

## The eggs and tadpoles of *Bufo coniferus* Cope in Costa Rica

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**Abstract:** Eggs and tadpoles of *Bufo coniferus* are described and illustrated. Eggs, averaging 1.77 mm in diameter, were in a double row within a double gelatinous tube averaging 4.16 mm in diameter. The largest tadpole was 27.8 mm total length. From egg deposition to metamorphosis required 37 days. Eggs and tadpoles are compared with those of other species of *Bufo*.

*Bufo coniferus* is a large toad which is widely distributed on both the Caribbean and south-west Pacific sides of Costa Rica, from near sea-level to about 1300 meters elevation. The species ranges from northern Costa Rica to Ecuador.

A pair in axillary amplexus was collected the evening of May 14, 1985, in a pond 25 m west of Río Quirí, Tapantí, Cartago, Province, Costa Rica. The female was 88 mm and the male 68 mm in snout-vent length. Pond creation appeared to be the result of long ago discontinued saw mill operations, for there remained old concrete foundations. The pond was in a steep-sided ditch-like depression. Water surface was as much as 70–80 cm below the top of the deepest part of the ditch. It drained into the Río Quirí via a constantly wet, sedge-covered gentle slope. Water flowed to the pond from the hills immediately to the west. Water depth above leaf and vegetation littered bottom was 8–10 cm; however, below this layer was another (30 to 60 cm) of very soft mud. Tadpoles of *Phyllomedusa lemur* and *Rana warschewitschii* were also collected.

### MATERIAL AND METHODS

During the early morning of May 15, 1985, the pair laid strings of eggs in a tangled mass in

an aquarium containing 5 cm of water and leaves, twigs and moss. Samples were preserved May 15th at midcleavage, stage eight (Gosner, 1960). All stage numbers refer to Gosner unless otherwise indicated. The remainder of the strings was placed in two aquaria with 6 cm of water and pieces of boiled watercress. Water was changed frequently to prevent fouling. Eggs were measured to the nearest 0.01 mm with an ocular micrometer in the stereoscope. Tadpole measurements with the ocular micrometer or a vernier caliper to 0.1 mm. Vouchers are deposited at the Museo de Zoología, Universidad de Costa Rica.

**Egg Description:** Eggs were deposited in strings within a continuous gelatinous encasing which contained a double row of vitelli that were black on the upper 2/3–3/4 and gray on the lower portion. There were 12–16 vitelli per 2.00 cm and ranged 1.67–1.86 ( $\bar{x}$  = 1.77, N = 23) in diameter. The sharply defined vitelline capsule was 1.74–1.90 ( $\bar{x}$  = 1.85, N = 23) (Fig. 1). The encasing had an outer thin envelope with rather distinct surface which surrounded a second, inner envelope. No partitions between vitelli were evident. Diameter of the outer envelope was 3.62–4.52 ( $\bar{x}$  = 4.16, N = 20); the inner envelope was 3.33–4.09 ( $\bar{x}$  = 3.71, N = 20). In a few short segments of the strings vitelli were found to be in a single row of 8–10 per 2.00 cm and also in more

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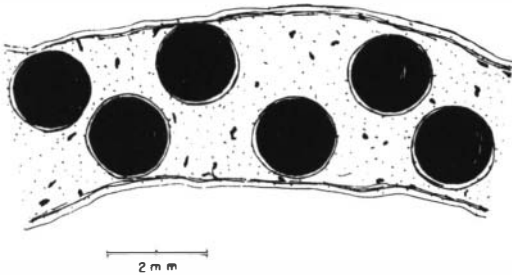


Fig. 1. Eggs of *Bufo coniferus*.

crowded triple rows of 18–24 per 2.00 cm. Within the single row, vitelli were 1.57–1.79 ( $\bar{x}$  = 1.70, N = 23) in diameter; while the vitelline capsule was 1.57–1.81 ( $\bar{x}$  = 1.74, N = 23). The outer envelope was 3.45–4.00 ( $\bar{x}$  = 3.74, N = 12) and the inner envelope 2.57–3.19 ( $\bar{x}$  = 2.96, N = 25). When in a triple row the vitelli were 1.67–1.81 ( $\bar{x}$  = 1.76, N = 23) with the vitelline capsule 1.74–1.86 ( $\bar{x}$  = 1.79, N = 23). Outer envelope 4.52–5.38 ( $\bar{x}$  = 4.93, N = 6), with the inner envelope 3.76–4.33 ( $\bar{x}$  = 3.98, N = 25). In six instances partitions between vitelli were observed in the single row arrangement, but none in the triple row. In general appearance the eggs of *B. coniferus* are similar to those of *B. boreas halophilus* and *B. valliceps* (Livezey and Wright, 1947). They differ from *B.b. halophilus* in having a smaller and thinner outer envelope; also the vitelli tend to be slightly larger, and darker on the vegetal portion. From *B. valliceps*, these are larger in all respects and the limit of the outer envelope is more distinct. Superficially *B. coniferus* eggs resemble those of *B. marinus* as illustrated by Breder (1946). However, the vitelli of *B. marinus* are proportionately smaller and there is only one gelatinous encasing, which is also smaller.

**Tadpole Description:** In life the tadpoles are black above and gray below. The tail is rather translucent and longer than the body. The largest premetamorphic individual was 27.8 at stage 41. Description based on three typical tadpoles at stage 36: Body ovoid in outline; slightly wider than deep; width 5.4–5.8 ( $\bar{x}$  = 5.6); widest at a point 1/3 distance black from tip of snout; depth 4.2–4.6 ( $\bar{x}$  = 4.47). Body length 8.1–8.6 ( $\bar{x}$  = 8.37); tail length 11.6–12.9 ( $\bar{x}$  = 12.7); body 65–72% ( $\bar{x}$  = 96%) of tail length. Total length 19.7–21.3 ( $\bar{x}$  = 20.5); the body made up 39–42%

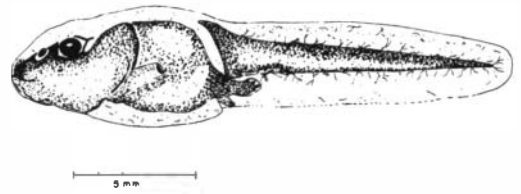


Fig. 2. Lateral view of *Bufo coniferus* tadpole, stage 36.

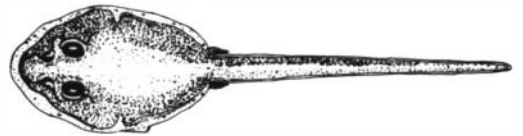


Fig. 3. Dorsal view of *Bufo coniferus* tadpole, stage 36.

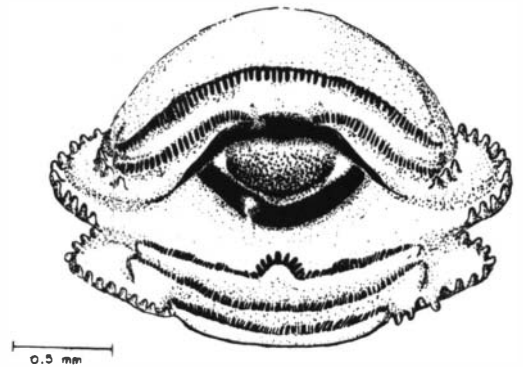


Fig. 4. Mouthparts of *Bufo coniferus* tadpole, stage 36. ( $\bar{x}$  = 40.67% ) of total length (Figs. 2,3). Snout rounded in dorsal profile; eyes not a part of the dorsal profile, directed dorsolaterally. Nostrils closer to eyes than snout, 1/3 the distance from the eyes to the tip of the snout. Sinistral spiracle closer to posterior end of body (70% of distance from tip of snout); located at midbody dorsoventrally, directed posteriodorsally at a 45° angle. Caudal fin about equal above and below the tail musculature. Dorsal fin slightly more heavily pigmented than ventral; both fins relatively clear and translucent; tail tip rounded. Tail musculature uniformly very heavily pigmented (blackish-brown in preservative) on dorsal 3/4 to almost entire depth; portion without pigment creamy-white to gray. Anal tube median. Mouth moderate, anteroventral in position (Fig. 4). Oral disc emarginate; papillae of upper labium confined to corners of mouth; 10–13 small papillae in outer row, 3–6 in inner on right side; 10–11 outer and 2–4

inner on left side. Lower labium also free of papillae except at corners; 9–15 on right, 9–13 on left. Beaks finely serrate, upper beak very slightly convex on dorsal 1/3, lateral portions sharply angled downward. Lower beak shallowly V-shaped. Denticle rows 2/3, both upper rows extending completely across mouth from under the lateral papillae, lower row slightly longer than upper and separated above beak about 1/4–1/3 length of beak. Lower denticle rows complete, all extensive across the width of oral disc, with longest at top, each of the next lower slightly shorter than the preceding. Dorsal body coloration very deep brown in preservative with black pigment blotches laterally and anteriorly. Venter gray with intestinal coil clearly visible. *B. coniferus* tadpoles can be distinguished from the geographically contingent species of *B. coccifer* and *B. valliceps* in that these two species have distinct white spots on the dorsal margin of the tail musculature (Limbaugh and Volpe, 1957; McDiarmid and Foster, 1981) while *B. coniferus* is solidly pigmented. There are also differences in the body to total length ratios; body comprises 44.54% in *B. coccifer* and 45.45% in *B. valliceps* of total length, while in *B. coniferus* the body makes up only 40.67%. *B. marinus* tadpoles are darker ventrally, with the intestinal coil less visible than in *B. coniferus*. *Bufo marinus* tadpoles, although about the same total length, have much more rotund bodies and less pigmentation in the ventral caudal fin (Breder, 1946; Savage, 1960). The most obvious difference between *B. coniferus* and *B. holdridgei* is that *B. holdridgei* has the oral disc complete (not emarginate) and has only four upper and three lower rather large papillae on either side of the oral disc (Novak and Robinson, 1975). *B. holdridgei* tadpoles are also considerably smaller, averaging only 15 mm and have a proportionately shorter tail. As with *B. holdridgei*, *B. periglenes* at 15 mm total length is considerably smaller than *B. coniferus* at an equivalent stage of development. The upper beak is weaker in *B. periglenes* and is smoothly convex (Savage, 1966), while the upper beak of *B. coniferus* is heavier and is only slightly convex on the middle 1/3.

**Notes on development:** The eggs were laid sometime between midnight and 6:00 A.M. of May 15 th. By about 8:00 A.M. on the 15th, when the samples were preserved, development had progressed to stage eight. Comparison of

development by hours cannot be made with data provided by Limbaugh and Volpe (1957) for *B. valliceps* because their material was maintained at a constant 25°C, while the *B. coniferus* specimens were kept in aquaria on an outside porch at 1200 m in Costa Rica, where the water temperature during development varied from 20.2 to 23.0°C. By 11:00 A.M. on the second day the embryos ranged from neural plate to neural tube (stages 13 to 16). At 11:00 A.M. on the fifth day hatching was completed; most young tadpoles adhering to the glass of the aquaria. At this time they were at stages 19 to 21 with fully developed gills, cornea not transparent, oral disc forming, and suckers obvious. Hatching in *B. valliceps* occurs at stage 17 (Limbaugh and Volpe, 1957), thus *B. coniferus* undergoes more prehatching development. Total length of seven individuals ranged from 5.95–6.95 ( $\bar{x}$  = 6.54). The snout-anus portion represents 52–68% ( $\bar{x}$  = 59.25%) of total length. At 11:30 A.M. on the sixth day the tadpoles were swimming actively and had attained stages 22–23. External gills were at their greatest development. Opercular folds were evident in most individuals, but some had the fold just beginning on the right side only. Myotomes of the tail musculature were distinct. Melanophores were not yet evident in the caudal fins. Seven tadpoles at this point were 6.62–7.95 ( $\bar{x}$  = 7.45) total length. The body made up 45–59% ( $\bar{x}$  = 49.43%) of the total length. Remnants of the suckers were large and the forming oral disc very apparent. On the seventh day at 3:00 P.M. the right operculum was closed on most individuals, but several still had both gills free.

At 3:30 P.M. on the eighth day the opercula were complete on all individuals examined (stage 25); there was no evidence of any limb bud formation. Melanophores were present on the dorsal surface of the tail musculature, but still absent on the dorsal and ventral caudal fins. Sucker remnants were still lightly present. Oral discs were advanced to the point of beaks and all denticle rows; there was the barest evidence of lateral papillae formation. The intestinal coil was obvious and contained food. At this time individuals had attained the typical tadpole appearance with ovoid body shape. Body was wider than deep, depth 73–81% ( $\bar{x}$  = 76%, N = 4) of width. The body comprised 43–46% ( $\bar{x}$  = 44.5%) of total length; total length 9.29–9.67 ( $\bar{x}$  = 9.45); width 2.52–2.70

( $\bar{x}$  = 2.62); depth 1.90–2.05 ( $\bar{x}$  = 1.98). The ninth day, at 3:00 P.M. tadpoles were very actively feeding. Golden flecks appeared in the iris of the eye. Limb bud length was greater than one-half the diameter (stage 28). Lateral papillae of the oral disc were clearly visible with a total of six to ten on each side. There was the barest vestige of the suckers remaining. There were still no melanophores in either the dorsal or ventral caudal fins, but a few were invading the ventral half of the tail musculature. At this stage total length was 9.95–11.57 ( $\bar{x}$  = 10.73, N = 4); body length 4.48–5.00 ( $\bar{x}$  = 4.69); tail length 5.48–6.57 ( $\bar{x}$  = 6.05); body width 2.95–3.19 ( $\bar{x}$  = 3.05); body depth 2.29–2.38 ( $\bar{x}$  = 2.32). Body length was 43–45% ( $\bar{x}$  = 43.75%) of total length; body depth was 75–77% ( $\bar{x}$  = 76.25%) of body width.

Stage 30, limb bud length twice the diameter, was reached by day 16. Upper half of the tail musculature heavily pigmented, lower mostly without pigment. Melanophores were beginning to appear in the dorsal caudal fin, mostly near base of tail and near the tail musculature. Oral disc with seven to nine upper and lower papillae, otherwise fully developed. Body depth 75–78% ( $\bar{x}$  = 76.67%, N = 3) of body width. Body depth 3.43–3.57 ( $\bar{x}$  = 3.52); body width 4.57–4.62 ( $\bar{x}$  = 4.59). Body length 42.9–44.4% ( $\bar{x}$  = 43.87%) of total length. Body length 7.0–7.4 ( $\bar{x}$  = 7.2); tail length 9.0–9.3 ( $\bar{x}$  = 9.2). Total length 16.2–16.7 ( $\bar{x}$  = 16.4). By day 25 the tadpoles had reached stages 36 to 39. The foregoing description of individuals at stage 36 covers the novel features. On day 34 tadpoles ranged from stages 39 to 44. Those at stages 43 and 44 (with all four limbs) possessed tails that were complete to one-half reabsorbed. Dorsal color pattern was developing; the dorsal ground color was brown with many light spots and flecks. The forearms had two or three light transverse bands; the upper arms one. There were two obliquely angled light transverse bands on the upper thigh surfaces and two light transverse bands on both the tibia and tarsus. The venter was still grayish. The first toadlet completed metamorphosis on the 37th day at a snout-vent length of 9.1. Color pattern of the limbs was essentially the same as at stages 43 and 44 except that the transverse bands were more prominent. A light line extended from just behind the tympanic area obliquely to the junction of the thigh, thus separating the dark

dorsal and lateral areas; venter creamy-white with many melanophores concentrated laterally. Throat was heavily pigmented containing many white guanophore spots. Dorsal warts appeared, but no indication of cranial crests; parotoid protuberances were beginning.

From hatching to first completion of metamorphosis took 33 days, and 37 days from time of egg deposition.

## RESUMEN

Se describen los huevos y renacuajos de *Bufo caniferus*, con dimensiones y observaciones sobre su desarrollo. Los huevos son de 1,77 mm de diámetro en una fila doble dentro de un tubo gelatinoso también doble, de 4,16 mm de diámetro. El renacuajo más grande fue de 27,8 mm (largo total). La metamorfosis requirió 37 días.

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