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DESCRIPTIONS OF *ATELOPUS* TADPOLES AND THEIR RELEVANCE TO ATELOPODID CLASSIFICATION

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ABSTRACT: The tadpoles of four nominal species of *Atelopus* (*certus, ignescens, minutus,* and *spumarius*) are described and illustrated. The tadpoles of *A. certus, ignescens,* and *spumarius* are like that of the previously known *A. varius* in having a large ventral mouth and suctorial disc and a median anal tube. Insofar as known, all species of *Atelopus* deposit unpigmented eggs in strings in torrential streams, except *minutus,* which lays pigmented eggs in strings in ponds. The tadpoles of *minutus* have small anteroventral mouths and dextral anal tubes; in both of these characters they are like the tadpoles of *Dendrophryniscus brevipollicatus,* which deposits its pigmented eggs singly in bromeliads. Tadpoles of two species of *Melanophryniscus* also have small anteroventral mouths, but these have median anal tubes; the eggs of *Melanophryniscus* are pigmented and deposited singly in water-filled cavities in the ground. It is suggested that on the basis of life history data *minutus* does not belong in the genus *Atelopus.*

THE 42 species of frogs currently recognized in the family Atelopodidae are presently grouped in four genera—*Atelopus* (34), *Dendrophryniscus* (2), *Brachycephalus* (1), and *Melanophryniscus* (5). The frogs in this family have been an enigma to taxonomists; recognition of the family as distinct from the Bufonidae is tenuous. Several species evidently are incorrectly placed generically.

The life histories of few atelopodids are known. Fernández (1926) described the tadpoles of *Melanophryniscus stelzneri,* and Carvalho (1949) described the eggs and tadpoles of *Dendrophryniscus brevipollicatus.* Bokermann (1967) reported on the life history and tadpoles of *Melanophryniscus moireirae,* and Starrett (1967) described the eggs and tadpoles of the same species and of *Atelopus varius.* We present here the descriptions of four additional species currently referred to the genus *Atelopus* and attempt to show that the characteristics of the larvae and eggs of atelopodid frogs are relevant to the classification of the group.

In the following descriptions the developmental stages are designated according to Gosner's (1960) system. All specimens are in the collections of the Museum of Natural History at the University of Kansas (KU); numbers in parentheses after the catalogue number indicate the number of specimens in each lot.

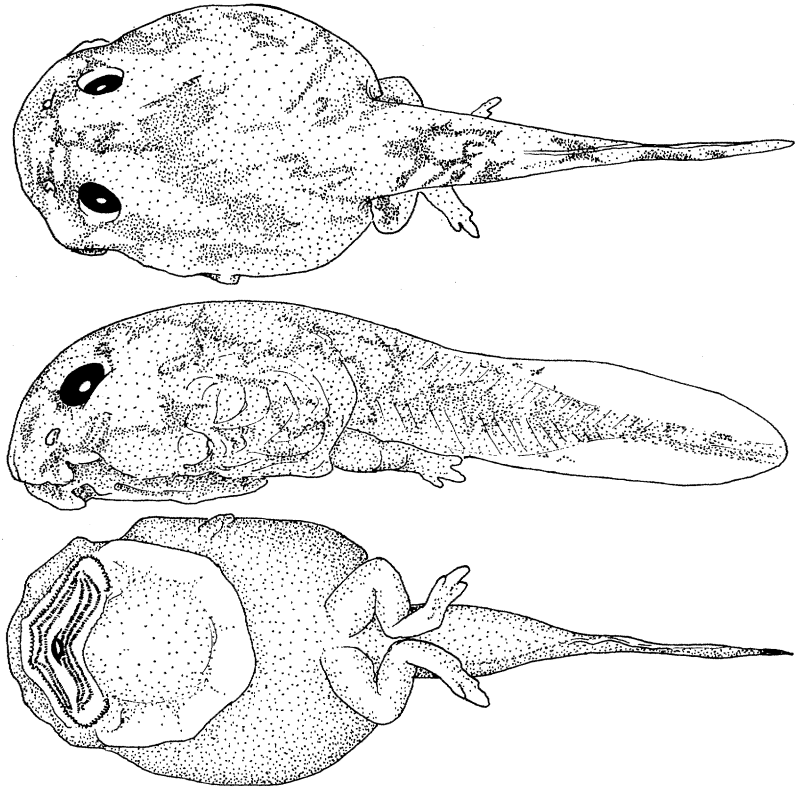

FIG. 1.—Tadpole of *Atelopus spumarius spumarius*, KU 121385, × 7.5.

Atelopus spumarius spumarius Cope
(Fig. 1)

Material.—KU 121385 (1)—Ecuador: Provincia Pastaza: Río Puyo, 3 km S Puyo, 980 m; 6 July 1968.

Description.—Developmental stage 37, body length 6.9 mm, total length 13.7 mm. Body depressed, flattened ventrally, 1.5 times as wide as deep; dorsal contour gradually curved anteroventrally to tip of snout; in dorsal view snout broadly rounded; body abruptly expanded posterior to eyes; widest at about two-thirds of its length, terminating abruptly. Eyes moderately large, separated by distance equal to about 2 times diameter of eye, directed anterodorsolaterally; nostrils small, much closer to eyes than to tip of snout. Spiracle sinistral, opening posterodorsally at a point below midline and about three-fifths of body length; anal tube median, short. Caudal musculature massive on anterior third of tail; musculature deep on anterior half of tail, narrowing abruptly at midlength, extending nearly to tip of acutely rounded tail. Caudal fins deepest at about three-fifths of length of tail; dorsal fin arched; ventral fin having level edge; dorsal fin not extending onto body.

Mouth large, ventral, followed by a large suctorial disc, which is widest

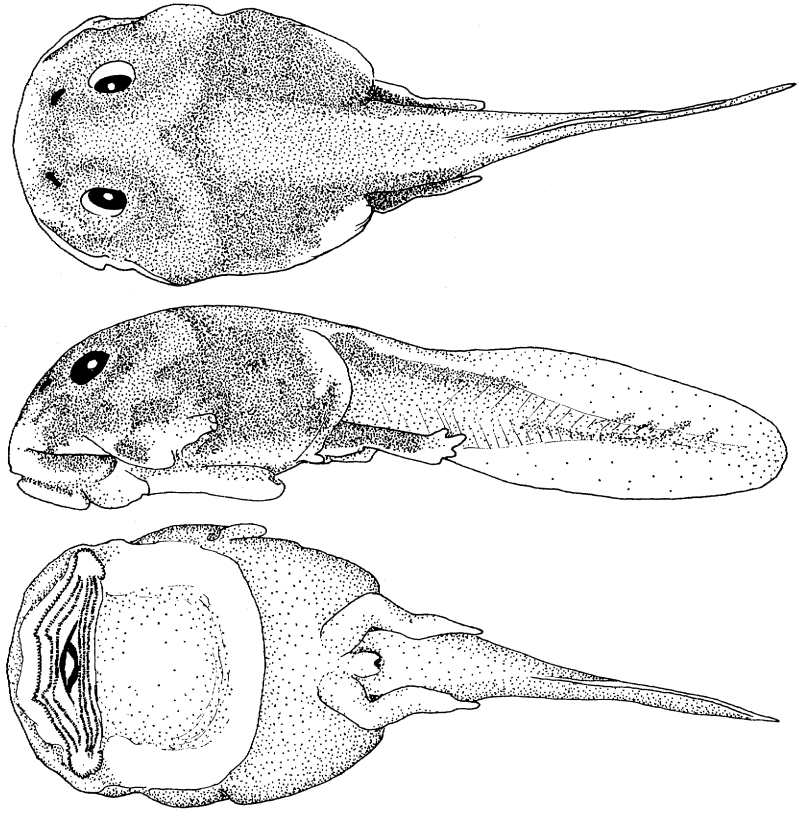

FIG. 2.—Tadpole of *Atelopus certus*, KU 116728, × 7.5.

anteriorly, extending two-thirds length of body; lower lip bare; elsewhere lips bearing single row of small blunt papillae. Two upper and three lower rows of teeth, all complete and approximately equal in length; first upper row angulate. Beaks thin, smooth; upper beak nearly transverse, about half length of broadly V-shaped lower beak.

Body dark above and laterally with scattered white flecks, somewhat paler ventrally; edge of suctorial disc lacking pigment; scattered pigment in middle of disc. Caudal musculature with vertical irregular cream and black bands; fins lacking pigment. In life, dark brown with pale brown markings.

Remarks.—The tadpole was obtained by kicking gravel on the bottom of a swiftly flowing stream (65 cm deep) and seining the disturbed aquatic organisms.

Although the single tadpole cannot be associated with *Atelopus spumarius spumarius* with absolute certainty, the only adult *Atelopus* found in the area are referred to that species. This species has been referred to in the literature as *A. pulcher* Boulenger and *A. spumarius* Cope; Rivero (1968) placed *pulcher* in the synonymy of *spumarius*.

TABLE 1.—Measurements (mm) of developmental stages of tadpoles of *Atelopus certus*.

Stage	N	Body Length	Total Length
25	4	5.5–5.8 (5.7)	12.3–13.3 (13.0)
26	1	6.3	13.3
29	1	6.3	13.6
33	3	6.3–6.9 (6.5)	13.3–14.1 (13.7)
36	3	6.7–7.0 (6.8)	13.6–14.5 (14.0)
38	1	7.0	14.5
42	1	7.0	13.3
44	1	7.0	13.1

Atelopus certus Barbour

(Fig. 2)

Material.—KU 116728 (15)—Panamá: Provincia Darién: upper Río San Antonio, vicinity of mouth of stream draining southwestern slope of La Jarcia (ridge), 280 m; 27 May 1967.

Description.—Developmental stages 25 through 44 (Table 1); stage 36, body length 6.7 mm, total length 13.6 mm. Body depressed, flattened ventrally, depth equalling three-fourths of width; dorsal contour gradually curved anteroventrally to tip of snout; in dorsal view snout broadly rounded; body constricted at level of eyes and at midlength; posterior edge of body terminating abruptly after narrowing to about half of its width. Eyes moderately small, separated by distance equal to about 3 times diameter of eye, directed dorsolaterally; nostrils small, closer to eyes than to tip of snout. Spiracle sinistral, opening posterodorsally at a point well below midline and at about three-fifths of body length; anal tube short, median. Caudal musculature massive on anterior third of tail; musculature deep anteriorly, narrow posteriorly, extending nearly to tip of bluntly rounded tail; ventral fin having level edge; dorsal fin low on anterior third of tail, elevated and gradually diminishing in depth posteriorly.

Mouth large, ventral, followed by large suctorial disc, which is widest anteriorly, shallowly indented laterally at midlength, and extending two-thirds length of body; lips bearing single row of short, blunt papillae, except median two-thirds of lower lip bare. Two upper and three lower rows of teeth, all complete and of about equal length; first upper row angulate; second and third rows narrowly separated from one another. Beaks moderately thin, smooth; upper beak a broad shallow arch; lower beak broadly V-shaped.

Body dark brown above and below with scattered white flecks; edge of snout and margin of suctorial disc lacking pigment; middle of disc lightly pigmented. Caudal musculature cream with brown pigment dorsally; fins clear except for finely scattered pigment dorsally and on proximal half of ventral fin. In life, black with golden bronze flecks, taking on greenish tint in advanced stages.

All specimens in stages 25–38 have two upper and three lower tooth rows. The metamorphosing tadpole in stage 42 has the suctorial disc but has lost the lower rows of teeth; the specimen in stage 44 lacks the disc and teeth.

Remarks.—The tadpoles were clinging to the upper sides of pebbles on the gravel bottom of a pool below a small waterfall by

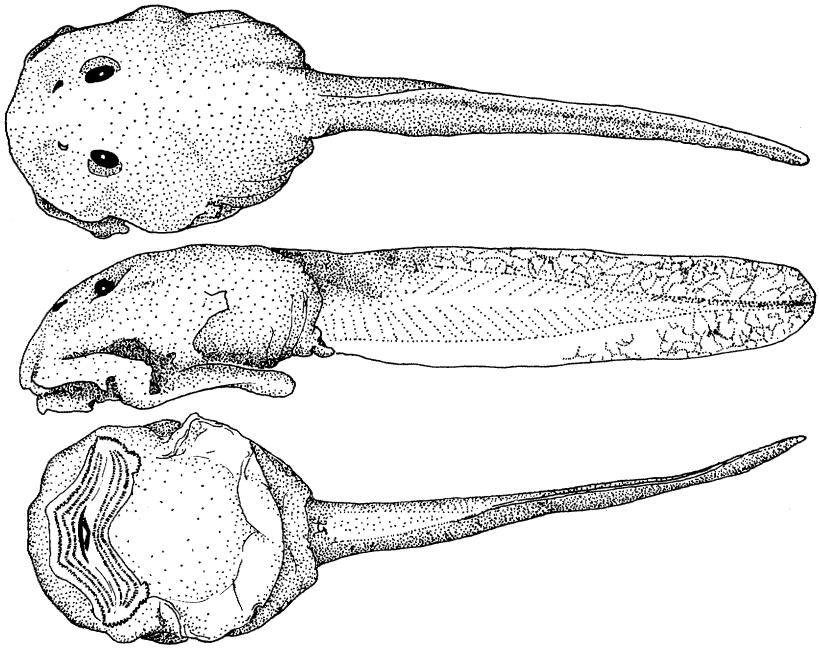

FIG. 3.—Tadpole of *Atelopus ignescens ignescens*, KU 124162, × 7.5.

day. The pebbles could be lifted slowly from the water without the tadpoles dropping off.

Only minor differences exist between these tadpoles and those of *Atelopus varius* described and illustrated by Starrett (1967). The latter specimens (KU 104317 from Costa Rica: Provincia Heredia: 5 km S Los Cartagos, 1960 m) have better developed labial papillae medially on the upper lip and a much less angulate first upper tooth row.

Barbour (1923) named *certus* as a subspecies of *Atelopus spurrelli*, but Dunn (1931) placed *certus* as a subspecies of *Atelopus varius*. Rivero (1963) casually referred to *Atelopus certus*. We are following Rivero's designation, not because we have evidence to support the specific distinctness of *certus*, but rather because the taxonomic relationships of the many named and un-named populations of *Atelopus* in Panamá are unknown at the present time. Consequently, we feel that the use of the specific name *certus* without indication of supposed subspecific relationship most clearly reflects our present state of knowledge.

The tadpoles are from the type locality, as can best be determined from Barbour and Brooks' (1923) description of the area. In the

immediate vicinity of the type locality, Charles W. Myers collected 335 adults of only one species in addition to the lot of tadpoles.

Atelopus ignescens ignescens (Cornalia)
(Fig. 3)

Material.—KU 124162 (33)—Ecuador: Provincia Cotopaxi: El Porvenir, 2 km (by road) W Campamento Mariscal Sucre, 3620 m (N slope Volcán Cotopaxi); 16 August 1968.

Description.—Developmental stage 25, body length (10 specimens) 4.3–5.3 (5.0) mm, total length 11.5–14.7 (13.2) mm. Body slightly depressed, flattened ventrally, depth equal to three-fourths width; dorsal contour curved from middle of domed body to snout; in dorsal view snout broadly rounded; body shallowly indented laterally at level of eyes and deeply indented at about midlength; posterior contour of body rounded; flange of suctorial disc protruding laterally beyond edge of body. Eyes small, separated by distance equal to 3 times diameter of eye, directed antero-dorsolaterally; nostrils small, somewhat closer to eyes than to tip of snout. Spiracle sinistral, opening postero-laterally at a point slightly below midline and about three-fifths of body length; anal tube short, median. Caudal musculature moderately robust, tapering gradually, terminating short of tip of bluntly rounded tail; fins shallow; dorsal fin present on anterior part of tail, not elevated at midlength; ventral fin having straight edge.

Mouth large, ventral, followed by large suctorial disc, which is widest anteriorly, slightly indented laterally, and extending about four-fifths of length of body; flange of oral sucker broad; median two-thirds of lower lip bare, rest of lips bearing single row of short blunt papillae. Two upper and three lower rows of teeth, all complete and of about equal length; first upper row angulate. Beaks thin, smooth; upper beak a broad shallow arch; lower beak broadly V-shaped.

Body black; caudal musculature dark brown; entire dorsal fin and posterior half of ventral fin venated with brown; minute flecks on anterior half of ventral fin; suctorial disc lacking pigment except medially. In life, body and tail black; fins gray.

Remarks.—The tadpoles were found by day in a narrow, swift, rocky stream in páramo; the water temperature was 19 C. All of the tadpoles were adhering to stones in the stream; most were on the undersides of stones. Few tadpoles released their grips when the stones were lifted out of the water.

Many adult and young *Atelopus ignescens ignescens* were found on the northern slopes of Volcán Cotopaxi; because no other *Atelopus* is known from these higher slopes of the volcano, the tadpoles described here almost certainly belong to *ignescens*. The only other frog having tadpoles and inhabiting the páramo there is *Gastrotheca marsupiatum*; the tadpoles of that species develop in ponds, have large robust bodies, and lack suctorial discs.

Atelopus minutus Melin
(Fig. 4)

Material.—KU 121386 (5)—Ecuador: Provincia Pastaza: Sarayacu, 400 m; 19 July 1968.

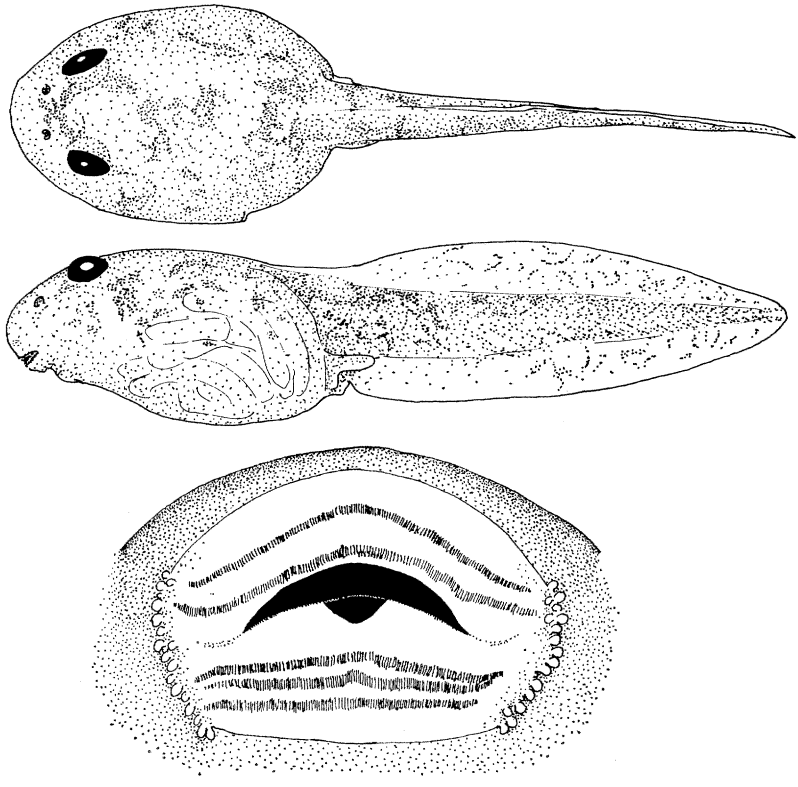

FIG. 4.—Tadpole of *Atelopus minutus*, KU 121386, × 7; mouth, × 25.

Description.—Two tadpoles in developmental stage 31 with body lengths of 5.8 and 6.5 mm and total lengths of 14.1 and 15.4 mm; three tadpoles in developmental stage 40 with body lengths of 7.5–8.5 (8.2) mm and total lengths of 19.3–20.1 (19.8) mm. Body ovoid in dorsal view, widest posteriorly, slightly wider than deep; snout in dorsal profile rounded, in lateral profile acutely rounded; eyes moderately large, separated by distance equal to about 2 times diameter of eye, directed dorsolaterally; nostrils small, narrowly separated, much closer to eyes than to tip of snout. Spiracle sinistral, opening posteriorly on midline at about two-thirds of body length; anal tube dextral. Caudal musculature gradually tapering posteriorly, extending nearly to tip of acutely rounded tail; ventral fin having equal depth throughout its length; dorsal fin deepest at about midlength, not extending onto body; depth of caudal musculature at midlength of tail about equal to depths of each fin.

Mouth small, anteroventral; lips shallowly infolded laterally; upper and lower lips bare; single row of small blunt papillae laterally; suctorial disc absent. Two upper and three lower rows of teeth, all complete; upper rows equal in length, slightly longer than lower rows; first and second lower rows equal in length; third lower row shorter. Beaks moderately slender, finely serrate; upper beak in form of broad arch with long slender lateral processes; lower beak broadly V-shaped.

Body and tail grayish tan with dark brown blotch between eyes and brown flecks scattered on body; transverse brown bands on dorsal part of caudal musculature; small brown flecks on caudal musculature, entire dorsal fin, and posterior third of ventral fin. In life, body brown; tail spotted with black. Feet in individuals in stage 40 reddish brown.

Remarks.—The tadpoles were found in a quiet murky swamp at the edge of tropical rainforest. The tadpoles are assigned to *Atelopus minutus* on the basis of the red coloration of the feet.

On the evening of 19 July 1968, two clasping pairs were found swimming in the same swamp; amplexus is axillary. Each pair was placed in a container of water. The following morning both females had deposited eggs in gelatinous strands 245 and 285 mm long, containing 245 and 291 eggs respectively. The eggs have a creamy white vegetal pole and a dark brown animal pole. The eggs are in two rows medially throughout most of the gelatinous strand; but in some places within the strand the eggs are in three rows; at the end of one strand the eggs are in a single row. The gelatinous strands of the two females have diameters of 5.0 and 7.5 mm. The eggs have diameters of about 0.8 mm; each egg is enclosed in a single membrane, which closely approximates the size of the egg. The eggs are not separated from one another by partitions, nor are there constrictions in the gelatinous strands, as described for the eggs of *Atelopus varius* by Starrett (1967).

Discussion

Among the atelopodid genera for which life history data are available, all of the tadpoles have two upper and three lower rows of teeth. *Dendrophryniscus brevipollicatus* is unique in depositing its eggs in bromeliads, and the tadpoles differ from those of other atelopodids by having the second upper tooth row interrupted medially and labial papillae present on the entire margin of the lower lip (Carvalho, 1949). *Melanophryniscus* and *Dendrophryniscus* are alike in having pigmented eggs that are laid singly and in having tadpoles with small anteroventral mouths. *Melanophryniscus* deposits its eggs in small terrestrial water-filled depressions; the tadpoles have labial papillae only laterally and have all tooth rows complete (Fernández, 1926; Bokermann, 1967). The anal tube is dextral in *Dendrophryniscus* and median in *Melanophryniscus*.

The eggs and tadpoles of *Atelopus certus*, *ignescens*, *spumarius*, and *varius* are alike in many characteristics and differ strikingly from those of *Dendrophryniscus* and *Melanophryniscus*. In these species of *Atelopus* and in gravid females of *chiriquiensis* and *senex* the eggs are large and unpigmented. Starrett (1967) noted that the eggs of *Atelopus varius* were deposited in strings with the eggs arranged in a single row and separated from one another by partitions. The tadpoles of these species of *Atelopus* all have a large

ventral mouth, huge suctorial disc, one row of labial papillae except on the lower lip, and a median anal tube. The tadpoles of *Atelopus ignescens* are somewhat different from those of the other three species of *Atelopus*. The former have proportionately larger oral suckers and longer shallower tails. *Atelopus ignescens* is a member of a group of species inhabiting high Andean páramos, whereas the other three species belong to lowland groups. With the acquisition of larvae of more species of *Atelopus*, larval features in combination with the characters of the adults may be useful in defining species groups in *Atelopus*.

The eggs and tadpoles of *Atelopus minutus* immediately set this species apart from the other *Atelopus*. The small pigmented eggs are deposited in strings in ponds. The tadpole has a dextral vent and a small anteroventral mouth with one row of labial papillae laterally. The oral characters of *minutus* are like those of *Melanophryniscus*, and the position of the vent is like that in *Dendrophryniscus*. The eggs of *minutus* are pigmented like the eggs of those two genera, but the eggs are laid in strings like those of *Bufo*. The adults of *minutus* are unlike other *Atelopus*; in some characteristics they are more like *Dendrophryniscus* than other atelopodids. Although we are convinced on the basis of life history data alone that *minutus* is not a member of the genus *Atelopus*, we defer the decision concerning its taxonomic placement to Roy W. McDiarmid, who currently is investigating the osteology and evolutionary relationships of the atelopodid frogs.

Starrett (1967:203) noted the similarities in larval structure of *Atelopus varius* and *Melanophryniscus moireirae* with that of bufonids and stated: "In spite of the modification for stream life in *Atelopus* tadpoles, the tooth row number and the position of the vent and spiracle are characteristic of the Bufonidae." The genera comprising the currently recognized family Atelopodidae all have the first and second presacral vertebrae fused (except *Brachycephalus*), an arcifero-firmisternal girdle, and a Bidder's organ (except *Brachycephalus*). With the exception of *Brachycephalus*, the genera of the Atelopodidae seem to form a closely related group that is not distantly related to *Bufo*. Actually the atelopodids are no more divergent from *Bufo* than are the modified bufonid genera, such as *Ansonia*. Thus, the recognition of the Atelopodidae as a family distinct from the Bufonidae does not seem to be justified.

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