valle del Cauca, Estación Silvicultura Bajo Calima, exact coordinates and elevation unknown, date and collectors unknown. Locality doubtful, see comment under Distribution.

Definition: The new species is placed in the genus *Atelopus* based on: snout pointed with head longer than wide; presence of supratympanic crest; absence of parotoid gland; absence of tympanic membrane and annulus. It is defined by the combination of the following characters: (1) A medi-

um-sized species with SVL of adult males  $29.9 \pm 2.92$  mm (N = 8) and one adult female 41.4 mm; (2) slender body (SW/SVL  $0.33 \pm 0.016$ , N = 7) with (3) long legs (TIBL/SVL  $0.40 \pm 0.024$ , N = 9) and (4) acuminate snout, protruding beyond the apex of lower jaw, with a knob-like protuber-



Figure 2. Adult male holotype of *Atelopus calima* sp. n. (ICN 35832) in preservative: (A) in dorsal, ventral and lateral views; (B) ventral surfaces of right hand and foot. Scale bars each equal 10 mm. Photographs: C. HEINE.

A new species of harlequin toad from Colombia



Dorsal and ventral aspects of preserved specimens from Bajo Calima (above, from left to right: two females, IAvH-Am 8652, 8665, one male, IAvH-Am 8653) referred to *Atelopus calima* sp. nov. and male paratypes (below, from left to right: ICN 26106-26108). Scale bar equals 10 mm. Photographs: C. HEINE.

ance on tip; (5) tympanic membrane and annulus absent; (6) phalangeal formula of hand 2-2-3-3, webbing absent on hand; (7) first finger short (THBL/HAND  $0.51 \pm 0.045$ ,  $N = 7$ ); (8) phalangeal formula of foot 2-2-3-4-3, foot webbing formula  $10-111-1\frac{1}{2}III\frac{1}{2}$  to  $1-2\frac{1}{2}$  to  $3IV2\frac{1}{2}$  to  $3-1V$ ; (9) dorsal and lateral skin smooth, covered with few scattered large and flat warts, with those on the flanks bearing clustered spiculae and those on the tympanic area presenting a conicular shape; large warts densely distributed on all dorsal surfaces of limbs; ventral surfaces smooth, areolate on chest, gular region and towards cloacal region, humerus and femur; (10) vertebral column conspicuous, neural process well-defined, visible through the skin; (11) in life, dark brown on dorsum, flanks cream in males and yellowish orange in females with brown warts; ventrally cream in males, orange in females; (12) in preservative, dorsal surfaces light brown with dark brown warts, becoming darker towards the tip of the snout and on limbs in most specimens; laterally whitish brown to cream with dark brown warts, head dark brown in lateral view; ventrally pale whitish to cream with brown marks in gular region in most specimens.

Diagnosis: *Atelopus calima* (Figs 2–4) can be readily distinguished from all other described species by the combination of medium body size, projected snout with a knob-like protuberance on the tip and dorsal as well as lateral skin smooth with few scattered large and flat warts which are covered with clustered spiculae on the flanks and whitish brown to cream flanks with dark brown warts in preservative. It is most similar to the central Cordillera endemics *A. nocturnus* and *A. sonsonensis*. Further, *A. calima* resembles the western Cordillera endemics *A. carauta*, *A. chocoensis*, *A. famelicus* (including its junior synonym *A. negreti*), *A. galactogaster*, *A. longirostris* (including its junior synonyms *A. boussingaulti* and *A. longirostris marmorata*), *A. lynchi* sensu stricto, *A. nicefori* and *A. pictiventris*, and the central Cordillera endemics *A. quimbaya*, *A. sanjosei* and *A. sernai*.



Figure 4. Amplexant couple of *Atelopus calima* sp. n. in life (individuals not collected), photographed in March 1988 at Reserva Nacional Forestal Bosque de Yotoco. Photograph: F. CASTRO-HERRERA.

The new species differs from *A. nocturnus* and *A. sonsonensis* in having clusters of spiculae on the lateral warts (vs. conicular to rounded warts lacking clustered spiculae) and in larger adult size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs.  $23.4 \pm 1.69$  mm,  $N = 6$ , in *A. nocturnus* and  $23.4 \pm 1.69$  mm,  $N = 6$ , in *A. sonsonensis*; females  $41.4$  mm,  $N = 1$ , vs.  $33.8 \pm 0.70$  mm,  $N = 3$ , in *A. nocturnus* and  $31.8$  mm,  $N = 1$ , in *A. sonsonensis*). In addition, *A. calima* can be distinguished from these species by lateral coloration in life (in males, flanks cream with brown warts vs. brown in *A. nocturnus*, bluish-greenish with brown reticulation in *A. sonsonensis*). Further, the new species lacks hand webbing (present in *A. sonsonensis*) and differs in the position of supratympanic crests in dorsal view (posteriorly directed towards flanks vs. posteriorly directed towards spine in *A. sonsonensis*).

*Atelopus calima* can be distinguished from *A. carauta* by its smaller size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs.  $39.6 \pm 1.56$  mm,  $N = 6$ ; females  $41.4$  mm,  $N = 1$ , vs.  $46.2 \pm 1.59$  mm,  $N = 3$ ), the presence of warts on dorsum and clustered spiculae on lateral warts (vs. dorsum smooth, few conicular warts and densely scattered minute conical warts on flanks and limbs), less developed supratympanic crest (vs. hyperossified crest with exostosis visible through the skin) and absence of any yellow life coloration in dorsal view (vs. present on prominent warts on all dorsal surfaces, canthus rostralis, supratympanic crest, first finger and tips of all digits).

The new species can be distinguished from *A. chocoensis* by the presence of clustered spiculae on lateral warts and conicular warts in tympanic area (vs. rounded warts on flanks, limbs and tympanic area), coloration in life (in females, dark to light brown or greyish brown on dorsum, occasionally darker towards the head, greyish olive on dorsal surfaces of limbs, flanks yellowish orange with brown warts, ventrally orange, and absence of irregular dorsal pattern vs. dorsally green with brown irregular brownish dorsal pattern), nostril situated distal of apex of lower jaw (vs. situated above) and almost plane, strongly projected snout profile in lateral view (vs. downwards directed short snout; Fig. 5).

*Atelopus calima* differs from *A. famelicus* by smaller size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs.  $37.1 \pm 2.64$  mm,  $N = 6$ ), indistinct pretympanic crest (vs. distinct ossified pretympanic crest fused with supratympanic crest) and by coloration (dorsal surfaces light brown [in life dark to light brown or greyish brown dorsum, greyish olive on dorsal surfaces of limbs] with dark brown warts, becoming darker towards the tip of the snout and on limbs in most specimens, laterally whitish brown to cream [in life cream in males, yellowish orange in females] with dark brown warts, head dark brown in lateral view; ventrally pale whitish to cream [in life cream to yellowish cream in males, orange in females] with brown marks in gular region in most specimens vs. dorsally black, occasionally with light [in life yellow] complete or incomplete dorsolateral line and dorsal markings; presence of tan [in life yellow] ventral side with dark markings).



Figure 5. Comparisons of heads in lateral view of preserved adult specimens of various *Atelopus* species. Left, top to bottom: *Atelopus calima* sp. n. (ICN 35832, male holotype), *A. nicefori* (ICN 622, female), *A. carauta* (IAvH-Am 1939, male paratype), *A. chochoensis* (IAvH-Am 5168, female), *A. pictiventris* (ICN 13594, male paratype); right, top to bottom: *A. longirostris* (ICN 19147, male), *A. lynchi* sensu stricto (IAvH-Am 1577, female), *A. famelicus* (ICN 32897, female holotype of *A. negreti*), *A. sonsonensis* (ICN 37516, female holotype), *A. galactogaster* (ICN 47895, male). Not to scale. Photographs: C. HEINE, A. PLEWNIA.

The new species can be distinguished from *A. galactogaster* by its smaller size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs. 35 and 37.4 mm,  $N = 2$ ), the presence of clustered spiculae on lateral warts and of warts on the dorsum (vs. presence of warts only on limbs with few small, flat, partially conical warts on flanks, tympanic area and posterior part of dorsum), canthus rostralis concave in dorsal view (vs. almost straight), in having a less a projected snout in dorsal view and in coloration (laterally whitish brown to cream [in life cream in males and yellowish orange in females] with dark brown warts, head dark brown in lateral view; ventrally pale whitish to cream [in life cream to yellowish cream in males, orange in females] with brown marks in gular region in most specimens vs. blackish brown flanks and a whitish venter with blackish brown ventral surfaces of limbs bearing numerous large whitish blotches both in preservative and in life).

*Atelopus calima* differs from the Ecuadorian endemic *A. longirostris* by smaller size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs.  $30.3 \pm 35.1$  mm,  $N = 5$ ; females 41.4 mm,  $N = 1$ , vs.  $40.7 \pm 47.1$  mm,  $N = 5$ ), presence of warts (vs. body smooth covered in dense minute conical dots that result in a velvety appearance of the skin on dorsum and flanks with larger conical dots scattered on flanks) and coloration (lack of light [in life yellow] dorsal and lateral dots, whitish brown to cream flanks [in life cream in males and yellowish orange in females] with dark brown warts, in females presence of orange ventral coloration in life vs. dorsum and flanks brown with light [in life yellow] irregular dots, venter whitish [in life white] without sexual dichromatism).

The taxon described herein can be distinguished from *A. lynchi* sensu stricto by its smaller size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs.  $34.5 \pm 16.01$  mm,  $N = 5$ ; females 41.4 mm,  $N = 1$ , vs.  $42.5 \pm 4.73$  mm,  $N = 5$ ), presence of warts (vs. body entirely smooth covered in dense minute conical dots that result in a velvety appearance of the skin with a dorsolateral band formed by small, partially clustered spiculae), presence of a knob-like protuberance on tip of strongly projected snout (vs. shorter pointed snout without knob-like protuberance), basal hand webbing absent (vs. present) and by coloration (head without light [in life cream] markings, whitish brown to cream flanks [in life cream in males and yellowish orange in females] with dark brown warts vs. head with a cream upper lip and a cream line running from supratympanic crest to tip of snout and flanks uniformly brown).

*Atelopus calima* can be distinguished from *A. nicefori* by having a longer head with an almost plane, strongly projected snout profile in lateral view (vs. short head with a strongly downward projected short snout), the absence of a dorsolateral row of warts and presence of clustered spiculae on lateral warts (vs. lateral warts and spiculae not clustered, forming a dorsolateral row) and by the absence of dorsal pattern (vs. chevron-like dark marks present in some specimens).

The new species differs from *A. pictiventris* in having strongly developed supratympanic crests (vs. poorly developed), few scattered large warts dorsally and clustered

spiculae on large lateral warts (vs. dorsum and flanks densely covered in large warts lacking spiculae), presence of a knob-like protuberance on tip of strongly projected snout (vs. shorter, sharply pointed snout without knob-like protuberance) and in lacking dark pigmentation ventrally except in the gular region (vs. venter brown with large irregular cream markings in preservative).

*Atelopus calima* can be distinguished from *A. quimbaya* in having clustered spiculae on warts on flanks (vs. single spiculae on flanks, not on warts and not clustered), less webbing on feet, absence of webbing on hand and absence of light dorsal pattern in preservative. Further, the type series of *A. quimbaya* differs in having a less pointed snout lacking a knob-like protuberance. However, when considering referred topotypic material, *A. quimbaya* has considerable variation in the number and extent of spiculae and in snout profile.

The new species differs from *A. sanjosei* in having dorsal and lateral skin smooth, covered with few scattered large and flat warts with those on the flanks bearing clustered spiculae (vs. dorsum covered with small spiculae and an oblique lateral line of warts), and by coloration (dark to light brown or greyish brown on dorsum without light markings, whitish brown to cream flanks [in life cream in males and yellowish orange in females] with dark brown warts vs. uniformly brown with light irregular dorsal markings [in life greenish yellowish to green] and partly with light [in life yellow] spots in the dorsolateral area).

*Atelopus calima* can be distinguished from *A. sernai* by its larger size (males  $29.9 \pm 2.92$  mm,  $N = 8$ , vs. 20.9 and 26.1 mm,  $N = 2$ ; females 41.4 mm,  $N = 1$ , vs.  $31.3 \pm 1.08$  mm,  $N = 4$ ), having dorsal and lateral sides covered with few scattered large and flat warts with those on the flanks bearing clustered spiculae (vs. dorsum almost smooth in females and finely granular with warts in males; lateral side with conical dots) and coloration (dark to light brown or greyish brown on dorsum without light markings, whitish brown to cream flanks [in life cream in males and yellowish orange in females] with dark brown warts vs. dorsally and laterally brownish [in life reddish brown] with tan markings [dorsally greenish and laterally yellowish in life]).

Description of holotype: Adult male. Body slender (SW/SVL 0.34); head longer than wide (HLSQ/HDWD 1.30); snout projected, protruding beyond apex of lower jaw, acuminate in dorsal view, forming a triangle from nostrils to the tip of the snout, blunt protruding knob on tip of snout; nostrils directed laterally, protuberant, not visible in dorsal view, situated about two third from eye to tip of snout in lateral view, anterior to apex of lower jaw; canthus rostralis well defined, concave in dorsal view, more rounded between eye and nostril than between nostril and tip of snout; loreal region slightly concave; lips not flared; top of the snout slightly depressed towards tip, concave between canthi in frontal view, head plain in lateral view; eyelid flared; tympanum and tympanic annulus absent; supratympanic crests well developed, slightly concave and par-

alle in dorsal view, exostosis visible through the skin, pre-tympanic crest poorly developed.

Limbs long and slender (TIBL/SVL 0.11); relative length of toes I < II < III < V < IV; phalangeal formula of foot 2-2-3-4-3, webbing formula of toes I<sub>0</sub>-II<sub>1</sub>-1<sup>1</sup>/<sub>2</sub> III<sub>1</sub>-2<sup>1</sup>/<sub>2</sub> IV<sub>2</sub><sup>1</sup>/<sub>2</sub> - I<sub>V</sub>; tarsal fold absent; foot about as long as tibia; outer metatarsal tubercle round, inner metatarsal tubercle indistinct; supernumerary tarsal tubercle poorly developed; subarticular tubercles on toes distinct, small, rounded; tips of toes rounded, not widened; toes lacking fringes; relative length of fingers I < II < IV < III; phalangeal formula of hand 2-2-3-3; webbing absent on hand; palmar tubercle rounded, well defined; thenar tubercle indistinct; supernumerary tubercles indistinct; subarticular tubercles of digits indistinct; tips of fingers rounded, not widened; first finger short (THBL 3.2 mm).

Dorsal and lateral skin smooth, covered with few scattered large and flat warts with those on the flanks bearing clustered spiculae and those on the tympanic area presenting a conical shape; large warts densely distributed on all dorsal surfaces of limbs; ventral surfaces smooth, areolate on chest, gular region and towards cloacal region, humerus and femur; vertebral column visible through the skin, neural processes conspicuous, sacral diapophyses and urostyle visible through the skin.

In preservative, dorsal surfaces brown with dark brown warts, becoming darker towards the tip of the snout; laterally light brown with dark brown warts, spiculae whitish, head dark brown; ventrally pale whitish to cream with brown throat and gular region. Coloration in life, according to J. D. LYNCH's field notes: "Dorsum very dark brown (almost black) becoming brown on flanks with very dark brown warts. Pale green ring around pupil - otherwise iris black. Venter off-white with a few tiny brown flecks; throat washed with brown; off-white pigment extending onto undersides of thighs, shanks, tip of tarsus-foot. Some small pale spots along lower edge of posterior surfaces of thighs."

Measurements (in mm) and proportions: SVL 28.8; TIBL 11.6; FOOT 11.0; HLSQ 10.8; ITOR 3.6; HDWD 8.3; EYDM 2.9; EYNO 3.0; ITNA 2.2; HAND 6.6; THBL 3.2; SW 9.9; FAL 8.5; TIBL/SVL 0.40; SW/SVL 0.34; HLSQ/SVL 0.38; FAL/SVL 0.30; HLSQ/HDWD 1.30; TIBL/HAND 1.76.

Variation: For meristic variation of characters see Table 1. Paratypes correspond to the description provided above. There is variation in the number and density of warts with UVC 7543 and 16080 lacking almost all warts on the dorsum and ICN 26106 lacking warts on the flanks except in the tympanic area. Some specimens deviate in their general appearance due to their poor state of preservation (ICN 26109-26111). Dorsal coloration can vary from dark (see above) to light (ICN 26106, UVC 10165) to reddish (UVC 7543, 16081) brown but warts are always dark brown. In some specimens (ICN 26106-26108), flanks are cream to whitish cream with brown warts. Ventral coloration is reddish cream in UVC 7543 and 16081 and white except on throat and chest in ICN 26111 and UVC 10165. We attrib-

Table 1. Morphological measurements (in mm) and proportions of the type series of *Atelopus calima* sp. n. (left) and the series from Estación Silvicultura Bajo Calima (right). The mean is followed by the standard deviation and the range in parentheses. For abbreviations see Material and methods.

	Males (N = 8)	Female	Males (N = 8)	Females (N = 2)
SVL	29.9±2.92 (26-34.7)	41.4	29.1±0.87 (27.6-30.2)	31.9, 33.2
TIBL	12.1±1.11 (10.5-13.9)	14.6	11.7±0.34 (11.4-12.3)	12.6, 14.8
FOOT	10.5±1.04 (9.6-12.9)	13.6	9.4±0.73 (8.1-10.6)	11.1, 11.4
HLSQ	10.6±0.74 (9.4-12)	11.0	9.5±0.92 (8.2-11.4)	10.4, 11.1
ITOR	3.5±0.57 (2.5-4.4)	8.8	3.2±0.52 (2.4-3.8)	3.4, 3.7
HDWD	8.3±0.49 (7.8-9.4)	10.4	8.2±0.70 (7.5-9.8)	9.1, 9.5
EYDM	2.9±0.15 (2.7-3.1)	2.8	2.7±0.24 (2.3-3.0)	3.3, 3.4
EYNO	2.6±0.31 (2.2-3)	3.4	4.3±0.35 (3.6-4.6)	3.4, 3.5
ITNA	2.5±0.2 (2.2-2.8)	3.4	7.8±0.47 (6.9-8.5)	9.5, 11.2
HAND	6.4±0.98 (4.78-8.3)	8.0	6.0±0.42 (5.5-6.6)	5.3, 7.1
THBL	3.4±0.42 (2.9-4.2)	2.2	2.5±0.65 (1.3-3.6)	1.9, 2.5
SW	9.7±1.21 (8.8-12.3)	13.2	9.1±0.28 (8.7-9.5)	10.5, 11.3
FAL	8.3±0.98 (7.3-10)	11.3	7.8±0.42 (7.2-8.2)	7.7, 8.7
TIBL/SVL	0.41±0.02 (0.39-0.44)	0.35	0.40±0.02 (0.38-0.43)	0.38-0.46
SW/SVL	0.29±0.12 (0-0.35)	0.32	0.31±0.01 (0.30-0.32)	0.34-0.33
HLSQ/SVL	0.36±0.04 (0.28-0.41)	0.26	0.33±0.03 (0.28-0.38)	0.33-0.33
FAL/SVL	0.28±0.03 (0.20-0.31)	0.27	0.96±0.08 (8.84-1.04)	0.81-0.91
HLSQ/HDWD	1.27±0.07 (1.12-1.37)	1.06	1.17±0.14 (1.11-1.42)	1.09-1.22
TIBL/HAND	1.31±0.10 (1.20-1.49)	1.83	1.30±0.12 (1.11-1.42)	1.17-1.45

ute variation in coloration mostly to preservation conditions. Sexual dimorphism is apparent in *A. calima* with the female being larger than males, lacking nuptial pads and having longer and more slender limbs.

In life, colour variation includes males being laterally cream and females being laterally yellowish orange (Fig. 4). In addition, the entire ventral side is orange in females, while it is cream in males.

**Distribution:** The new species' only confirmed locality is the Reserva Nacional Forestal Bosque de Yotoco and its vicinity at ca. 1500–1900 m a.s.l. on the eastern versant of the Cordillera Occidental, Valle del Cauca, Colombia (Fig. 1). The reserve is part of an isolated premontane forest fragment, combining dry and cloud forest elements (Fig. 6) that are distributed beyond the 559 ha of protected area (ESCOBAR MANRIQUE 2001). The forest is characterized by different degrees of disturbance (logging, burning, hunting etc.) from times before the designation as a reserve in 1959. The reserve is immersed in a matrix of privately owned pastures for livestock. The average temperature is 20°C and the average rainfall 1500 mm per year, with high and low rainfall seasons, March to May and September to November, and August being the driest month (ESCOBAR MANRIQUE 2001).

In historical times, the species might have occupied a larger area in this transient forest of the Cordillera Occidental of which much is destroyed or heavily disturbed today. However, the presence of *A. calima* at Estación Silvicultura Bajo Calima (Fig. 1) seems doubtful (series IAvH-Am 8652–8655, 8659, 8662–8666). *Atelopus calima* at its type locality as well as morphologically similar and apparently related congeners (see Diagnosis) are montane forest species that occur at elevations > 1000 m a.s.l., while Estación Silvicultura Bajo Calima comprises lowland



Figure 6. Habitat of *Atelopus calima* sp. n. in the Reserva Nacional Forestal Bosque de Yotoco. Photo taken in August 2019. Photograph: A. PLEWNIA.

rainforest at < 100 m a.s.l. As far known, apart from the single series at IAvH, *A. calima* has never been reported from the Bajo Calima region, while here the fairly distinct *A. spurrelli* is known to occur (RUEDA-ISAZA et al. 2022) and sympatric occurrence is quite rare in harlequin toads (LÖTTERS 1996).

**Life history:** Little is known about the ecology and behaviour of the new species, which even back in the 1970s and 1980s was obviously rare. Specimens were found active in leaf litter or hidden in rotten tree trunks during the day in the vicinity of small streams within the forest (CASTRO-HERRERA et al. 2007; J. D. LYNCH, field notes). An amplectant pair (Fig. 4) was found in March 1988, suggesting reproduction during the onset of the early rainy season. At Yotoco, about 20 sympatric amphibian species are known, including other regional endemics such as *Andinobates bombetes*, *Centrolene savagei*, *Strabomantis cerastes*, *S. ruizi*, *Pristimantis deinops* and *P. juanchoi* (VALENCIA-ZULETA et al. 2014).

**Conservation status and threats:** We suggest listing *A. calima* as Critically Endangered under criteria A2a,c,e of the IUCN Red List of Threatened Species as (1) it is known from only three threat-defined localities from where it has not been seen in three decades (the last record is that of the holotype in July 1994), despite continuous surveys in the Yotoco area, (2) all of which are severely fragmented and suffer from habitat modification, and (3) all populations are threatened by the impact of the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) (cf. LÖTTERS et al. 2023). The EOO of the new species is hard to estimate, as all three records lie on a straight line of 65 km. The AOO is 12 km<sup>2</sup>. However, note that one of the records is doubtful (see Distribution).

In the Yotoco area, where two of three known localities are situated, deforestation of suitable forests is widespread with only few forest fragments remaining. However, the species is known from one isolated and fragmented protected area, Reserva Nacional Forestal Bosque de Yotoco.

*Bd* is considered a main driver of extinctions in *Atelopus* (e.g. LA MARCA et al. 2005, LIPS et al. 2008, LÖTTERS et al. 2023) and has been confirmed in *Strabomantis ruizi* (UVC 13251) from the Reserva Nacional Forestal Bosque de Yotoco, collected in 1996 (VELÁSQUEZ-E. et al. 2008) as well as from the general area (cf. OLSON et al. 2021). We expect that *Bd* is likely to have caused the disappearance of *A. calima* from all of its known localities.

**Etymology:** The specific name *calima* is a noun in apposition in dedication to the Calima culture (ca. 1600 BC to 1700 AD), which during their early Ilima and Yotoco phases exclusively inhabited the upper Río Calima region and its vicinities in the Cordillera Occidental where the new species is found. The Calima people honoured anurans, which they also depicted in the form of jewellery. We propose to use the English common name 'Calima Harlequin Toad' and the Spanish common name 'Rana Arlequín de Calima' for this new species.

### Discussion

The new species is well distinguished from other *Atelopus* species on the basis of morphological characters. In the absence of more detailed information it is difficult to identify synapomorphies and to access the phylogenetic position of *A. calima* compared to congeners. Because it shares many characters with other *Atelopus* from the Cordillera Occidental and Cordillera Central (i.e., it is most similar to *A. nocturnus* and *A. sonsonensis*), it is possible that the new species is part of a wide-spread western and central Andean clade containing other species from both sides of the Río Cauca valley.

Although we have doubt in the new species' presence in the Bajo Calima area (see Distribution), it is necessary to refer to two *Atelopus* specimens, male and female, reported from Cisneros at ca. 320 m a.s.l., Departamento Valle del Cauca (FMNH 43850, 43851; Fig. 7), about 30 km airline each from Bajo Calima and the type locality of the new species (Fig. 1). While we also doubt the correctness of the locality given for these specimens, because to the best of our knowledge there is no other *Atelopus* material ever reported from the area, they clearly do not resemble *A. calima*. They differ in larger size (male SVL > 45 mm), in lacking dorsal warts and clustered spiculae on flanks, snout

profile (bent downwards towards apex) and coloration (the male presents an irregularly shaped and interrupted yellowish line from tip of snout to groin, the female presents a chevron-like mark on the back). RIVERO (1963) and COCHRAN & GOIN (1970) allocated the Cisneros specimens to *A. longirostris*, while PETERS (1973) suggested they may represent an undescribed taxon. More recently, CANNATELLA (1981) referred them to *A. lynchi*, along with material from El Tambo and Río Michenque (Departamento del Cauca) on the Pacific versant of the Cordillera Occidental in Colombia. The El Tambo and Río Michenque material was later described as a distinct species, *A. famelicus*, which we consider a valid taxon. We conclude that the Cisneros specimens cannot be allocated to *A. calima* and may either represent *A. famelicus* or an undescribed species.

Including *A. calima*, we recognize 13 described *Atelopus* species from montane forests at elevations > 1000 m a.s.l. in the Cordillera Occidental and the northern Cordillera Central of Colombia (see Fig. 1, plus *A. lynchi* sensu stricto on the Colombian-Ecuadorian border that is not shown in Fig. 1). Apart from the Cisneros specimens, we are aware of material from additional populations of unclear taxonomic status requiring further studies. Of these, we here comment on two considered as potentially new species by RUEDA-ALMONACID et al. (2005): (1) *Atelopus* sp. 4 from



Figure 7. Dorsal, ventral and lateral views of preserved unidentified *Atelopus* specimens from Cisneros, Departamento Valle del Cauca, ca. 320 m a.s.l. (FMNH 43050, adult male, and 43051, adult female), probably conspecific with *A. famelicus*. Scale bar equals 10 mm. Photographs: J. MATA.

“municipio de Pensilvania, Parque Nacional Natural Selva de Florencia, 2000–2150 m a.s.l.” (Departamento Caldas) in the Cordillera Central; (2) *Atelopus* sp. 20 from “municipio de Santuario, Río San Rafael, Alto de Las Cascadas, Parque Nacional Natural Tatamá, 2000–2150 m a.s.l.” (Departamento Risaralda) on the eastern versant of the Cordillera Occidental.

Material of *Atelopus* sp. 4 comprises a series of four specimens (ICN 36520–36523) and resembles *A. sonsonensis* from a nearby locality (Figs 1, 8). Both share a dorsum covered with large warts, flanks and forearm cov-

ered with warts with conicular tip and spiculae, all limbs bearing rounded and conicular warts dorsally, webbing on hand present, supratympanic crest posteriorly directed towards spine and reddish-brown dorsum with dark warts in females, brown dorsum and flanks with bluish pattern in *A. sp. 4* and greenish to bluish pattern in male *A. sonsonensis* in life. However, the two series differ in SVL: *Atelopus* sp. 4, two males 26.8 and 29.2 mm, two females 37.4 and 40.8 mm; *A. sonsonensis*, 14 males,  $23.4 \pm 1.78$  mm, one female 31.1 mm. Based on our comparisons, we tentatively consider them conspecific.



Figure 8. Dorsal, ventral and lateral views of preserved adult females of *Atelopus* sp. 4 (ICN 36521, left) and *A. sonsonensis* (holotype ICN 37516, right). Scale bar equals 10 mm. Photographs: C. HEINE, A. PLEWNIA.

Material of *Atelopus* sp. 20 comprises a series of three specimens (IAvH 4871–4873) and resembles *A. nicefori* from the same general area (Figs 1, 9). Both particularly share a medium size ( $26.7 \pm 15.88$  mm), smooth dorsum with conic warts towards and on flanks, non-conic warts on dorsal surfaces of limbs and a short head with a downward projected short snout in lateral view. Further, females of both species share a dark dorsum with lighter flanks covered with brown warts and venter cream with brown spots in gular region in preservative

and an irregular dorsolateral band of conic warts. The only difference noticed is ventral pattern in males (cream with dark pigment in gular region only in *A. nicefori* vs. cream with irregular brown blotches and a brown throat and chest in the only male known from Río San Rafael) and dorsal coloration (brown with dark chevron pattern in some specimens vs. dark green with brown chevron pattern in some specimens). We consider this potential intraspecific variation and tentatively assign *Atelopus* sp. 20 to *A. nicefori*.



Figure 9. Dorsal, ventral and lateral views of preserved adult females of *Atelopus* sp. 20 (IAvH-Am 04871, left) and *A. nicefori* from (ICN 622, right). Scale bar equals 10 mm. Photographs: C. HEINE, A. PLEWNIA.

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- Atelopus quimbaya* – Colombia: Risaralda: Pereira, Parque Regional Ucumari, Cedral-Ceilan trail, ICN 23339 (holotype), ICN 23340–23347 (paratopotypes).
- Atelopus sanjosei* – Colombia: Antioquia: Anorí, La Primavera, municipio de Anorí, 450 m a.s.l., CSJ-h 0001 (holotype, formerly CSJ 1785), CSJ-h 0002, 0003 (paratopotypes, formerly CSJ 1786, 1788).
- Atelopus sernai* – Colombia: Antioquia: km 5.8, San Féli-Boqueron road, ICN 04166 (holotype), 04120, 04242, 04243, 23703 (paratopotypes).
- Atelopus sonsonensis* – Colombia: Antioquia: Sonson, Vereda Caunzal, about 15 km SE Argelia, 1500 m a.s.l., ICN 37516 (holotype) ICN 37517–37530 (paratopotypes); Caldas: Pensilvania, km 18 on road to Arboleda, 2000–2450 m a.s.l., ICN 36520–36523 (series of *Atelopus* sp. 4, here tentatively assigned to this species).
- Atelopus* sp. (cf. *famelicus*) – Colombia: Valle del Cauca: Cisneros, FMNH 43050, 43051.

### Appendix

#### Material examined in addition to the new species

- Atelopus carauta* – Colombia: Antioquia: Parque Nacional Natural las Orquídeas, IAvH-Am 603 (holotype, before IND-AN 603), 1939 (likely the paratype that before was IND-AN 604), ICN 3184 (paratype); Frontino, Nutibara, Murri, Alto de Cuevas, kms 16–23 on Nutibara road, La Blanquita, Finca El Palmar, ICN 16262–16269.
- Atelopus chocoensis* – Colombia: Valle del Cauca: El Cairo, Quebrada Boquerón, IAvH-Am 5168; trail between Río Planco (probably a typo for Río Blanco), Surama drainage, and La Pradera (on road to El Cairo, on eastern slope), below finca la Florida, LACM 135951 (holotype), LACM 135952–135954 (paratopotypes); Chocó: San José del Palmar, Cerro Torrá, northeastern versant, IAvH-Am 3961; Cerro Torrá, northern versant at 1920–2500 m a.s.l., UVC 10175–10177 (paratypes); Cerro Torrá, eastern versant at 2300 m a.s.l., UVC 10178 (paratype); Las Amarillas, 3 km down del Boquerón western versant way to El Cairo, UVC 9121.
- Atelopus famelicus* – Colombia: Cauca: La Costa, KU 145050 (holotype), KU 145051–145054, 145056, 145057 (paratopotypes); Río Michenque, KU 145058–145060 (paratypes); El Tambo, Hacienda Tambito of Fundación Proselva, ICN 32897–32920 (type series of *A. negreti* and additional material collected along with it).
- Atelopus galactogaster* – Colombia: Antioquia: Ituango, Parque Nacional Natural Paramillo, 1300–1800 m a.s.l., ICN 47894–47897.
- Atelopus longirostris* – Ecuador: Pichincha: Chontapamba, ICN 19145–19147; between Latacunga and Quito, southern Quito (locality probably in error), MNHNP 0207 (holotype of *A. boussingaulti*); Imbabura: Intag, CJ 5521, 5582, 5583, NHMW 3872/1.
- Atelopus lynchi* sensu stricto – Ecuador: Carchi: Maldonado, 1410 m a.s.l., KU 178412 (holotype), KU 178413–178416 (paratopotypes); Colombia: Nariño: Reserva Natural La Planada, 7 km S Chucunéz, IAvH-Am 1432–1435, 1444–1446, 1577–1579; Reserva Natural La Planada, vereda Pialapi, IAvH-Am 1575–1576.
- Atelopus nicefori* – Colombia: Antioquia: km 15, Urrao-Caicedo road, 2700 m a.s.l., ICN 621–625; Vereda El Chuscal, border with Caicedo, 2585 m a.s.l., ICN 1163, 1165, 1167–1169, 1290–1293, 1304, 1305, 1353–1367, 1380, 1381; El Chuscal, ICN 1269; Vereda El Chuscal, Quebrada Las Juntas, km 16.1, Urrao-Caicedo road, ICN 18060; Vereda La Nevera, Urrao-Caicedo road, ICN 3484, 3485; Risaralda: Parque Nacional Natural Tatama, Planes de San Rafael, Alto de las Cascadas, IAvH-Am 04871–04873 (series of *Atelopus* sp. 20, here tentatively assigned to this species).