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Atelopus (Anura: Bufonidae)
From a Venezuelan Cloud Forest**

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A New Frog of the Genus *Atelopus* (Anura: Bufonidae)
From a Venezuelan Cloud Forest

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In July 1981, the author made collections in the "Pueblos del Sur," a region southwest of the city of Mérida, in the Andes of Venezuela. One of the objectives of the collecting sorties was to find a frog that Pascual Soriano, mammalogist at the Universidad de Los Andes, had seen and photographed nearly a decade ago. Slides taken by Soriano showed an *Atelopus* with a coloration quite different from any other Venezuelan species of the genus (Fig. 1). It was also of particular interest since no *Atelopus* was known from the Andes between the Táchira depression, near the Colombian border, and the vicinities of the city of Mérida.

After an unsuccessful search in many other nearby water courses, the frog was found in the exact stream visited by Soriano. As expected, the frog proved to represent an undescribed species.

As a gesture of our valued friendship, I take special pleasure in naming this frog after Soriano, discoverer of the species,

Atelopus sorianoi, new species
(Figs. 1, 5C)

Holotype. CVULA 2783, an adult ♀ with mature eggs. Cloud forest 10 Km. SSE Tovar, 2718m., Estado Mérida, Venezuela. Collectors: Enrique La Marca, Jesús and Miguel Molinari, 26 July 1981.

Allotype. CVULA 2784, an adult ♂ with enlarged testes; *Paratypes*. CVULA 2785-2792; LACM 134418-134419 (skeletons); topotypes, same data as onomatophore.

Diagnosis. (1) Body and limbs not elongated; (2) head broader than long; (3) snout subacuminate, dorsally concave, protruding over lower jaw; (4) nostrils closer to tip of snout than to eye; (5) canthus rostralis sharp, angular; (6) eye diameter larger than distance between eye and nostril; (7) tympanum and tympanic annulus absent; (8) posterior end of squamosal elevated; (9) two dorsolateral glandular ridges, often broken into row of warts; (10)

upper dorsum smooth, lower dorsum tuberculate; (11) venter smooth to finely granular, no ventral disc; (12) tibia length 37.1% SVL; (13) heel of the adressed hind limb reaches temporal region; (14) fingers almost free, not keeled; (15) feet moderately webbed, formula $I1^- - 2^+II2 - 2^-III2 - 3^+IV3^+ - 2^-V$ (Savage and Heyer system, 1967); (16) relative length of adressed toes = $4 > 5 \geq 3 > 2 > 1$; (17) subarticular tubercles flat, single; (18) anterior end of parasphenoid free from underlying osteocranium and acutely pointed; (19) no external vocal sac in $\delta \delta$; (20) uniform orange-red coloration, without markings.

Atelopus soriano is referred to the *ignescens* group (Peters, 1973). It most closely resembles *A. carbonerensis* Rivero, but is distinct in having a more angular canthus rostralis and different coloration (Fig. 1). See comparisons, below, for other differences.

Description. A relatively large *Atelopus* (SVL 38.9 ± 0.8 mm, range 38.2-39.8, N=5, in $\delta \delta$; SVL 44.9 ± 2.6 mm, range 42.2-49.1, N=5, in $\text{♀} \text{♀}$); snout subacuminate in dorsal view; distinct depression between nostrils; tip of snout rounded in dorsal view; snout distinctly protruding beyond lower jaw, acutely pointed in lateral profile; thick ridge along canthus rostralis; canthus rostralis sharp, angular; loreal region vertical, concave; nostrils rounded, directed laterally and slightly backwards, elevated; nostrils closer to tip of snout than to eye; eyes protruding above and lateral to head; eye diameter greater than distance from anterior border of eye to nostril; pupil black, iris golden; head narrower than body, broader than, or as wide as, long; interorbital surface concave, with two low longitudinal cranial ridges; interorbital distance 1.5 times greater than eyelid width; eyelid thickened along outer border; external tympanum and annulus absent; supratympanic crest well developed; no vomerine odontophores; no vocal sac or vocal slits in $\delta \delta$; tongue narrow, elongated, posterior 1/4 not adherent to floor of the mouth; tongue broader at its posterior end, latter rounded or lanceolate, not notched; choanae round to oval, anterior border concealed (except in holotype) by palatal shelf of maxillary arch.

Outlines of suprascapulae, neural spines of vertebrae, dorsal surface of squamosals, dorsolateral expanses of sacral diapophyses and posterior end of urostyle visible; anal opening on low protuberance, directed straight backwards; anal opening well above midlevel of thighs; fingers with rudimentary web; fingers almost free, no lateral ridges; first finger distinct, thickened (more conspicuously in mature $\delta \delta$); third finger equal to or longer than distance between eye and tip of snout; relative lengths of adressed fingers: $3 > 4 > 2 > 1$; subarticular tubercles on fingers low, rounded to ovalate; inner metacarpal tubercle single, rounded; finger tips rounded, same width as penultimate phalanx; pads rounded apically; relative lengths of adressed toes:

4 > 5 ≥ 3 > 2 > 1; toe tips rounded, not expanded; subarticular tubercles on toes flat, single, inconspicuous; inner metatarsal tubercle elongate, flat, inconspicuous; outer metatarsal tubercle smaller than inner, rounded, slightly elevated; webbing formula (S/H system): I1⁻ - 2⁺II2 - 2⁻III2 - 3⁺IV3⁺ - 2⁻V; heel of adpressed hind limb reaches temporal region; tarsal fold absent.

Skin. Head smooth; tip of snout, canthi rims and supratympanic crest thickened; temporal region finely spiculated; few elevated warts on lower dorsum; two dorsolateral ridges of warts (verrucae), one each side, from posterior border of squamosals to inguinal region; extremities more granular than body (smooth bracelet on forearms of holotype); upper dorsum smooth, lower dorsum spiculate or finely granular; few low elevated tubercles may be present on sacral region; venter smooth to finely granular; throat smoother than elsewhere; ventral surfaces of extremities less granular than dorsal; flanks coarsely granular; groin with wrinkles.

Coloration. In life: body uniformly red-orange, without markings of any kind (Fig. 1); no green or dark areas surrounding nostrils. In preservative: uniformly cream or yellow.

Sexual dimorphism. Supratympanic crests (dorsal surface of squamosals) tending to be more pronounced in ♂♂ than ♀♀; forelimbs long, slender, in ♀♀, short, stocky, in ♂♂; ♂♂ with keratinized pad on first finger, to base of second in some; dorsal and lateral surfaces of limbs more granular in ♂♂ than in ♀♀; ♂♂ with more acute tip of snout; tendency in ♂♂ for head to be as wide as body, in ♀♀ narrower than body; adpressed limbs with knee and elbow touching or overlapping in ♂♂, not touching in ♀♀; ♀♀ larger than ♂♂.

Osteology. Osteological information for *Atelopus soriano* was obtained from two skeletons (LACM 134418, ♀, and LACM 134419, ♂). Comparisons were made with four skeletons of *A. carbonerensis* (LACM 134416, ♀; LACM 134417, ♂; UMMZ 153655, ♀; and UMMZ 153656), and one skeleton of *A. crucigerum* (LACM 127301). Only those traits discussed by McDiarmid (1971) as having interspecific variation are presented.

Nasals separated medially; anteromedial and posterodistal edges of nasals free from underlying osteocranium; posterior part of occipital grooves in frontoparietal covered with bone; medial wing of vomer present, giving choana opening an oval shape (in *A. carbonerensis* the medial wings of the vomer are well developed, directed backwards, giving the choana a rounded shape); anterior end of parasphenoid acutely pointed, free from underlying sphenethmoid (in *A. crucigerum* broad, subelliptical; in *A. carbonerensis* round and partially or completely fused-pointed in UMMZ 153655); anterior projection of dorsal arm of squamosal present; quadratojugal well developed, overlapped by maxilla and

lower shaft of squamosal; anterior extension of sphenethmoid complex ossified, flat in LACM 134418, round and thick in LACM 134419 (flat in *A. carbonerensis*; not ossified in *A. crucigerum*); atlas completely fused with first trunk vertebra; six presacral vertebrae; urostyle fused to sacrum; pectoral girdle pseudofirmisternal, sternum well developed and ossified; prepollex distinct, about same length as metacarpal 1, and fused with it in its anterior end; phalangeal formula: 1 - 2 - 3 - 3 for manus, and 2 - 2 - 3 - 4 - 3 for pes.

Measurements. The following measurements are based on the type series (except LACM 134418-134419); the mean is followed by the standard deviation, and the range is indicated within parenthesis.

SVL ♂♂ = 38.9 ± 0.8 (38.2-39.8); SVL ♀♀ = 44.9 ± 2.6 (42.2-49.1); head width = 11.5 ± 0.8 (10.6-12.4); internostril distance = 3.75 ± 1.3 (3.8-4.3); hand = 9.32 ± 3.3 (9.7-10.8); foot = 15.79 ± 1.0 (14.6-17.8); tibia length = 15.5 ± 0.8 (14.7-15.9). All the specimens are adults; ♀♀ with convoluted oviducts and eggs; ♂♂ with enlarged brown thumb and white testes > 3.7mm.

Habitat. All specimens of *Atelopus soriano* were found on the ground, along a cascading mountain stream, in a relatively undisturbed cloud forest (Bosque Pluvial Montano in the classification of Ewel, Madriz and Tosi, 1976). Ambient temperature was 10.8°C. Strong gusts of wind, mist and descending fog were recorded at collecting time (12:30-13:00 h.). A dense canopy covered the habitat, which was rich in epiphytic plants (orchids, bromeliads, *araceas*, ferns).

Ewel et al. (1976) characterized this kind of forest as having an annual average precipitation over 2000mm, with excess of water throughout the year, and being almost completely restricted to sloping terrains frequently exposed to strong winds.

Other anurans sympatric with *Atelopus soriano* were a species of the *Hyla bogotensis* group (Duellman, 1972) and a species of *Colostethus*. Nocturnal collections will probably reveal a more diverse anurofauna. *A. soriano* was very common at the type locality, but collections in streams at nearby cloud forests failed to produce more specimens. This may suggest a very restricted distribution. Accelerated destruction of forests in the area (Fig. 3) threatens the future of the species.

Comparisons. Four other species of *Atelopus* occur in Venezuela. Differential characters for those species are given below (characters for *A. soriano* in parenthesis). *A. carbonerensis* is the frog most closely resembling *A. soriano*. *A. carbonerensis* has a curved or slightly angular canthus rostralis (sharp, angular), less elevated nostrils, different webbing (see discussion), yellow coloration with brown markings (orange-red without markings), and larger ♂♂ - SVL 43.4 ± 1.6 mm, range 40.3-46.0, N = 52 (SVL

38.9 ± 0.8mm, range 38.2-39.8, N = 5). Rivero (1972:605) stated that *A. carbonerensis* lacks brown markings. This is in error, since the species usually shows a brown spot around the nostril (Fig. 2) and occasionally has brown marking on different parts of the body (e.g. several specimens in lot UMMZ 57403, considered *A. oxyrhynchus* by Rivero (1961: 170), and KU 132853, 132883-132884, 132892, among others).

*Atelopus crucigerum crucigerum*¹ (Lichtenstein and Martens) has yellow or green coloration with labyrinthic brown markings (orange-red without markings), eye diameter equal to distance between eye and nostril (larger), and heel of the adpressed hind limb extending to anterior corner of eye (to temporal region). *A. crucigerum vogli* Müller is similar to *A. c. crucigerum*, differing in few characters (Rivero, 1961). Both forms have been reported only from the Coastal Range of Venezuela (Cordillera de La Costa, 100 to 1100m). The single skull of *A. crucigerum* available for this study has the anterior extension of the sphenethmoid complex not ossified, whereas *A. soriano*i has it ossified.

Atelopus mucubajiensis Rivero is a smaller frog — SVL 31.1 ± 0.8mm, range 30.0-41.7 in ♂♂; SVL 39.9 ± 0.1mm, range 39.9-40.0 in ♀♀ (SVL 38.9 ± 0.8mm, range 38.2-39.8 in ♂♂; SVL 44.9 ± 2.6mm, range 42.2-49.1 in ♀♀), with a more pointed snout (subacuminate), eye diameter equal to distance between eye and nostril (larger), and yellow coloration with brown markings (orange-red without markings). Rivero (1972: 606) stated that the heel in *A. mucubajiensis* extends to the elbow of the adpressed forelimb. This statement is in error because in *A. mucubajiensis* the heel reaches the temporal region, same condition seen for *A. soriano*i.

Atelopus oxyrhynchus Boulenger is more tuberculate than *A. soriano*i, with canthus rostralis curved (sharp, angular), squamosals not prominent — Fig. 5A (posterior end of squamosals elevated, Fig. 5C), yellow-brown coloration with numerous brown markings (orange-red, without markings), and often with canthal and supratympanic bands (absent). Rivero (1961: 169) stated that *A. oxyrhynchus* has the third finger shorter than the distance between eye and tip of snout. The character was used to differentiate *A. oxyrhynchus* from other Venezuelan *Atelopus*. The specimens of *A. oxyrhynchus* studied here (90) have the third finger longer

¹ The name *cruciger*, as currently used in the combination *Atelopus cruciger*, is a noun in apposition to the generic name. The species was originally designated *Phrynidium crucigerum* (Lichtenstein and Martens, 1956), with the epithet *crucigerum* used as an adjective modifying the generic name. In compliance with the art. 30 of the International Code of Zoological Nomenclature, the name *crucigerum*, as originally proposed, should be maintained.

than the distance between the eye and the tip of the snout, a condition also seen in *A. sorianoi*. Therefore this character does not have the taxonomic importance suggested by Rivero. *A. oxyrhynchus* (♂♂ and ♀♀) are densely tuberculate, while in *A. sorianoi*, ♂♂ are more tubercular than ♀♀, and both sexes are considerably smoother than *A. oxyrhynchus*.

Atelopus sorianoi is also easily distinguished from all members of the *ignescens* group (*sensu* Peters, 1973) outside Venezuela by its distinctive coloration. Other characters for differentiation are provided below (characters for *A. sorianoi* in parenthesis). *Atelopus arthuri* Peters, of Ecuador, has dorsum smooth (lower dorsum tuberculate), and snout with pointed tip (not pointed tip); *Atelopus bomolochos* Peters, of Ecuador, has rounded snout (subacuminate), and heel of the adpressed hind limb reaches arm insertion (to temporal region); *Atelopus carrikeri* Ruthven, of Colombia, has head as long as wide (broader than long), nostrils equidistant from eye and tip of snout (closer to tip of snout), canthus rostralis rounded (sharp, angular), fingers with lateral ridges (ridges absent), and subarticular tubercles divided (single); *Atelopus halihelos* Peters, of Ecuador, has dorsum smooth (lower dorsum tuberculate), with low glandular pustules (absent), and webbing extending to tip of all toes, except IV toe (different webbing); *Atelopus ignescens* (Cornalia), of Colombia and Ecuador, has nostrils equidistant from eye and tip of snout (closer to tip of snout), fingers with lateral ridges (absent), and subarticular tubercles divided (single); *Atelopus nepiozomus* Peters, of Ecuador, has rounded snout (acuminate), canthus rostralis curved (sharp, angular), and dorsum and sides of body and legs with low, rounded warts (smooth, except lower dorsum); *Atelopus nicefori* Rivero, of Colombia, has head longer than wide (broader than long), nostrils equidistant from eye and tip of snout (closer to tip of snout), finger with lateral ridges (absent), and heel of the adpressed hind limb reaches posterior border of eye (to temporal region); *Atelopus pachydermus* (Schmidt), of Colombia and Ecuador, has rounded snout (subacuminate), and subarticular tubercles absent (present); *Atelopus pedimarmoratus* Rivero, of Colombia, has head as wide as long (broader than long), rounded snout (subacuminate), fingers with weak lateral ridges (absent), venter finely pustular (smooth), and small transverse ridges from chin to chest (absent); *Atelopus walkeri* Rivero, of Colombia, has a canthus rostralis curved (sharp, angular), fingers with weak lateral ridges (absent), heel of the adpressed hind limb reaches posterior border of eye (to temporal region), external vocal sac in ♂♂ (absent), and slight ventral disc (absent).

Discussion. The closest relatives of *Atelopus sorianoi* seem to be *A. oxyrhynchus* and *A. carbonerensis*, both forms currently recog-

nized as subspecies of *A. oxyrhynchus* Boulenger (Rivero, 1972). A constant difference in coloration and degree of dorsal tuberculation between the two forms has already been noted. A more accurate comparison provides other differential characters previously ignored, of which the most conspicuous are: *A. carbonerensis* ♂♂ are larger (SVL = 43.4 ± 1.6 mm; range 40.3-46.0; N = 52) than *A. oxyrhynchus* ♂♂ (SVL = 39.9 ± 1.1 mm; range 39.1-42.0; N = 11); *A. carbonerensis* ♂♂ have posterior end of squamosals elevated, while *A. oxyrhynchus* ♂♂ do not (Fig. 5a, b); nostrils are more elevated in *A. carbonerensis*, which also has a more concave canthus rostralis (Fig. 5b). In *A. oxyrhynchus* the web usually reaches beyond base of penultimate phalanx on toe V (2^- of Savage/Heyer formula), and does not reach the tip of toe I. In *A. carbonerensis* the web does not go beyond penultimate phalanx on toe V (2 of S/H formula), and reaches the tip of toe I; in *A. oxyrhynchus* both ♂♂ and ♀♀ are densely tuberculate. In *A. carbonerensis* the ♂♂ are more tuberculate than ♀♀, even though both sexes are much smoother than *A. oxyrhynchus*.

Besides the noted morphological differences, electrophoretic data (Durant, 1976) do not support Rivero's contention of conspecificity between *A. carbonerensis* and *A. oxyrhynchus*. Evidence for gene flow between both forms is absent, and the constancy of the differences and the allopatric distribution of *A. carbonerensis* and *A. oxyrhynchus* call for a revision of Rivero's thesis. In assigning specific rank to both forms, I have followed Wiley's (1981, chapter 2) suggestions. The most parsimonious decision is to consider both forms as fully distinct species, and they are so treated in the present paper.

Atelopus sorianoi most closely resembles *A. carbonerensis* (Figs. 1, 2, 5). Habitats for both species are separated by the lowlands of the Chama River valley (Fig. 4). Deep xerophytic valleys separate *A. sorianoi* from *A. carbonerensis* and *A. oxyrhynchus*, and most of the cloud forests of the region have been destroyed and replaced by secondary plant formations or pasture (Sarmiento et al., 1971; Fig. 3).

It is possible that *A. carbonerensis*, *A. oxyrhynchus* and *A. sorianoi* are species derived from an ancestral stock once widely distributed in cloud forests during the last glaciation. At present no synapomorphy is known that unites the three species. It could also be possible that they are the result of independent speciation events. Several workers have pointed out that frogs of the genus *Atelopus* have very local distribution, and that differences in vegetation, humidity, drainage systems, and physiography may have accounted for much of the speciation within the genus (e.g. Rivero, 1963:112; McDiarmid, 1971:58; Peters, 1973:44). *A. sorianoi* may be the result of isolation and an adaptive response to very humid environments.



Fig. 1. *Atelopus soriano*, new species; ♂ from type locality (specimen not collected). Photo by P. Soriano.

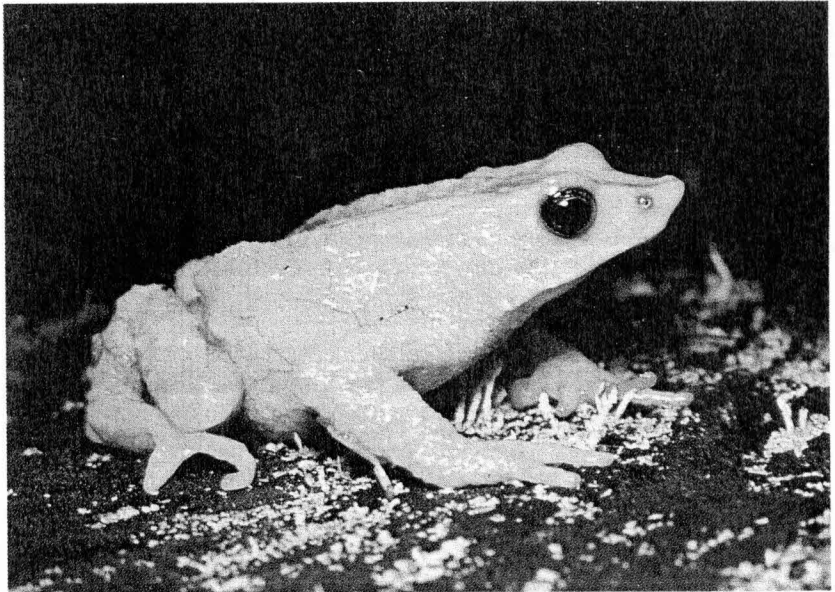


Fig. 2. *Atelopus carbonerensis*, ♂ from La Carbonera, Estado Mérida. Photo by P. Soriano.

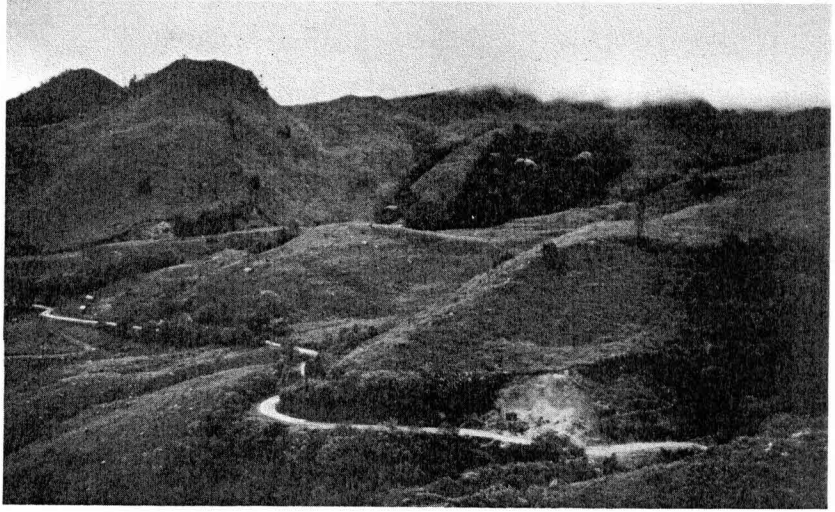


Fig. 3. Remnants of cloud forests near the type locality of *Atelopus soriano*. The cleared lands are used as pasture.

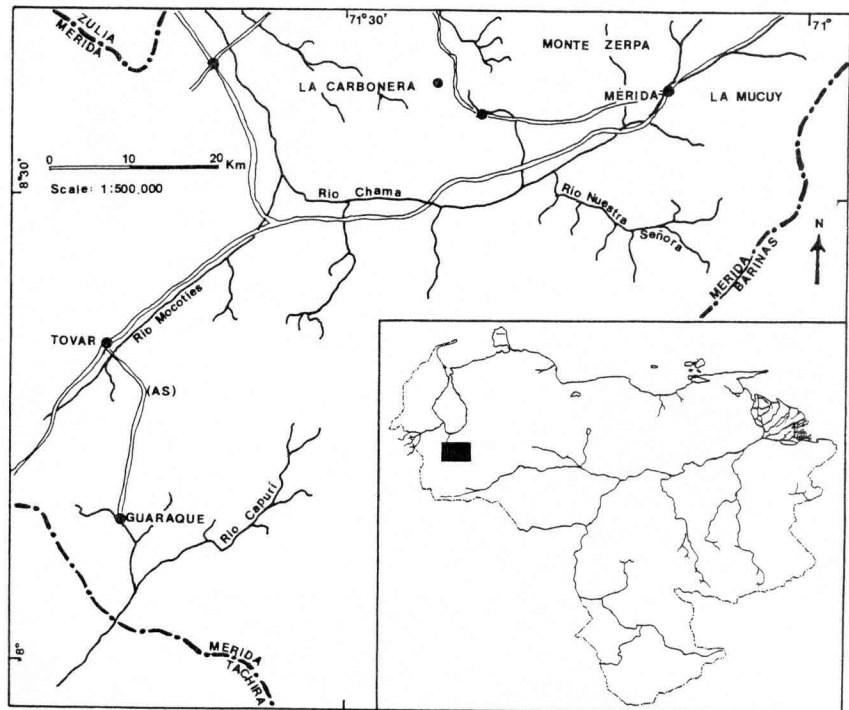


Fig. 4. Map of the localities discussed in the text. Solid square in the inserted map of Venezuela indicates the location of the area shown in detail. Type locality of *Atelopus soriano* is indicated by the symbol (AS).

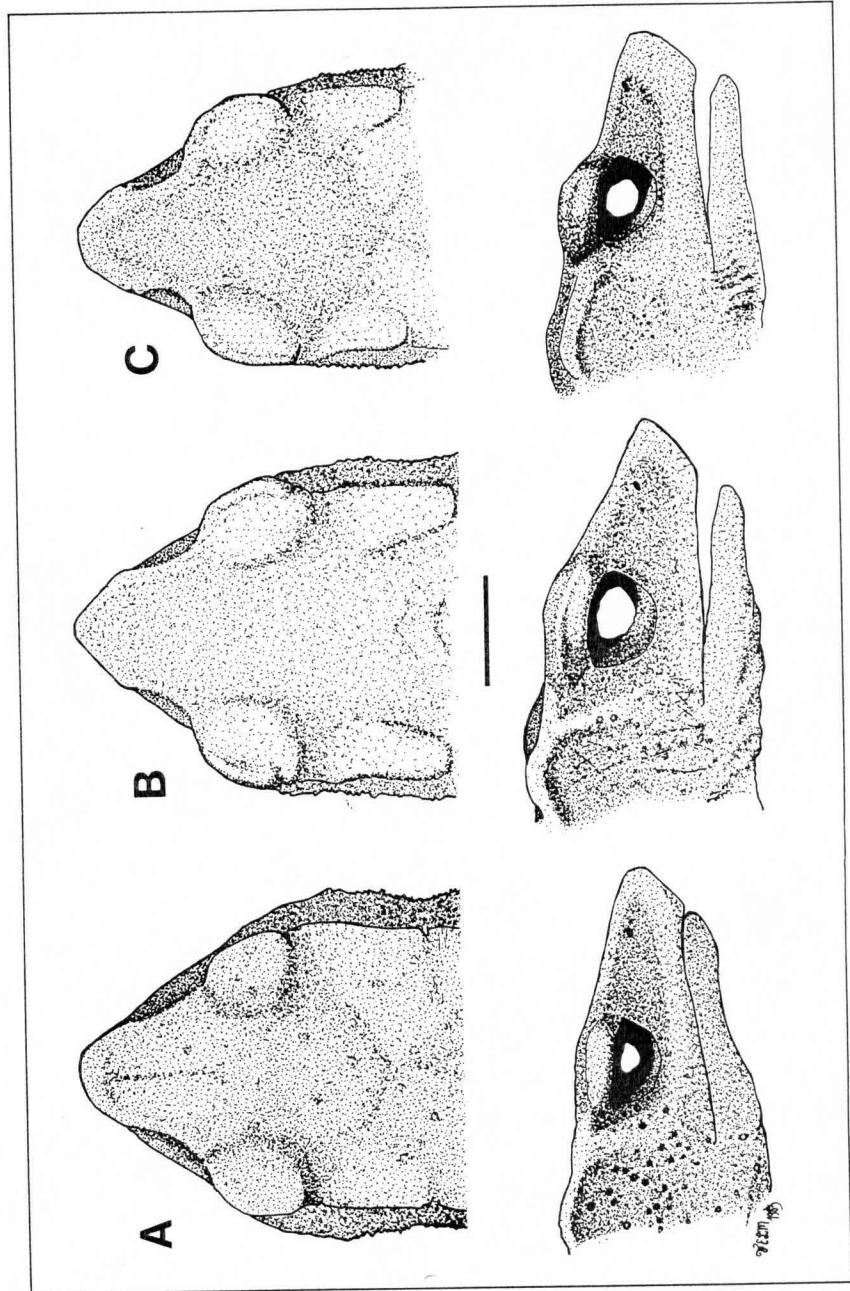


Fig. 5. Dorsal and lateral views of A) *Atelopus oxyrhynchus* (CVULA 2795, ♀); B) *A. carbonerensis* (CVULA 2794, ♀); C) *A. sorianoi* (CVULA 2783, ♀, holotype). The bar represents 5 mm.

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Specimens examined

Atelopus carbonerensis. VENEZUELA: Mérida; La Carbonera, Bosque San Eusebio, BYU 41829-41832; LACM 134416-134417 (dry skeletons); UCM 54213; CVULA 2793-2794; La Carbonera, AMNH 90311-90313; UMMZ 57403 (18); USNM 118676-118677; San Eusebio, nr. La Carbonera, 2400 m, MCZ 65970-65973.

Atelopus crucigerum. VENEZUELA: Aragua; Rancho Grande, LACM 127301 (C & S. skeleton).

Atelopus crucigerum crucigerum. VENEZUELA: Aragua; Rancho Grande, LACM 41912-41913.

Atelopus mucubajensis. VENEZUELA: Mérida, Páramo de Mucubají, La Corcovada, 3400 m, UCM 54212; CVULA 2819; Distrito Rangel, tributary to Rio Santo Domingo, 9100 ft., UMMZ 171692-171698.

Atelopus oxyrhynchus. VENEZUELA: Mérida; Monte Zerpa, CVULA 831-834, 2796; Mérida, MCZ 3804-3805; FMNH 3652; Rio Mucujún, Culata Mts., 9000 ft., FMNH 5646; Culata, AMNH 10593-10596; Mérida, 1630 m, UMMZ 51268, 58902(6), 71609; 153655-153656 (C & S. skeletons); La Mucuy, nr. Truchicultura, 2450 m, CVULA 2795; 32 Km NW Mérida, on road to La Azulita, 2010 m, KU 132847-132913.

Atelopus sorianoi. VENEZUELA, Mérida; 10 Km SSE Tovar, 2718 m, LACM 134418-134419 (dry skeletons); CVULA 2783-2792 (holotype and paratypes).

Abbreviations:

AMNH: American Museum of Natural History; BYU: Brigham Young University; CVULA: Coleccion de Vertebrados, Universidad de Los Andes, Mérida; FMNH: Field Museum of Natural History; KU: Museum of Natural History, University of Kansas; LACM: Los Angeles County Museum; MCZ: Museum of Comparative Zoology, Harvard; UCM: University of Colorado Museum, Boulder; USNM: United States National Museum.

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Resumen

Una nueva especie de anfibio anuro, *Atelopus soriano*, es descrita de un bosque pluvial montano del Estado Mérida, Venezuela. La especie es fácilmente diferenciada de cualquier otro *Atelopus* en base a su coloración rojizo-naranja. Se provee comparación con todas las especies de *Atelopus* del grupo *ignescens* reportadas hasta el presente.

Las ranas *Atelopus carbonerensis* Rivero and *A. oxyrhynchus* Boulenger son elevadas a la categoría de especies. Se sugiere la utilización del nombre *A. crucigerum* para la especie actualmente conocida como *A. cruciger*.

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