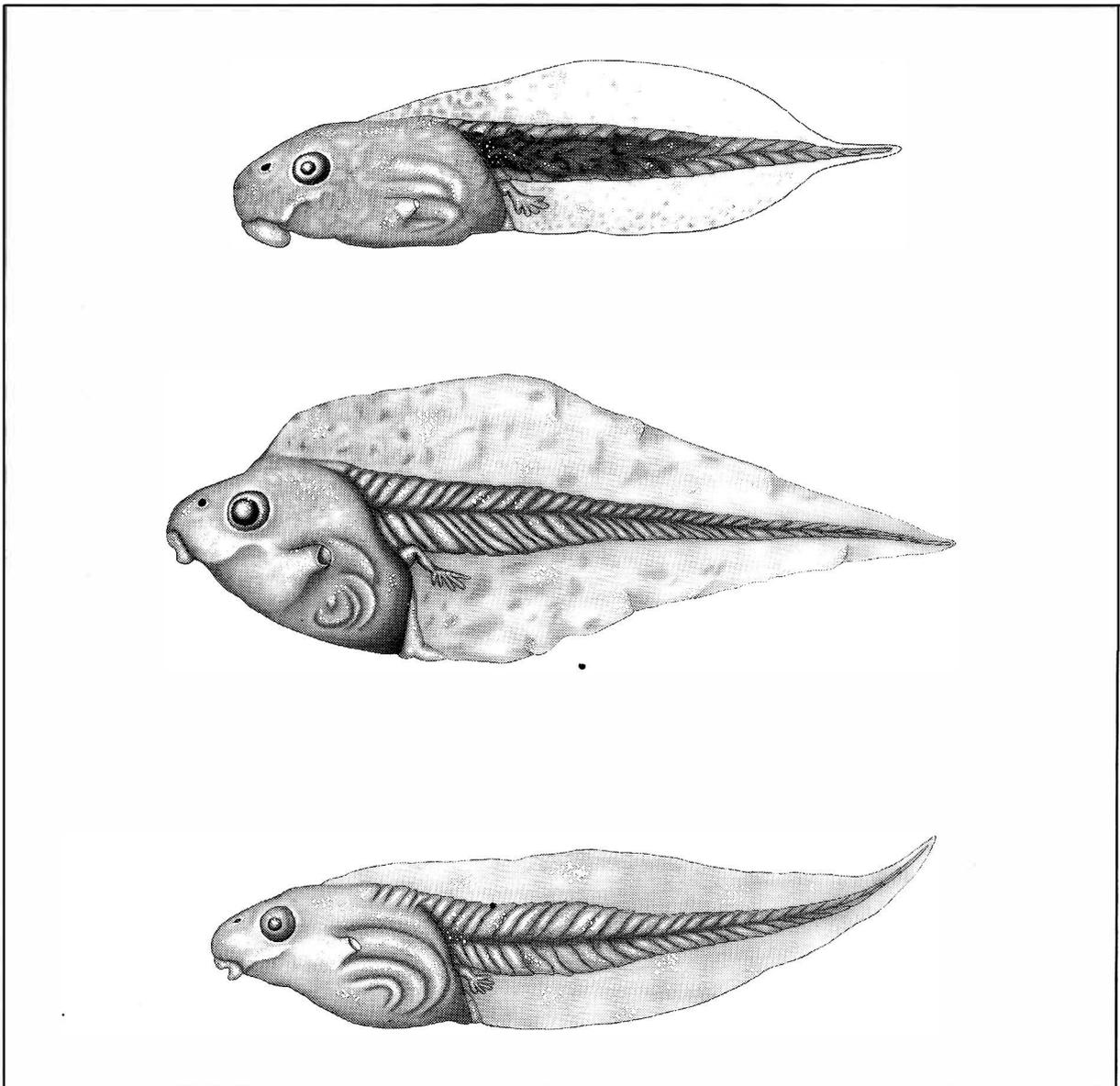


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DESCRIPTION OF TADPOLES OF THREE SPECIES OF *SCINAX* (ANURA: HYLIDAE)

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Larval morphological characteristics have been used to cluster species of *Scinax* in seven species groups and to support the monophyly of some of these groups. However, our present knowledge of *Scinax* tadpoles is incomplete; currently, tadpoles of only 21 of the approximately 80 recognized species have been described. Herein, we describe and illustrate the external morphology and oral disc characteristics of larval *Scinax berthae*, *S. nebulosa*, and *S. boesemani*. The presence of a "labial arm" supporting the P3 tooth row in *S. boesemani*, and its absence from *S. nebulosa*, is discussed in the light of our limited knowledge of tadpoles of species of other *Scinax*.

INTRODUCTION

The genus *Scinax* consists of approximately 80 species grouped in seven species groups (Duellman & Wiens, 1992; Peixoto & Weygoldt, 1987). The species in this genus exhibit a rich diversity of tadpole external morphology. An analysis (in progress) by one of us (AIK) of tadpole morphology and character evolution in *Scinax* brought to our attention the lack of information on larval characteristics for several species in this genus. An examination of tadpoles available in collections successfully located tadpoles of three species whose larval characteristics have not been reported. Herein we describe the tadpoles of *Scinax nebulosa* and *S. boesemani*, redescribe the tadpole of *S. berthae*, and provide comments on larval habitat and biology.

MATERIALS AND METHODS

The following descriptions are based on material preserved in 10% buffered formalin. Descriptive terminology follows that of Altig (1970) and Kehr & Williams (1990). The morphometric variables considered are those suggested by Lavilla & Scrocchi (1986). Museum abbreviations are: KU: University of Kansas, Natural History Museum; USNM: National Museum of Natural History, Smithsonian Institution; CECOAL: Centro de Ecología Aplicada del Litoral, Corrientes, Argentina. Measurements were taken with dial calipers and recorded to the nearest 0.1 mm; for detailed information on how measurements are taken refer to Lavilla & Scrocchi (1986, Figure 1). These variables are abbreviated as follows: TL (total length), BL (body length), TaL (tail length), BW (body maximum width), BWE (body width at eyes), BWN (body width at nostrils), BH (body maximum height), FH (fin height), TMH (tail muscle height), RSD (rostrispiracular dis-

tance), SPD (spiracular-posterior distance), FN (fronto-nasal distance), NO (narial-ocular distance), N (nostril diameter), E (eye diameter), EN (extranarial distance), IN (internarial distance), EO (extraorbital distance), IO (interorbital distance), ODW (oral disc width), RG (rostral gap), MG (mental gap). One tadpole was measured for each species. Tadpoles were staged using Gosner's table of normal development (Gosner, 1960). Drawings were made with the aid of a camera lucida attached to a Wild M3C stereomicroscope.

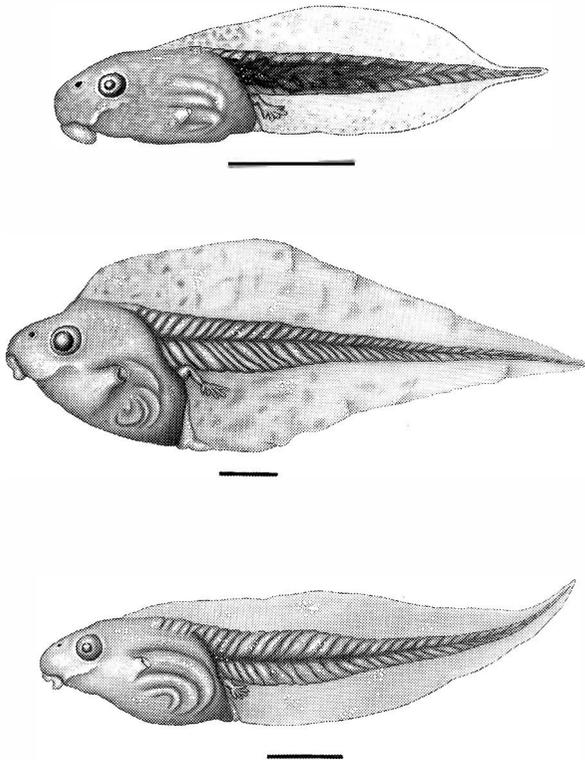
We consider illustrations to be a most important component of tadpole descriptions, consequently in the discussion we identify with an asterisk (*) those descriptions that included tadpole illustrations.

DESCRIPTIONS

SCINAX BERTHAE (BARRIO, 1962)

See Fig. 1 and 2 (top). The tadpole of *Scinax berthae* was mentioned briefly by Gallardo (1987). This description lacks morphometrics and illustrations, and did not identify voucher specimens. Here we describe the tadpole of *S. berthae* based on specimens collected at Punta Lara (34°47'S; 58°01'W), Province of Buenos Aires, Argentina, by A. Kehr on February 10, 1988. A subset of these individuals was raised through metamorphosis to confirm the species identification. An additional specimen has been deposited in the U.S. (USNM 346876). The specimen illustrated (CECOAL 001) is at Gosner Stage 37 and has the following measurements: TL = 21.8, BL = 8.4, TaL = 13.4, BW = 5.3, BWE = 4.8, BWN = 4.0, BH = 4.5, FH = 4.7, TMH = 2.2, RSD = 6.0, SPD = 2.4, FN = 1.1, NO = 0.8, N = 0.3, E = 1.3, EN = 2.6, IN = 2.1, EO = 4.6, IO = 2.8, ODW = 2.3, RG = 1.0. Tadpoles of *S. berthae* are characterized by an overall ovoid body that is wider than high (BW/BH

FIG. 1. Tadpoles of: *Scinax berthae*, Gosner stage 37, CECOAL 001 (top); *Scinax nebulosa* Gosner stage 37, KU130154 (middle); and *Scinax boesemani* Gosner stage 37, USNM291285 (bottom). Bars = 5 mm.



= 1.17). The snout is rounded both in lateral and dorsal views. The nostrils are dorsolateral, located nearer to the eyes than to the snout. The eyes are lateral. The spiracle is single, sinistral, and lateral; although it opens below the mid-level of the body, it is visible in dorsal view. The vent tube is 2.0 mm long, lies along the ventral mid-line, and opens slightly dextrally. The tail represents about 62% of the total length. The tail fin height is slightly greater than that of the body. The dorsal fin extends onto the body and is slightly higher than the ventral fin. The height of the ventral fin is subequal to the height of the tail musculature. The shape of the tail tip is flagelliform, with a rounded tip.

The oral disc is anteroventral. A single row of medium-sized marginal papillae borders the oral disc. The labial tooth row formula is: 2(2)/3. The length of row A1 is 2.2 mm and that of A2 is 2.0 mm. On the posterior labium, the length of row P1 is 2.0 mm, P2 is 1.9 mm, and P3 is 1.8 mm. The length of the beak is approximately 1.0 mm. The upper and lower beaks are serrated and approximately 20% keratinized (as suggested by pigmentation). The upper beak is broadly W-shaped and the lower beak is V-shaped.

In life, the body is brown dorsally and has a wide, brownish inter-orbital band. The body is pale brown laterally. The caudal musculature is brown, and has a wide, irregular, darker brown longitudinal band for about half of its length. This band is flanked above and below by pale yellow bands. The dorsal band extends posteriorly for about 80% of the total tail length,

whereas the ventral one extends for only about 20% of the tail length. The colouration of preserved specimens is similar to that of living individuals. In lateral view the body colouration is light brown with small brownish and reticulate spots. The yellow tail bands disappear in preserved specimens. The area of the throat is semi-transparent and the intestinal coils are visible through the skin. The tail fins are transparent with small, brown, patches of melanin. These melanin patches are more abundant on the ventral fin, and they tend to accumulate on the first quarter in the dorsal fin.

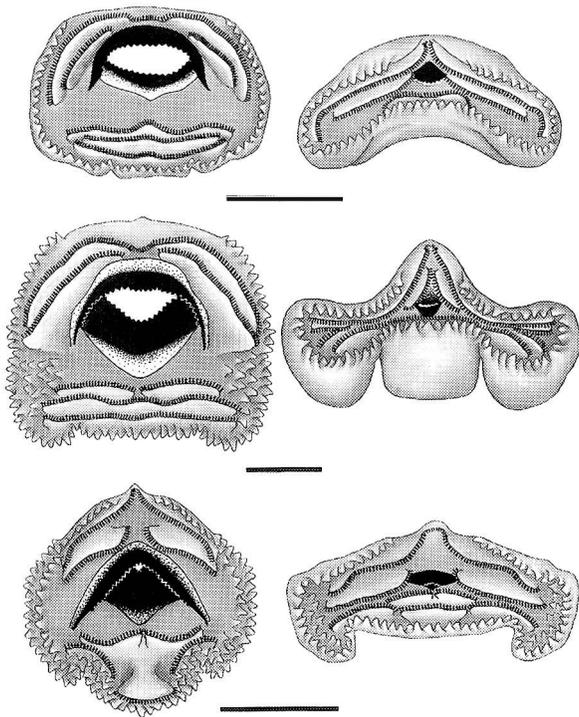
Biology. The breeding season of *Scinax berthae* extends from late September through December; eggs are unpigmented, about 0.9 mm in diameter, and deposited underwater, attached to the submerged stems of aquatic vegetation (Barrio, 1962). The tadpoles were collected in a small temporary pond on flooded lowlands within a gallery forest. This pond was approximately 5 m long and 3 m wide, with a maximum depth of 0.4 m; however, water depth varied with occasional rains and flooding from the Rio de la Plata. The pond had a muddy bottom with large accumulation of organic matter, and little sun exposure. Gallardo (1987) reported larvae to exhibit "abrupt and quick movements."

SCINAX NEBULOSA (SPIX, 1824)

See Fig. 1 and 2 (middle). The description is based on specimens identified by M. L. Crump and W. E. Duellman and deposited in the herpetological collection of the Natural History Museum, The University of Kansas. Duellman & Wiens (1992, p. 20) subsequently treated tadpoles from this lot as *S. nebulosa*. Illustrations and measurements are for a representative Stage-37 tadpole from lot KU 130154. These specimens were collected at IPEAN, 3 km E. Belém, Pará, Brazil, on 11 April, 1970, by M. L. Crump and W. E. Duellman. The measurements are as follows: TL = 52.3, BI = 14.8, TaL = 37.6, BW = 9.0, BWE = 8.9, BWN = 7.3, BH = 16.0, FH = 17.9, TMH = 5.0, RSD = 9.3, SPD = 4.1, FN = 1.8, NO = 1.4, N = 0.5, E = 2.0, EN = 5.3, IN = 4.5, EO = 8.6, IO = 8.5, ODW = 3.6, RG = 1.0. In tadpoles of *Scinax nebulosa* the body is higher than wide (BH/BW = 1.78). Neuromasts are clearly visible dorsally. The nostrils are dorsolateral, nearer the eyes than to the tip of the snout. Eyes are lateral. Eye diameter is 2.0 mm, and pupil diameter is 0.8 mm. The spiracle is single, sinistral, and located laterally in an approximately 45° angle with the horizontal axis of the body. The spiracle opening is located immediately below the mid-level of the body and is slightly visible dorsally. The vent is dextral. The length of the tail represents approximately 72% of the total length. The FH is approximately 12% higher than the body height. The dorsal fin largely extends onto the body. The tail fins are of about equal height, and about 1.5 x the height of the caudal musculature. From the middle of the tail caudally, the tail fins taper uniformly to a narrow tip.

The oral disc is almost terminal. The oral disc possesses well-developed ventrolateral folds. A row of

FIG. 2. Closed (right column) and opened (left column) oral discs of: *Scinax berthae* CECOAL 001 (top); *Scinax nebulosa* KU130154 (middle); and *Scinax boesemani* USNM291285 (bottom). Bars = 1 mm.



large marginal papillae borders the oral disc. Submarginal papillae form patches within the ventrolateral folds. The labial tooth row formula is: 2(2)/3 (1). In the anterior labium, tooth rows A1 and A2 are about equal in length (3.2 mm). At the middle of A1 there are about 40 teeth/mm. In the posterior labium, tooth rows P2 and P3 have an equal length of 2.9 mm, whereas P1 is slightly shorter (2.7 mm). The maximum length of the beak is 1.8 mm. The upper and lower beaks are pigmented and serrated. The upper beak is broadly W-shaped and is 80% keratinized (=pigmented), whereas the lower beak is V-shaped and 60% keratinized (=pigmented).

Colouration in life was registered in M. Crump's field notes (MLC 1766) as follows: "Dark olive green-grey above. Venter silvery-white. Tail grey; tail fin tannish-grey, some faint orange with dark pigment spots. Iris bronze with dark pigment accumulation anteriorly and posteriorly. In deep swamp pond." In preservative, these tadpoles are light brown, almost whitish. The caudal fins are transparent with brown melanin spots that accumulate more heavily on the anterior half of the dorsal and ventral fins.

Biology. No reports are available on the biology and natural history of tadpoles of this species.

SCINAX BOESEMANI (GOIN, 1966)

See Fig. 1 and 2 (bottom). The following description is based on specimens deposited in the herpetological collection of the National Museum of

Natural History, Smithsonian Institution. The tadpoles were collected at Kaieteur National Park (elevation approximately 480 m), Potaro-Siparuni State, Guyana, on March 30, 1989, by R. P. Reynolds and subsequently identified and assigned to this species by R. Altig. Illustrations and measurements are for a typical Stage-37 tadpole (USNM 291285). The measurements are as follows: TL = 34.3, BI = 11.5, TaL = 22.8, BW = 6.5, BWE = 6.5, BWN = 4.8, BH = 7.7, FH = 7.5, TMH = 3.0, RSD = 6.8, SPD = 3.5, FN = 1.3, NO = 1.1, N = 0.2, E = 1.8, EN = 3.1, IN = 2.7, EO = 5.9, IO = 5.0, ODW = 2.0, RG = 0.5. Tadpoles of *Scinax boesemani* have a high body shape (BH/BW = 1.18). The snout is rounded in dorsal and lateral views. The nostrils are dorsolateral, nearer the eyes than to the tip of the snout. Eyes are lateral. The spiracle is single, sinistral, and lateral. The spiracle opening is located immediately below the mid-level of the body. The vent is short (0.7 mm) and dextral. The tail represents about 66% of the total length. The FH is less than the body height. The dorsal fin extends onto the body. The tail fins are of equal height, and are about 25% shorter than the height of the tail musculature. The tail uniformly tapers to a slender flagelliform tip.

The oral disc is anteroventral and has ventrolateral folds. The oral disc is bordered by a row of medium-sized marginal papillae; a row of submarginal papillae is found laterally. Additional patches of submarginal papillae are found within the ventrolateral folds. The labial tooth row formula is: 2(2)/3 (1-2). On the anterior labium, tooth row A1 is 1.67 mm while A2 is slightly shorter, 1.57 mm. At the middle of A1 there are about 36 teeth/mm. In the posterior labium, tooth row P1 is 1.6 mm long and P2 is 1.7 mm. P3 is short (0.5 mm) and positioned at the end of an extended arm. The maximum length of the beak is 1.1 mm. The upper and lower beaks are V-shaped, strongly serrated, and about 70% keratinized (= pigmented).

Colouration in life is not available. Preserved specimens are very light yellow in colour, almost whitish, without spots or reticulation. Caudal fins are completely transparent. The body skin is transparent and the intestinal coils and other internal organs are visible through the skin laterally and ventrally.

Biology. There is no information available on the natural history of this species. The tadpoles collected at Kaieteur National Park were found along the sandy bottom of a stream with approximately 30-35 cm of water.

DISCUSSION

The genus *Scinax* was recently resurrected by Duellman & Wiens (1992) to include many medium to small Central and South American hyloid treefrogs previously placed in the genus *Oloolygon*. The tadpoles of less than one third of the recognized species of *Scinax* are known; these tadpoles show an exceptionally high amount of ecological and morphological diversity. Larval characteristics and reproductive biology (e.g.,

oviposition site) are important features that have been used to support the monophyly of some species groups (Duellman & Wiens, 1992).

Ecologically, *Scinax* tadpoles range from being ground bromeliad inhabitants (i.e. *S. perpusilla* species group) to stream-associated forms (i.e. *S. catharinae* species group). However, most are found among vegetation in small temporary ponds (e.g. *S. rostrata* species group). The tadpoles described to date range from some with extremely high tail fins and filamentous tail tips (i.e. pond forms) to species with elongated tails and much reduced tail fins (i.e. semi-arboreal species). This amount of larval diversity raises the question of whether differences among the tadpoles could be used to identify monophyletic units within *Scinax*.

Scinax berthae is placed currently in the *Scinax staufferi* species group. Of the 13 species recognized in this group (Duellman & Wiens, 1992), the tadpoles were previously known for only three: *S. staufferi* (Duellman, 1970*; León, 1969); *S. squalirostris* (Cei, 1980*); and *S. parkeri* (Vizotto, 1967). The description of the tadpole of *S. berthae* provides additional information. However, the features that these tadpoles share seem to be widespread within *Scinax* and not sufficient to define this group or to suggest relationships to other species groups in the genus.

Scinax nebulosa is one of nine species currently included in the *Scinax rostrata* group (*S. boulengeri*, *epacrorhina*, *garbei*, *kennedyi*, *pedromedinae*, *proboscidea*, *rostrata*, *sugillata*, and *nebulosa*, Duellman, 1972; Duellman & Wiens, 1992; Frost, 1985). The tadpoles of only four of these species are known: *S. boulengeri* (Duellman, 1970*); *S. rostrata* (Duellman, 1970*; Hero & Mijares Urrutia, 1995*); *S. garbei* (Duellman, 1978); and *S. sugillata*, (McDiarmid & Altig, 1989-1990*). The tadpole of *S. pedromedinae* has never been fully described although Duellman & Wiens, 1993, briefly mentioned this tadpole. Known tadpoles of the *S. rostrata* group (including *pedromedinae*) share the presence of an "arm" on the posterior labium that supports the P3 tooth row (McDiarmid & Altig, 1989-1990), except for the *S. rostrata* tadpoles described by Duellman (1970). However, McDiarmid & Altig (1989-1990) questioned the identity of the tadpole described by Duellman (1970). Furthermore, Duellman & Wiens (1992) included *S. rostrata* among the species having fang-like teeth and a labial arm supporting the lowermost tooth row. Recently, Hero & Mijares-Urrutia (1995) redescribed the tadpole of *S. rostrata* based on tadpoles collected in Venezuela and reared through metamorphosis to confirm identification, and these tadpoles possess a labial arm supporting the P3 tooth row. This labial arm is absent in the *S. nebulosa* tadpole described here. If the presence of a labial arm is a synapomorphy for the *S. rostrata* group (and furthermore relates the genus *Scarthyia* to the *S. rostrata* group, as suggested by McDiarmid & Altig, 1989-1990), then either we need

to remove this species from the *S. rostrata* group or explain the lack of labial arm in specimens here described as *S. nebulosa*. A taxonomic rearrangement based on this single larval character is premature given the lack of information on larvae for the other four species in the group. A possible explanation could be that the sample we have described as *S. nebulosa*, considered as such by Duellman & Wiens (1992), are in fact another species of *Scinax* and not *S. nebulosa*.

The last tadpole described is that of *Scinax boesemani*, which is a member of the *S. x-signata* species group. According to Duellman & Wiens (1992) and Frost (1985), there are six species in this group, but only the tadpoles of two species have been described, *S. cruentomma* (Duellman, 1978) and *S. acuminata* (Mecolli, Dixon & Yanosky, 1994*). Once again, there are not enough tadpoles described to help define this group on larval characters. However, one characteristic is worth noting. The presence of a P3 tooth row supported by an extended arm that is similar to that described for species of the *S. rostrata* group may indicate a closer relationship of *S. boesemani* to that group than previously thought. Alternatively, additional data on tadpole biology, feeding behaviour, and diet are needed to explain this apparent convergence in oral structure. A modified P3 tooth row is not present in *S. cruentomma* or *S. acuminata*.

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