

## Description of a bufonid and two hylid tadpoles from western Ecuador

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The tadpoles of the frog species *Bufo haematiticus*, *Trachycephalus jordani*, and *Oloolygon sugillata* are described from collections from Pichincha Province, Ecuador. Marked ontogenetic changes in coloration characterize postmetamorphic *Trachycephalus jordani*. An unusual structure (here called a labial arm) supports the third posterior tooth row in *Oloolygon sugillata*; it is characteristic of the *rostrata* group of *Oloolygon* (Hylidae) and the monotypic hylid *Scarthyia ostinodactyla*.

### INTRODUCTION

During a study of the herpetofauna of Centro Científico Rio Palenque in western Ecuador, we gathered information on the life histories of amphibians at this lowland wet forest site. Among the samples are developmental series of three frog species with undescribed tadpoles: *Bufo haematiticus* Cope, 1892, *Trachycephalus jordani* (Stejneger & Test, 1891) and *Oloolygon sugillata* (Duellman, 1973).

### METHODS AND MATERIALS

All specimens were collected at the Centro Científico Rio Palenque, Provincia Pichincha, Ecuador in 1979 by Roy W. MCDIARMID (National Museum of Natural History), Eugene W. SCHUPP and Bruce C. JAYNE (University of South Florida), and Kenneth MIYATA (Museum of Comparative Zoology). The science center, a field station better known as "Rio Palenque", is located 47 km south of Santo Domingo de los Colorados on the main road from Quito to Guayaquil. This lowland tropical wet forest is virtually an island in a sea of banana and oil palm plantations. Rainfall data from Puerto Ila, about 8 km north of the Rio Palenque station, suggest that the area receives approximately 2650 mm of annual precipitation (see discussion in DODSON & GENTRY, 1978).

We collected eggs and larvae in the field, took eggs laid in plastic bags by pairs collected in amplexus in the field, and returned them to the station to be reared. Tadpoles were kept at room temperature in ambient light, in pond or rain water in small plastic containers, and fed TetraMin, a commercially available tropical fish food. Tadpoles also scraped algae growing on the sides of the containers. At periodic intervals we preserved samples in 10% buffered formalin to obtain a developmental series. Specimens are deposited in the collections of the National Museum of Natural History (USNM), Washington.

Descriptive terminology follows that of ALTIG (1970) and WASSERSUG (1980), and the staging system is that of GOSNER (1960). We define body terminus as the point at which an imaginary line connecting the apices of the tail myotomes intercepts the posterior part of the body. Eye diameter equals orbital diameter, not corneal diameter. Other measurements involving the eye, nares and spiracle are made to the centers of those structures. All measurements are in millimeters. Oral muscles were examined with polarized light.

## DESCRIPTIONS

### *Bufo haematiticus* Cope, 1862

(fig. 1A, 2A)

We collected unpigmented developing embryos in stage 20 on 8 March and reared some of these specimens through metamorphosis (USNM 285161-285172). A stage 37 specimen (USNM 285172) has the following measurements: 20.8 total length, 7.7 body length, 2.1 basal tail muscle height and width, 1.3 maximum dorsal and ventral fin heights located 6.8 from body terminus, 5.1 body width, 3.6 body height, 0.7 eye diameter, 0.3 pupil diameter, 3.2 interorbital distance,  $0.4 \times 0.2$  narial diameters, 1.9 internarial distance, 0.9 snout - naris, 2.1 snout - eye, 5.6 snout - spiracle, 1.0 naris - eye, and 2.5 transverse oral disc diameter. Other major characteristics include: oral disc anteroventral, emarginate with wide anterior and posterior gaps in the uniserial marginal papillae; labial tooth row formula 2(2)/3; eyes dorsal; spiracle sinistral; vent medial; dorsal fin terminates near the tail - body junction; neuromasts not visible.

From above, the snout is subovoid; in profile it slopes gently and is subelliptical. The relatively large ovate nares face anterolaterally; a slight rim encircles most of their perimeters and a large papilla lies medially. The spiracle is situated laterally on the body and opens posteriorly through a round aperture. The lateral wall of the non-pigmented, free tube is slightly shorter than the medial one, which is ca. 0.4 mm long. The vent tube has all walls of similar length. Fins terminate in a rounded tip and are clear except at the anterior base of the dorsal fin.

Marginal papillae on the oral disc are small, and those on the most anterior and posterior margins are weakly developed. Submarginal papillae are lacking. Labial teeth are small and weakly keratinized with a density of ca. 82/mm at the center of A-1. The sheath of the upper jaw is narrow and weakly keratinized, and the edge has a broad, medial shallow indentation. The lower jaw sheath is narrow and broadly V-shaped. Within the mouth two lingual papillae are widely spaced; the median ridge is absent.

The body is uniformly dark dorsally, although the pigment appears to reside deep in the skin layers. A central patch of diffuse pigment occurs on the throat; the belly skin is devoid of melanic pigment and the viscera are clearly visible.

A specimen in stage 20 (USNM 285161) that was collected and preserved on 8 March measures 7.1 total length. The embryo is unpigmented with a large U-shaped adhesive gland and has two, three-branched gills on each side and a large ovoid white yolk mass that measures 1.5 (22% of total length). Specimens (USNM 285162) preserved five days later are in stage 27 and measure 7.8. They are lightly pigmented except for the snout and dorsal half of the caudal musculature; yolk is obvious. Specimens (USNM 285164) preserved on 29 March (16 days later) are in stage 29 and measure 13.4; yolk is still obvious. A specimen (USNM 285166) preserved on 19 April (after another 21 days of development) is in stage 37. Metamorphs (USNM 285168-285171) preserved in May and July are in stage 46 and measure 9.7 snout-vent length (SVL). They are uniformly dark. Food was provided during development and apparently eaten by some tadpoles as evidenced by the reddish color from the TetraMin in their guts.

Early embryos of *Bufo haematiticus* were collected about midday on 8 March in a small still-water area adjacent to Lodo Creek. Male *B. haematiticus* are known to call along small forest streams in Costa Rica and Ecuador (McDIARMID, pers. observation). The tadpole of *Bufo haematiticus* is similar in most morphological features to tadpoles of most other species of *Bufo*. Development from a relatively large egg, the absence of pigment in the early embryos, and the persistence of yolk in the gut of stage 37 tadpoles are notable exceptions to the *Bufo* norm. Experiments by CRUMP (1989) showed that tadpoles of *Bufo periglenes* can develop through metamorphosis without feeding. Sibling individuals completed metamorphosis at the same time whether they were fed or not, but the fed individuals were larger. A large yolk supply that persists late in development suggests that a mode (development with facultative feeding) similar to that reported in *Bufo periglenes* also may be operating in *B. haematiticus*. We are tempted to suggest that other forest species of *Bufo* (e.g., some populations in the *typhonius* group) with large unpigmented eggs may have similar developmental modes.

### ***Trachycephalus jordani* (Stejneger & Test, 1891)**

(fig. 1B, 2B)

We have larval specimens in stages 24 - 44 (USNM 285297-285307), recent metamorphs, juveniles and adults for study. A stage 34 specimen (USNM 285304) has the following measurements: 37.9 total length, 10.2 body length, 4.2 basal tail muscle height, 3.8 basal tail muscle width, 4.3 maximum dorsal fin height located 7.8 from body terminus, 3.4 maximum ventral fin height located 7.7 from body terminus, 8.0 body width and height, 1.0 eye diameter, 0.5 pupil diameter, 7.1 interorbital distance, 0.4 narial diameter, 4.6 internarial distance, 1.1 snout - naris, 3.1 snout - eye, 8.9 snout - spiracle, 2.3 naris - eye and 3.1 transverse oral disc diameter. Other major characteristics are: oral disc anteroventral, non-emarginate with biserial array of blunt marginal papillae with a wide anterior gap; labial tooth row formula 4(1-2, 4)/6(1); eyes lateral; spiracle sinistral; vent medial; dorsal fin terminates at the level of the spiracle; neuromasts faintly visible.

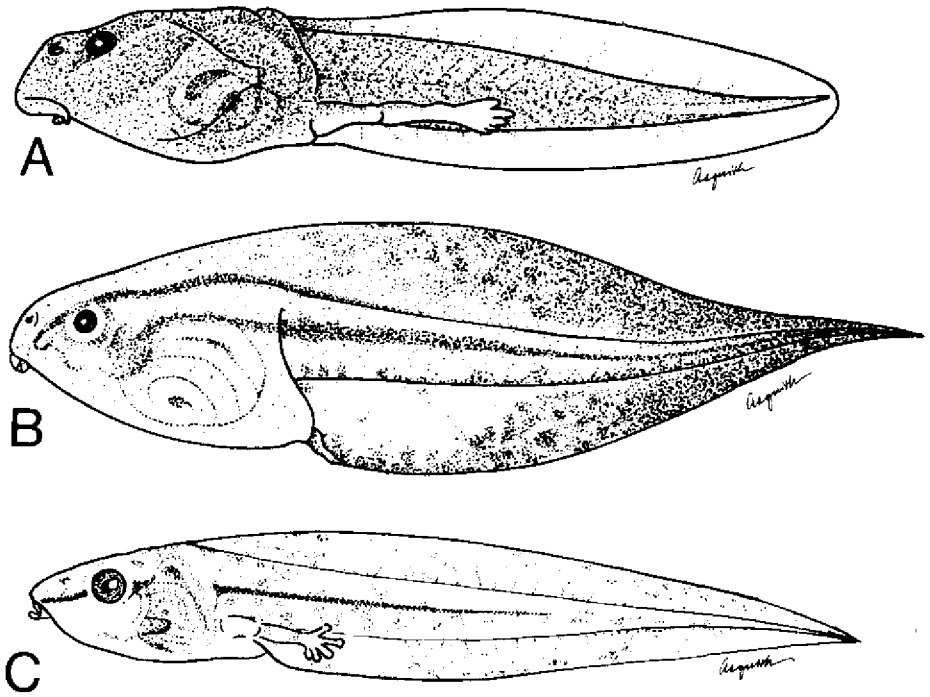


Fig. 1. – Lateral views of the tadpoles of (A) *Bufo haematiticus* (USNM 285172), (B) *Trachycephalus jordani* (USNM 285304), and (C) *Oloolygon sugillata* (USNM 285287) from the Centro Científico Rio Palenque, Pichincha Province, Ecuador.

The snout is semicircular from above and steeply slopes to a rounded tip in profile. The round nares face anterolaterally, are situated laterally on the margin of the dorsal silhouette, and lack ornamentation other than a weak, pigmented rim. The eyes are situated vertically and face laterally. The body is globular. The laterally placed spiracle has a lateral wall that terminates anterior to the origin of the very short medial wall. The clear spiracular tube extends posterodorsally. The ventral wall of the vent tube is shorter than the lateral walls and is heavily blotched with dark pigment. The high tail fins terminate in a prominent (5.5 mm) flagellum.

Marginal papillae on the oral disc (ca. 30/mm midventrally) have pigmented cores, and submarginal papillae occur in a small ventrolateral patch. The narrow, completely keratinized upper jaw sheath has a broadly arched edge with a straight median section and short serrations. The lower jaw sheath is narrow and broadly V-shaped. There are ca. 72 teeth/mm at the middle of A-3 and densities appear similar in other rows. Two simple lingual papillae stand next to each other in the mouth, and the medial ridge is hemispherical with small irregular papillae on its free margin.

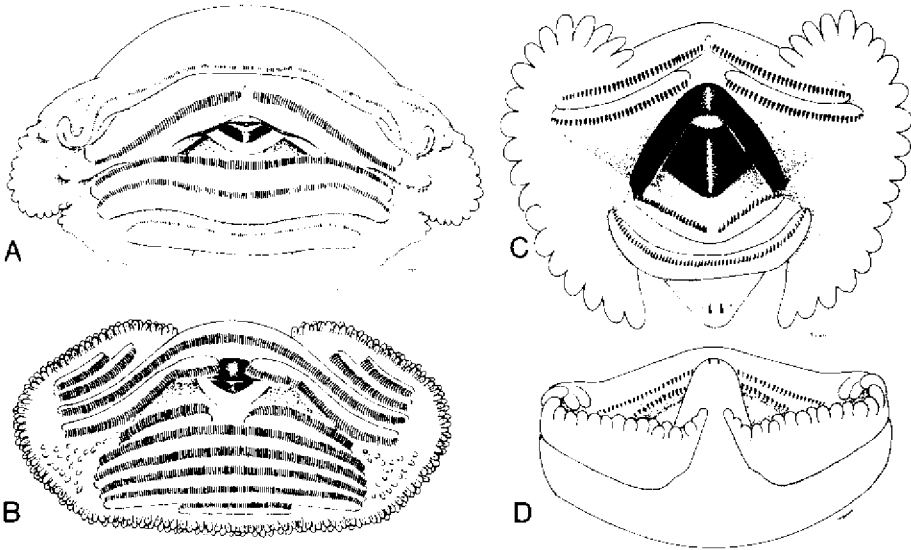


Fig. 2. — Oral discs of (A) *Bufo haematiticus* (USNM 285172), (B) *Trachycephalus jordani* (USNM 285304) and open (C) and closed (D) oral discs of *Ololygon sugillata* (USNM 285287) from the Centro Científico Río Palenque, Pichincha Province, Ecuador.

In smaller specimens, the fins are clear, and a prominent dark stripe divides the tail musculature into non-pigmented areas dorso- and ventrolaterally. During larval development prominent blotches gradually appear in both fins, become more intense, and fuse distally so that the distal third of the tail and the flagellum becomes dark brown to black in large individuals. Pigment in the ventral fin is concentrated at the basal margin. The light dorsolateral tail stripe of smaller tadpoles persists on larger specimens, while the lower light stripe is at least partially obliterated. Diffuse dark pigment on the dorsal surface of the tail musculature extends onto the body to the anterior margin of the brain. The body is lightly pigmented with uniformly arranged small melanophores. The dorsal wall of the nasal canal is darkly pigmented.

A live metamorph of *Trachycephalus jordani* at stage 44 found out of water on a grass blade was pale greenish yellow dorsally with a pair of irregularly-edged white dorsolateral stripes extending from above the eyes posteriorly to the base of the tail. The dorsal parts of the brain case and vertebrae were clearly visible through the skin. The tail was heavily flecked with irregular white spots (guanophores) that were the same color as the dorsolateral stripes.

Preserved metamorphs (USNM 285303) at stage 45 are ca. 17 SVL and have a uniformly light dorsum with a faint, light dorsolateral stripe and a wide, darker lateral stripe. By 20 and 23 SVL, small *Trachycephalus jordani* are brown laterally with light dorsolateral stripes extending from the tip of the snout to the groin; the middorsal area is slightly darker than the stripes. In frogs ca. 25 SVL the lateral margins of the dorsal color are darkened, better defining the dorsolateral stripes. Specimens at ca. 28 SVL have a lighter middorsal area and

a tan middorsal stripe bordered by narrow brown stripes. These narrow stripes delimit light dorsolateral stripes that are bounded laterally by a broad, dark brown lateral stripe. Ventrolaterally and ventrally the frogs are pale tan. This striped dorsum is obvious in metamorphs up to 33 SVL. Adult *T. jordani* greater than 60 SVL are uniform brown with no indication of stripes. External evidence of the co-ossified skin and skull that eventually results in the peculiar casque head characteristic of the species begins to appear in metamorphs at ca. 26 SVL.

The tadpoles were collected from a large temporary pond located in an oil palm and banana plantation near the entrance to the station. Eggs with a black animal pole were found in a surface film at 16.00 h on 9 February. Tadpoles (USNM 285297) reared in the laboratory from these eggs had reached stages 21 and 22 by 01.00 h on 11 February when some were preserved. At 5.6 total length they have paired adhesive glands and large filamentous gills. Tadpoles (USNM 285298) preserved 28 h later measure 7.6 – 8.8 and are at stages 24 and 25. They are darker and have obvious adhesive glands, keratinized jaw sheaths, and two anterior and two posterior rows of labial teeth. Their body and base of the caudal musculature are pigmented. A larva (USNM 285299) preserved on 28 February from the lab-reared series measures 29 total length at stage 28. Three anterior and five posterior tooth rows are present in this specimen. Most of the larvae (USNM 285300) from a field sample collected from the pond on 23 February are in stages 27 - 32. Another collection (USNM 285301) made on 26 February contains a specimen at stage 33. Specimens (USNM 285302) collected from the pond one day later (27 February) are in stages 36 - 44 and are beginning to show the juvenile color pattern. Most specimens (USNM 285303) taken at the pond on 2 March are in stages 44 and 45. Samples of tadpoles (USNM 285305-285307) from a second cohort include specimens in stage 25 (10 March) and stage 27 (3 days later).

A medial gap in the distal labial tooth row(s) on the anterior labium is a character that *Trachycephalus jordani* tadpoles share only with *Phrynohyas venulosa* (DUELLMAN, 1970) and *Osteocephalus taurinus* (DUELLMAN & LESCURE, 1973). DUELLMAN (pers. comm.) and a reviewer of this manuscript have questioned the correct identification of the specimens from French Guiana described as *O. taurinus*. We continue to refer to them as *O. taurinus* pending further study. The occurrence of a hylid tadpole with a 4/6 labial tooth row formula in a pond habitat is unusual. At this time we are unable to offer an explanation for this high labial tooth row configuration.

#### ***Ololygon sugillata* (Duellman, 1973)**

(fig. 1C, 2C, 2D)

We have specimens in stages 8 - 44 (USNM 285280-285288) available for study. A stage 37 individual (USNM 285287) has the following measurements: 35.4 total length, 9.5 body length, 4.5 basal tail muscle height, 4.4 basal tail muscle width, 2.3 maximum dorsal fin height located 13.8 from body terminus, 3.4 maximum ventral fin height located 7.7 from body terminus, 6.1 body width, 6.4 body height, 1.8 eye diameter, 0.7 pupil diameter, 7.1 interorbital distance, 0.4 narial diameter, 4.2 internarial distance, 2.0 snout - naris, 4.0 snout - eye, 7.1 snout - spiracle, 2.1 naris - eye and 2.0 transverse oral disc diameter. Other major characteristics are: oral disc almost terminal with wide dorsal and ventral gaps in the uniserial

marginal papillae; labial tooth row formula 2(1-2)/3(1); eyes lateral; spiracle sinistral; vent dextral; dorsal fin terminates at tail-body junction; neuromasts not visible in intact specimens under incident light.

The nearly circular (cross-section) body and rather elongate snout coupled with a low dorsal fin give the tadpole of *Ololygon sugillata* an overall streamlined appearance. The slight rim of the circular nares is indistinctly crenulate. Pigmentation lining the medially curved nasal canals makes them obvious through the lightly pigmented skin. The large, vertically-aligned eyes are visible from below. The lateral spiracle tube is unpigmented with an oval aperture facing posterodorsally; the lateral wall is shorter than the short medial wall by approximately one-half of the aperture diameter. The small vent aperture opens above and is separate from the margin of the ventral fin. The tail tapers uniformly to a narrow point. The rectus abdominis muscles are well developed beneath the posterior third of the gut, and the gut spiral is narrower than in most tadpoles.

The oral disc is roughly circular with similar wide gaps in both the dorsal and ventral marginal papillae and lacks submarginal papillae. Tooth density is ca. 41/mm at the center of A-1; only 2 - 6 labial teeth occur in row P-3. A notable gradation toward smaller, more closely spaced teeth appears in the lateral sections of each row. Row A-1 is broken medially by a narrow cleft that allows the two halves of the row to overlap slightly when not in use. The wide upper jaw sheath forms a V-shaped arch with ca. 30 serrations/mm; the wide lower jaw sheath forms a broad U-shaped arch. No lingual papillae occur on the transversely oval tongue anlage, and the median ridge is roughly triangular with a frayed distal edge.

A peculiar structure supports the posterior tooth row in *O. sugillata*. The central part of the lower labium is modified as an "arm" rooted within a prominent depression immediately behind the oral disc. The arm is partially free from the oral disc proper, supports P-3, extends beyond the margin of the lower labium, and divides the ventral marginal papillae medially (fig. 2C). In preserved specimens and presumably in live specimens when they are not feeding, the oral disc is folded or closed (fig. 2D) in a configuration typically attained at the end of a feeding stroke. With the disc closed, row P-3, which is positioned at the end of the labial arm, lies anterior to A-1, and row P-2 rests between A-1 and A-2.

The labial arm and its musculature extend deeply beneath the intermandibularis, which lies at the anterior margin of the depression behind the oral disc. GRADWELL (1968, 1972) and STARRETT (1973) noted the presence of the mandibulolabialis in the lower labium of tadpoles, but STARRETT (1973) incorrectly located the origin of this muscle on the infrastroral cartilage. Our observations and those of GRADWELL (1968, 1972) indicate that the origin is on the ventrolateral base of Meckel's cartilage. The muscle inserts near the tooth ridges and near the bases of the marginal papillae of the lower labium. We call this muscle the mandibulolabialis inferior. The similar m. superior serves the tooth rows on the upper labium. WEBER (1898) seems to be the only author to recognize the mandibulolabialis superior in tadpoles.

In *O. sugillata* the m. inferior extends anteriorly and divides into lateral and medial branches. Approximately 6 to 8 fibers of the lateral branch terminate within the tooth ridge of P-1 and 4 to 5 continue to P-2. Approximately 10 fibers insert near the bases of the marginal papillae lateral to the ends of the lower tooth rows. The medial branch passes anteriorly along the ventral side of Meckel's cartilage and then medially at the point where the infrastroral cartilage articulates with Meckel's cartilage to enter the root of the labial arm. This closely-

packed array of approximately 10 to 12 fibers extends nearly to the tip of the arm.

The m. superior extends anteriorly and then dorsally as a narrow band. Near the lateral tips of A-2 the band expands into a tight fan about 0.2 wide. The distal portions of all fibers (ca. 10) in this fan-shaped array bend medially slightly beyond A-2 but do not approach A-1. The more medial of these fibers arc sharply medially and extend just in front of A-2 to terminate at the medial break in this tooth row. The actions and function of the labial arm of this lentic tadpole are not known. The massive musculature of the arm suggests powerful movements that seem to be contradicted by the small number of teeth at the tip of the arm.

The dorsum, fins and tail musculature are evenly blotched with dark pigment. A dark stripe of subdermal pigment extends from the eye to the oral disc. Dense pigment covers the dorsum of the brain. A darkly pigmented vessel is aligned with the apices of the caudal myotomes. The venter is clear and the gut is obvious.

Adults of *Ololygon sugillata* were breeding in February and March in the large pond in the oil palm and banana plantation along the entrance road to the station. The other species that DUELLMAN (1973) reported from the site were breeding at the same time. A pair (USNM 285277-285278) collected at 22.00 h on 2 March laid eggs in a plastic bag. We preserved some of these eggs at 09.00 h on 5 March.

An egg at stage 8 (USNM 285280) has a vitellus diameter of 1.3 and a total diameter of 1.6. The dorsal third of the egg is darkly pigmented and one membrane is visible outside the vitelline membrane. A specimen (USNM 285281) raised from these eggs and preserved on 8 March measures 7.2 and is at stage 20. Circular adhesive glands lie ventrolateral to the stomodeum and the yolk mass measures ca. 3.3 long. Two gills on each side have three to five, long (0.4 mm) filiform fimbriae. A stage 25 specimen (USNM 285282) preserved 5 days later (13 March) measures 10.3 and has large (0.3 mm) unpigmented remnants of adhesive glands lateral to the oral disc. The P-3 "arm" with 3 labial teeth appears as a small tubercle on the posterior face of the P-2 tooth ridge. Marginal papillae are well separated from the P-3 arm. A metamorph at stage 44 (USNM 285288) measures 11.1 SVL.

Tadpoles of three (*Ololygon boulengeri*, *garbei*, and *rostrata*) of the seven species placed in the *rostrata* group by DUELLMAN (1972) have been described. *O. boulengeri* (DUELLMAN, 1970; SAVAGE & VILLA, 1986) and *O. garbei* (DUELLMAN, 1978) have the same labial arm configuration as we describe for *O. sugillata*. SAVAGE & VILLA (1986 : 95) described the situation in *O. boulengeri* as the "...short lowermost denticle row mounted on a vertically movable extension ...". However, the tadpole that DUELLMAN (1970, fig. 72) associated with *O. rostrata* lacks the prominent labial arm of other members of the *rostrata* group, and has an oral disc similar to species currently placed in the *rubra* group of the genus *Ololygon*. The nature of this structure and its apparent occurrence only in frogs of the *rostrata* group is so striking, that we suspect that the tadpole described as *O. rostrata* from Panama is not of that species. The presence of this peculiar arm in the tadpole of *Scarthyla ostinodactyla* (DUELLMAN & DE SA, 1988) suggests that this monotypic genus may be more closely related to members of the *rostrata* group of *Ololygon* than to other hyliid frogs.



## RESUMEN

Se describe los renacuajos de *Bufo haematiticus*, *Trachycephalus jordani*, y *Ololygon sugillata* a base de especímenes de la Provincia de Pichincha, Ecuador. Se encuentra en *Ololygon sugillata* el "brazo labial", una estructura rara que apoya la tercera fila posterior de dientes. Esta estructura es característica del grupo *rostrata* de *Ololygon* (Hylidae) y de la hylid monotípica *Scarthyla ostinodactyla*.

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