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MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 110

**Descriptions of Tadpoles
of Middle American Frogs**

BY
PRISCILLA STARRETT

ANN ARBOR
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN
JANUARY 30, 1960

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Lower left: Eggs of *Cochranella fleischmanni*.

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DESCRIPTIONS OF TADPOLES OF MIDDLE AMERICAN FROGS

ANURAN larval stages often provide valuable information on the relationships of the species. Orton, (1957), indeed, has proposed a classification of frogs based on the type of tadpole. At present, however, little or nothing is known of the life histories of many species of frogs, especially in the large Neotropical fauna. Because of this gap in the knowledge of anuran life histories, special effort was made to secure tadpoles of every species possible during a three-month collecting trip in the summer of 1957, in México and Central America. This paper presents descriptions of previously unknown tadpoles and additional information on certain others which were collected in Middle America in the course of the trip. In addition, the tadpoles of *Hyla zeteki* Gaige, which were originally collected and briefly described by Dunn (1937), are illustrated and described more fully. Unless otherwise noted, the specimens are in the collection of the Museum of Zoology, University of Michigan (UMMZ); catalog numbers listed for each species refer to this collection.

The identification of larval stages is often a problem. It is difficult to associate tadpoles with adults collected in the same locality, at the same time, especially in those species in which the non-breeding activities of the adults take place away from the breeding sites. Two techniques were therefore employed to assure correct identification of the tadpoles. First, eggs obtained from breeding adults were hatched and the tadpoles reared. Second, when tadpoles of unknown parentage were obtained, part of each series was kept alive and some individuals raised through metamorphosis to identifiable frogs. Other individuals from each series were preserved at various stages to associate the various tadpole and adult structures. The live tadpoles were kept in one-pint plastic containers. Holes were punched in the covers which fitted tightly and prevented spilling. The containers were enclosed in terry-cloth sacks, made for this purpose, and kept wet, thus providing cooling by evaporation during hot parts of the trip. In this way living tadpoles were successfully transported the 4800 miles from Costa Rica to Michigan by truck with very few casualties. Even forms from mountain brooks survived the trip.

Elevations were determined by means of a Taylor Auto-Altimeter which reads to 12,000 feet above sea level and is calibrated in 200-foot intervals. The altimeter was checked frequently at known elevations and found to be quite reliable.

In the discussion which follows, measurements refer to total length from snout to tip of tail unless otherwise stated. The total length of each

species before metamorphosis is given. This may be misleading for forms reared entirely in captivity because the tadpoles may be stunted by lack of food or crowded conditions. However, the measurements have value as indicators of general size and are therefore included. With the exception of the centrolenids and *Rhinophrynus*, series of tadpoles including individuals with well-developed hind legs were available for every species described. Each series was examined for ontogenetic changes in pigmentation, mouthparts, and shape of body and tail, in order that comparable stages would be used for the descriptions. With the exceptions noted, the tadpoles described are those which had hind legs, but which did not show any metamorphic changes of the mouthparts. These individuals were considered mature, with characteristic pigmentation and body form as represented in the available series. The larval stages of *Bufo valliceps* described and numbered by Limbaugh and Volpe (1957) were studied to determine whether they could be applied to the tadpoles described in this paper, but it was decided that such application would be misleading because of differences between *B. valliceps* and the other species in both absolute and relative chronology of appearance and loss of various features.

ACKNOWLEDGMENTS

I am indebted to many people and institutions for assistance in the various phases of this project. Dr. Aristides Palacios, Director General of the Instituto Tropical de Investigaciones Científicas, San Salvador, El Salvador, most generously made available to us the facilities of the Institute. He and his staff made our stay there a pleasant and profitable one. Sr. Alejandro Salazar very kindly provided us with meals and living quarters on his coffee and cattle finca, Hacienda La Cumplida, near Matagalpa, Nicaragua. In Costa Rica, members of the staff of the Instituto Interamericano de Ciencias Agrícolas at Turrialba, especially Dr. L. R. Holdridge and Sr. Gerardo Budowski, gave us valuable information on local conditions and the vegetation of the country, and made useful suggestions about possible collecting areas. Dr. Holdridge also made arrangements for us to stay at the American Cinchona Plantation on Volcán Poás. Sr. Jorge Pérez, a student at the institute, made several trips with us and introduced us to some good collecting areas. Also in Turrialba, Sr. Edilberto Camacho provided working space for us at "La Hulera," an experimental rubber station of STICA (Servicio Técnico Interamericano de Cooperación Agrícola). In addition, he made arrangements for our visit to the STICA rubber station, "Los Diamantes," near Guápiles. Mr. and Mrs. Robert Bartlett made our stay at Los Diamantes a most pleasant one. To all of these people I wish to extend my sincere appreciation.

I wish also to thank Thomas M. Uzzell, Jr., and my husband, Andrew Starrett, for their assistance in collecting the tadpoles and for their patience and cooperation in the care of the live animals during the long trip back to Michigan.

Finally, I am indebted to Jay M. Savage, Andrew Starrett, and Charles F. Walker for help during the preparation of the manuscript, for reading the manuscript and offering many valuable suggestions.

For loan of comparative material acknowledgment is made to the authorities in charge of the herpetological collections of the American Museum of Natural History (AMNH), the University of Kansas Museum of Natural History (UKMNH), the Academy of Natural Science of Philadelphia (ANSP), and the United States National Museum (USNM).

RHINOPHRYNIDAE

Rhinophrynus dorsalis Duméril and Bibron

On June 26, a large series of tadpoles (UMMZ 118685) was collected from muddy roadside puddles 2.5 miles west of Tehuantepec, Oaxaca, México. Two distinct size-classes are represented. The larger tadpoles are between 40 and 50 mm. in length and are very similar to the description of *Rhinophrynus dorsalis* tadpoles (Orton, 1943). Small hind legs are present and the feet are quite suggestive of those of adult *Rhinophrynus* in general shape and relative toe length. The small tadpoles, 20 mm. in length, are like the large ones except in the mouthpart structures. No barbels are present around the mouth. Instead, two irregularly-shaped fleshy protuberances occur on the upper jaw, one just medial to each eye (Fig. 1). Some

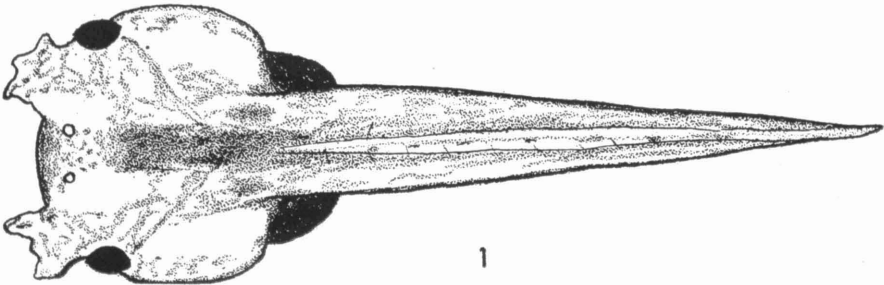


FIG. 1. Dorsal view of the tadpole of *Rhinophrynus dorsalis*.

of these small tadpoles were kept alive and observed to lose the protuberances and develop barbels as they matured. The first barbel to appear was the median ventral one, which was often noticeable while the protuber-

ances were still present. The next barbels appeared in the regions of the protuberances which eventually were resorbed, leaving only the barbels surrounding the mouth.

The small tadpoles have long, undifferentiated, coiled digestive tracts. In contrast, the large tadpoles have huge stomachs very similar to those of adult frogs. The only material present in the digestive tracts of the younger tadpoles appeared to be silt. The older tadpoles are apparently quite carnivorous for most of their stomachs contained at least one tadpole each. Most of the food items are small *Rhinophrynus* tadpoles, but there was one tadpole with horny beaks and occasional insect larvae. Larvae of *Hyla baudini* (Duméril and Bibron) and *Engystomops pustulosus* (Cope) were collected in the same puddles with those of *Rhinophrynus*.

The live tadpoles are very similar in general appearance to those of *Xenopus*. However, they swim in a horizontal position and were not observed to float obliquely in the water with tail tip vibrating rapidly as feeding *Xenopus* larvae do. The *Rhinophrynus* tadpoles seem to be positively phototactic; large swarms gathered in the light of our flashlights.

LEPTODACTYLIDAE

Engystomops pustulosus (Cope)

A series of tadpoles of this species was collected from a cement cistern on the grounds of the Instituto Tropical de Investigaciones Científicas, San Salvador, El Salvador, on July 4. All stages were present from foam nests to metamorphosed toadlets.

The mouthparts of a tadpole of this species illustrated by Breder (1946, Fig. 9) are very similar to those of the specimens in the present series. An examination of Breder's material showed that the lateral view illustrated in his paper was made from a very small tadpole which lacked most of the diagnostic characters possessed by older tadpoles. Since no description was included in his text, one is given here.

DESCRIPTION OF TADPOLE.—UMMZ 118663 (large series). Size before metamorphosis, 25 mm.; body somewhat depressed, greatest depth three-fourths of width which equals three-fifths of body length; tail length slightly less than one and one-half times body length; tail height one-third of length; dorsal tail fin does not extend onto body; musculature extends almost to rounded tip of tail. Eyes very large and dorsally situated; inter-orbital distance equals one-fourth of body width; nostrils closer to eyes than to tip of snout. Spiracle about one-half way back on body and rather low on left side. Anal tube dextral. Body brownish, belly light; tail musculature brown; brown blotches present on dorsal and ventral fins, especially

on the edges. Mouth as illustrated by Breder with $2/3$ tooth rows and an incomplete row of papillae with lateral indentations.

The tadpole of *E. pustulosus* differs from those of *Leptodactylus* (Orton, 1951; Fernández and Fernández, 1921) in having laterally indented lips and a dextral vent. Tadpoles of at least some species of *Pleurodema* (Fernández, 1927; Fernández and Fernández, 1921) have $2/3$ tooth rows with laterally indented lips, but they have a median vent. The tadpole of *Odontophrynus americanus* (Duméril and Bibron) (Fernández and Fernández, 1921) has $2/3$ tooth rows, laterally indented lips, and a dextral vent as does *Engystomops*.

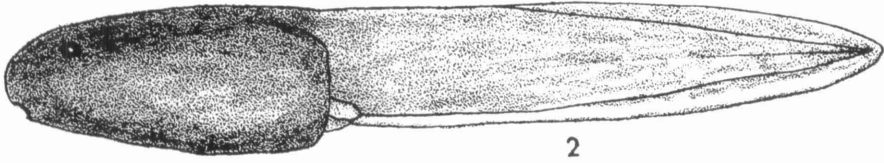
DENDROBATIDAE

Dendrobates pumilio O. Schmidt

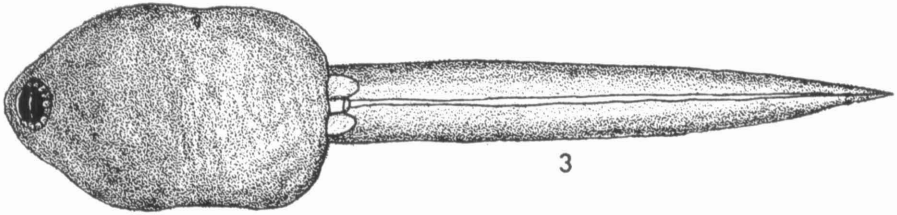
Tadpoles were obtained in two different localities. On July 14, at Hacienda La Cumplida, Department of Matagalpa, Nicaragua, four were collected from bromeliads six feet above the ground near a stream running through a coffee-banana grove at an elevation of 2400 feet. One bromeliad contained an individual nearing metamorphosis; it measured 25 mm. The forelegs were starting to erupt and the tail may possibly have undergone some resorption. Another bromeliad contained three tadpoles of two different sizes. A small specimen, 10 mm. in length, had hind leg buds barely visible. In two larger individuals, 16 and 18 mm. long, the hind leg buds were larger, but the toes were not differentiated. Adults of *D. pumilio* were quite common on the ground in the area, and frequently were found near the bases of banana plants during the day.

Two other tadpoles were collected from a large bromeliad ten feet above the ground near a stream in open woods at Los Diamantes (1000 feet), Limón Province, Costa Rica, on August 10. The larger tadpole was allowed to transform and the smaller one (18 mm.) with hind leg buds was preserved. Two adults of *D. pumilio* were taken from the same bromeliad. Several others were collected on the ground in the same area.

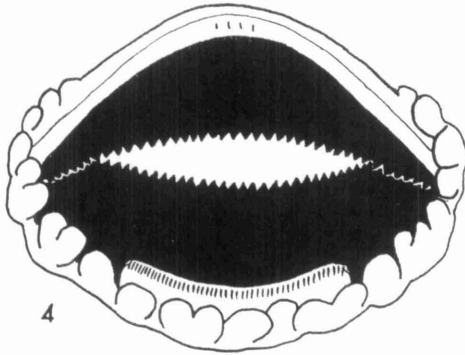
DESCRIPTION OF TADPOLE.—UMMZ 118655–56 (6 specimens), Figs. 2, 3, and 4. Body quite depressed, guitar-shaped from dorsal view, truncated posteriorly; greatest depth of body three-fourths of width which is equal to body length; tail moderately short, one and two-thirds times body length; height nearly uniform throughout, equal to one-seventh of length; tail fin very low, absent dorsally for about one-fourth of tail length; musculature extends almost to rounded tail tip. Eyes small, dorsally situated; interorbital distance slightly more than one-third body width. Spiracle on the left ventro-lateral edge of the body about one-half way back; opening very



2



3



4

FIGS. 2, 3 and 4. Lateral and ventral views, and mouthparts, of the tadpole of *Dendrobates pumilio*.

small. Anal tube median, short. Body heavily pigmented, uniformly dark; in life dark blue, in formalin brownish black; tail fin similarly colored, but lighter posteriorly; at about time of eruption of forelegs a reddish tinge became apparent on belly. Mouth ventral, nearly terminal, quite small, equals less than one-third of body width; single row of very large papillae borders mouth ventrally and at the sides; papillae begin just anterior to the lateral mouth edges and extend ventrally; huge beaks cover

entire area inside papillae; beaks armed with sharp serrations; inside of mouth also lined with black keratin forming a "floor" and "roof." Tooth rows much reduced and modified; formula 0/1 or 1/1; anterior row absent or consisting of a few scattered denticles; maximum number of denticles 7 in five tadpoles; short posterior row crowded in between lower beak and papillae.

The mouthparts of this *Dendrobates* are strikingly different from those of other described dendrobatids in the combination of the reduced number of tooth rows and the very heavy beaks. *Dendrobates auratus* (Girard) (AMNH 51767) has 2/3 tooth rows and moderately heavy beaks. Some Bolivian tadpoles in the Michigan collection (UMMZ 58947), identified as those of *D. braccatus* Cope, but more probably actually *D. pictus* Duméril and Bibron, have 2/3 tooth rows with small beaks and laterally indented lips and are very similar to some *Phyllobates* (Breder, 1946; Dunn, 1924) and *Prostherapis* (Dunn, 1944). The low sinistral spiracle present in *D. pumilio* also occurs in *D. auratus* and *D. braccatus*. A median vent is found in *D. pumilio* and *D. auratus* whereas the vent in *D. braccatus*, *Phyllobates*, and *Prostherapis* is dextral.

CENTROLENIDAE

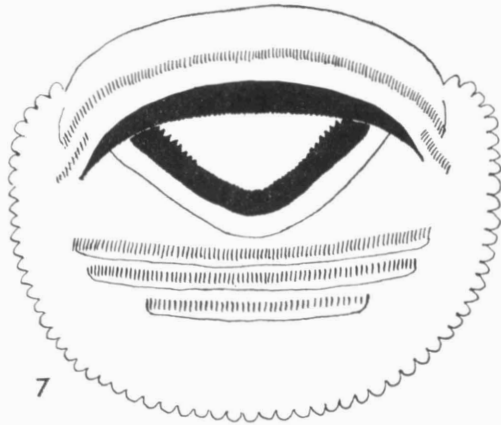
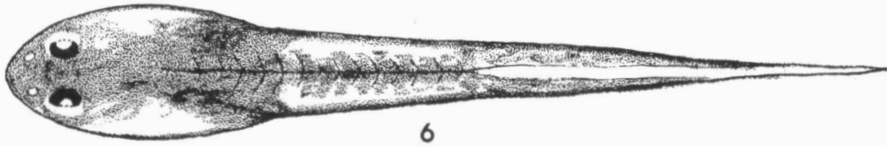
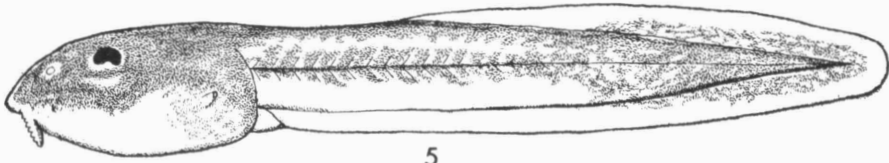
Tadpoles were hatched from eggs of five species of centrolenids. They were kept alive for periods up to five months, but they proved difficult to rear and none reached a size greater than 20 mm. With the exception of those of *Teratohyla*, the tadpoles were similar in appearance. *Centrolene prosoblepon* is described below in detail. The descriptions of the other species are briefer, emphasizing distinguishing characteristics such as the ratio of body to tail length, color, and mouthparts. The inclusion of many measurements and proportions might be misleading because of the small size of the individuals. In general, the following features characterize the group: body elongate, slender; tail width slightly less than that of body; tail very long with narrow fins; coloration pale, pink in life (owing to large blood sinuses); eyes appear crescent-shaped in dorsal view; spiracle sinistral, posterior; anal tube long, median; tooth rows 2/3, inner anterior row very short; intestine short, coiled. At hatching, all species are without suckers or the external gills, which had been clearly visible within the egg capsule. The tadpoles of *Centrolene prosoblepon* and *Cochranella granulosa* developed from partially or entirely black eggs. The larvae in the egg capsules and at hatching were black and gradually became paler. Those of *Cochranella reticulata* and *C. fleischmanni* developed from uniformly green eggs, and the embryos and newly-hatched larvae were quite

pale and transparent. These gradually acquired gray coloration. The larvae of *Teratohyla spinosa* also developed from green eggs, but the embryos acquired more dark pigment than those of *Cochranella reticulata* and *C. fleischmanni*, and consequently were darker at hatching. The older tadpoles of all of these species were similarly colored, as a result of convergence from the rather distinctive colorations shown by the embryos.

Centrolene prosoblepon (Boettger)

Eggs and calling adults were collected on July 25 at about 4500 feet on the south slope of Volcán Turrialba, Cartago Province, Costa Rica. The eggs were fastened between two leaves of ginger lily (*Hedychium*) about six feet above a fast-moving stream. The egg mass, roughly 50 mm. in diameter, was spread in a single layer over the upper surface of the lower leaf and was only partially covered by the upper leaf. The eggs were large and the jelly rather loose. The total size of each egg with capsule was 9–11 mm. Black embryos were developing within them and they were still black at hatching, at which time they measured 12.3 mm. An amplexing pair of *C. prosoblepon* was collected and allowed to lay. The eggs, which did not develop, were like those in the collected clutch. Each was uniformly black with no white vegetal pole. The diameter of the vitelline membrane was 2 to 3 mm.; of the capsule, 11 mm.

DESCRIPTION OF TADPOLE.—UMMZ 118661 (17 specimens), Figures 5, 6, and 7. Body elongate and slender; greatest depth nine-tenths of width which is about one-half body length; tail two and one-fifth times as long as body; tail height one-fifth length; fins low; musculature does not extend to rounded tip. Eyes small, dorsally situated; interorbital width less than one-half body width; eyes when viewed from above with characteristic crescent shape, apparently owing to lack of pigment in the ventral portion of the eyeball; nostrils about midway between eyes and snout. Spiracle sinistral, situated posteriorly, almost nine-tenths of distance from snout to vent. Anal tube long, median. Color, pale; dorsal part of body light brown in formalin, ventral part transparent; pattern occurs on musculature as dorsal and lateral streaks anteriorly, solid pigmentation more posteriorly; fins pigmented posteriorly. Mouth ventral, nearly terminal, three-fifths as wide as body; lips wide, with papillate edges, interrupted anteriorly by outer anterior tooth row which forms margin of mouth. Tooth rows 2/3; inner anterior row very short, consisting of small rows of denticles lateral to beak; posterior rows complete, decreasing in length posteriorly; beaks well developed and wide in lateral extent; lower beak prominently serrated posteriorly and slightly serrated in front.

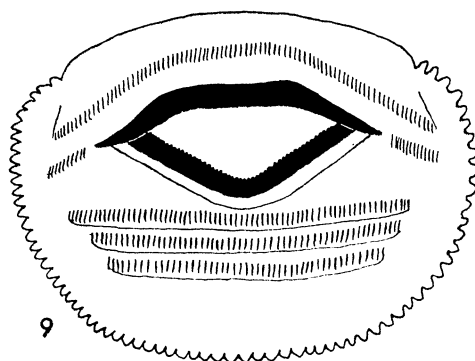
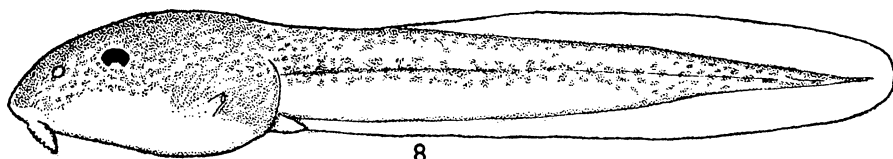


FIGS. 5, 6 and 7. Lateral and dorsal views, and mouthparts, of the tadpole of *Centrolene prosoblepon*.

Cochranella fleischmanni (Boettger)

Several sets of eggs of this species were observed. Adults and eggs were collected at San José de la Montaña, Heredia Province, Costa Rica, at 5000 feet on the southwest slope of Volcán Barba, July 27 and 28. Four egg masses were seen on the undersurfaces of leaves growing from a fallen tree 6–10 feet above a torrential mountain brook (Pl. I). The clutches

contained 15, 18, 18, and 22 eggs in various stages of development. A calling adult male was taken from the upper surface of one of these egg-bearing leaves. Amplexing *C. fleischmanni* in captivity laid eggs very similar to these. Individuals of this species from Hacienda La Cumplida, Nicaragua, were also observed to lay similar eggs.



FIGS. 8 and 9. Lateral view and mouthparts of the tadpole of *Cochranella fleischmanni*.

The recently laid eggs were light green and the developing embryos yellow on green yolk. The jelly was more compact than in *Centrolene prosoblepon*. The egg with capsule measured 6 mm. in diameter and the diameter of the whole mass was 25 mm. The eggs were placed very close together. One of the clutches from San José de la Montaña was brought back and allowed to hatch. The larvae were very pale gray at hatching.

Breder (1946) illustrated a tadpole, supposedly that of *Cochranella fleischmanni*, from Panamá. An examination of his specimens (AMNH 51773) revealed that none of his illustrations represent any of the species described in the present paper, and indeed it is doubtful that they are

centrolenids. Some centrolenids were present in Breder's collection, but these were very young larvae still within the eggs and not the specimens illustrated.

DESCRIPTION OF TADPOLE.—UMMZ 118658 (16 specimens), Figures 8 and 9. Body elongate and slender; tail two and three-fifths times as long as body; tail height one-fifth of length. Spiracle four-fifths of way back on body. Color paler than in *Centrolene prosoblepon*; scattered dots of pigment laterally and dorsally on tail musculature; fins not pigmented. Mouth similar to that of *Centrolene*; upper beak less arched; third posterior tooth row nearly as long as second; lower beak with small uniform serrations throughout.

Cochranella reticulata Taylor

A calling adult male and eggs of this species were collected, on July 29, 6.2 miles from the bridge over the Río Reventazón, along the road from Turrialba to Peralta, Cartago Province, Costa Rica. The elevation was about 3000 feet. The approximately 40 green eggs were fastened to the under surface of a leaf about 18 feet above a fast-moving rocky stream. They were small and formed an extremely compact single-layered mass. The diameter of the whole jelly mass was 20 mm., and the individual eggs with capsules measured 3–4 mm. each. The adult frog was taken from the upper surface of the same leaf. Upon hatching these larvae were very pale, measured 12.1 mm., and had very long tails.

Of the two species of centrolenids breeding at this locality, the eggs of one, *Cochranella granulosa*, have been definitely identified (see below). The eggs described here are considered to belong to the second species, *C. reticulata*. The presence of the calling male on the same leaf is additional evidence, as calling males of *C. fleischmanni* have also been found close to eggs which later proved to belong to their own species.

DESCRIPTION OF TADPOLE.—UMMZ 118657 (12 specimens), Figure 10. Similar to tadpole of *C. fleischmanni*, but tail longer at hatching and color paler; tail of old tadpole two and three-fifths times as long as body; dorsal part of body with brown blotches; tail musculature with brown blotches dorsally and laterally; pigment in depressions between myotomes posteriorly; tail fins clear. Mouth ventral, nearly terminal; papillate disc surrounding all but anterior portion. Tooth rows 2/3; outer anterior row complete, inner anterior rows very short, occurring only lateral to beaks; outermost posterior row not well developed at this stage (probably, in larger tadpoles, nearly as long as inner two); anterior beak more heavily pigmented than posterior, doubly arched and weakly pigmented medially, often appearing broken; posterior beak armed with small equal serrations.

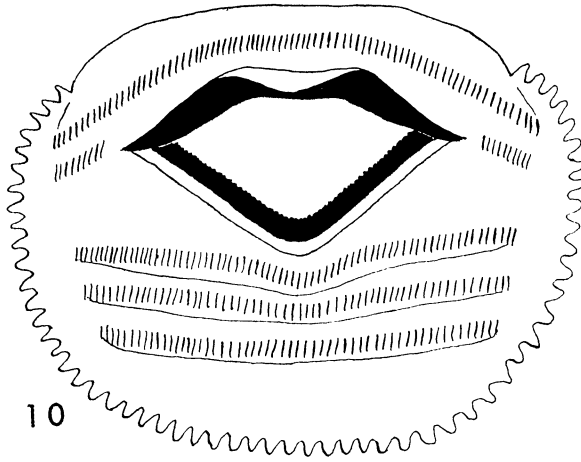


FIG. 10. Mouthparts of the tadpole of *Cochranella reticulata*.

Cochranella granulosa (Taylor)

Calling adults and eggs were collected August 3 at the same locality as were the *C. reticulata* above. The eggs were suspended from the tip of the upper surface of a leaf growing about 15 feet above the same stream described above. These eggs were small, the diameter of each with capsule was about 3 mm., without capsule 1.5 mm. The total mass measured 20 by 35 mm., and the approximately 50 eggs were arranged in a loose unlayered bunch. Each egg was black with the vegetal half white. Five adults, including an amplexing pair and calling males, were taken from the same tree. The female laid eggs exactly like the ones described. Neither of these clutches developed. The area was revisited August 12 and two more sets of eggs, fastened to the leaves in the manner described above, were taken from the same tree. One clutch contained approximately 60 eggs with overall diameters of 3 mm., and the other consisted of about 55 eggs with diameters of 5–6 mm. The eggs in both sets contained developing black embryos. At hatching, the larvae were black and measured 11 mm. The larger eggs conceivably may not have been those of *C. granulosa*, although their proximity to the other sets of eggs of this species favors this identification. Of the other three species of centrolenids collected in this same locality, the eggs of two, *Centrolene prosoblepon* and *Cochranella reticulata*, have been described above. These large eggs, then, might have been laid by the third species, *Cochranella albomaculata*, although neither this species nor *Centrolene prosoblepon* was calling at this time.

DESCRIPTION OF TADPOLE.—UMMZ 118659 (small series), Figure 11. Quite similar to tadpole of *Centrolene prosoblepon*; tail 2.3 times as long as body; spiracle seven-tenths of way back on body. Color similar to that of *C. prosoblepon*, brownish dorsally on body and tail musculature; few dots of pigment on posterior dorsal and ventral tail fins. The mouth differs from that of *Centrolene* in having the upper beak less arched, anterior tooth rows longer, and the three posterior tooth rows of nearly equal length. The serrations on the lower beak differ in becoming gradually narrower medially, although of uniform length throughout.

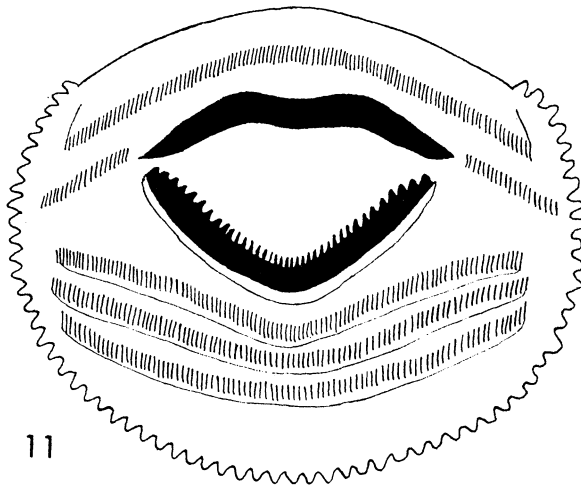
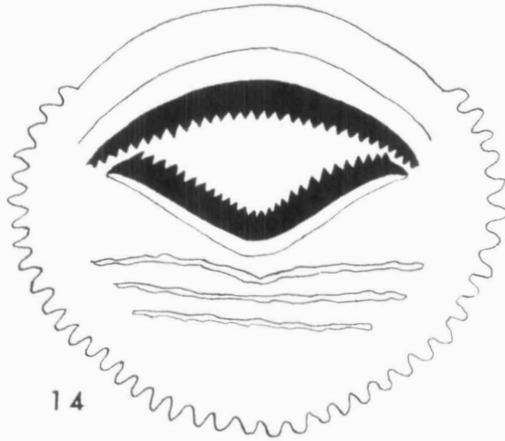
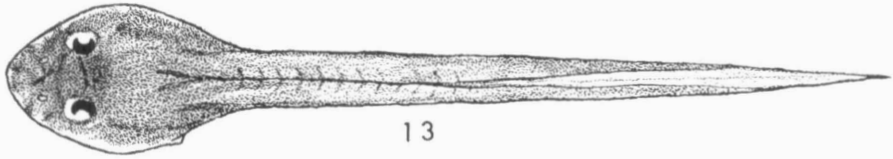
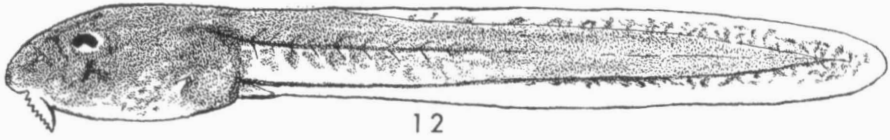


FIG. 11. Mouthparts of the tadpole of *Cochranella granulosa*.

Teratohyla spinosa (Taylor)

Calling *Teratohyla* and eggs were collected August 9 at Los Diamantes, Costa Rica. Two clutches of eggs were taken from the under surfaces of leaves two to three feet above a tiny stream which flowed into a fast-moving river nearby. At the time the eggs were collected, yellow embryos were coiled about green yolk. Judging by analogy with conditions in *Cochranella reticulata* and *C. fleischmanni*, it seems probable that the eggs of *Teratohyla* are entirely green when laid. One mass contained 18 and the other 25 eggs with diameters of 5–7 mm. The diameter of the smaller mass was 25 mm. The eggs in each mass were in a single layer with loose jelly which did not form discrete egg capsules as in *Cochranella fleischmanni* and *C. reticulata*. The embryos became darker during development and at hatching were dark gray.



FIGS. 12, 13 and 14. Lateral and dorsal views, and mouthparts of the tadpole of *Teratohyla spinosa*.

DESCRIPTION OF TADPOLE.—UMMZ 118662 (16 specimens), Figures 12, 13, and 14. Body more oval-shaped from dorsal view than those of other centrolenids; greatest depth of body three-fifths greatest width which equals three-fifths of length; tail length two and two-fifths times that of body. Eyes dorsal, crescent-shaped; spiracle four-fifths of way back on body. Anal tube median. Color on dorsal body brown; venter light with median dark

line; dorsal part of tail musculature brown, anterior ventral part light; fins with few scattered spots. Mouth ventral, nearly terminal; lips wide, with papillate edges, interrupted anteriorly; no tooth rows on any specimens; irregular ridges present in positions at which tooth-bearing ridges would ordinarily be; beaks armed with long pointed serrations which are smaller in anterior portion of lower beak.

All the other centrolenids of the same or smaller sizes had tooth rows well developed. It is, therefore, possible that the tadpoles of this species do not develop denticles.

HYLIDAE

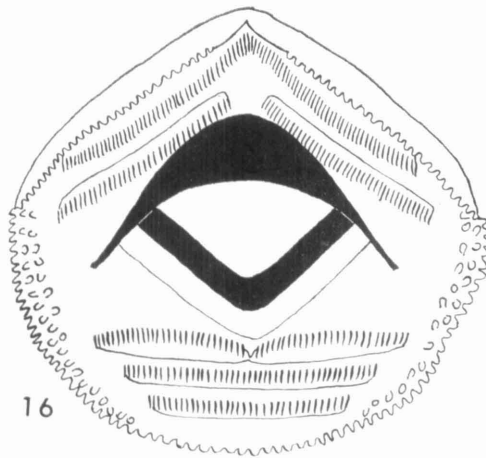
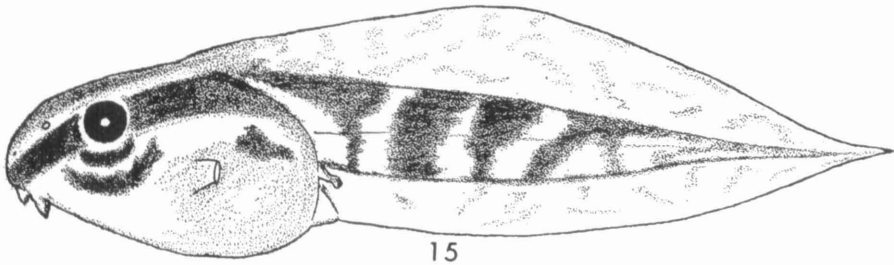
Hyla elaeochroa Cope

Breeding individuals of *Hyla elaeochroa* were collected on the night of August 8 at the Instituto Interamericano de Ciencias Agrícolas experimental cacao station at La Lola, Limón Province, Costa Rica. They were calling very late at night after a downpour, two to four feet above the water of a slightly rain-swollen stream. A pair was placed in a plastic sack at the time of capture and between 7:00 and 7:15 A.M. numerous tiny black and white eggs were laid. These hatched less than 24 hours later. Some of the tadpoles were reared through metamorphosis.

DESCRIPTION OF TADPOLE.—UMMZ 118679 (11 specimens), Figures 15 and 16. Maximum total length before metamorphosis, 31 mm.; body robust and somewhat compressed; greatest depth about three-fifths of length from snout to vent and equal to greatest width; tail length twice that of body; greatest depth about one-third of length; musculature extends to slender, pointed tip; dorsal tail fin high, extends onto body. Eyes moderately large, directed laterally; minimum interorbital width two-thirds of body width; nostrils nearer to eyes than to end of snout. Spiracle sinistral and located seven-tenths of distance from snout to vent. Anal tube short, dextral. Color dark, forms pattern; a wide black line extends from snout through eye to beginning of tail musculature; blotches of black pigment on back and below eye; belly light; pigment on tail musculature tends to form vertical bars; melanophores present on both dorsal and ventral tail fins. Mouth ventral, three-fifths of body width and triangular-shaped; lips wide, bordered by fringes of papillae with a narrow anterior interruption; lateral patches of papillae present. Tooth rows 2/3; anterior rows of same extent laterally, inner row interrupted medially; posterior rows decreasing gradually in length from inner to outer, inner row indented medially; beaks well developed, without serrations; pigmented.

A comparison of the tadpoles of this species with those of another

member of the *Hyla rubra* group, *Hyla strigilata* Spix (USNM 96526), from Brazil, showed certain similarities. The mouth-parts of the two are almost identical in the shape of the mouth, distribution of papillae, and number and configuration of tooth rows. However, the upper beaks of the two species are shaped differently and both upper and lower beaks of



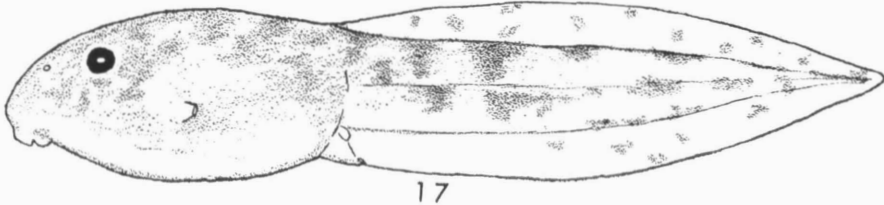
FIGS. 15 and 16. Lateral view and mouthparts of the tadpole of *Hyla elaeochroa*.

H. strigilata are serrated in contrast to the smooth margins of *H. elaeochroa*. The tadpoles are similar in body shape and in the position of vent and spiracle, but the eyes are smaller and the tail fins somewhat lower in *H. strigilata*. The tadpoles of the latter species do not have the striking color pattern of *H. elaeochroa*. Although this might possibly result from

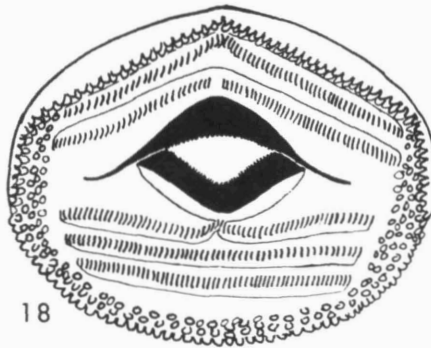
fading in preservative, the pattern of melanophores still evident on the tadpoles of *H. strigilata* suggests fairly uniform coloration in life.

Hyla moraviensis Taylor

A series of tadpoles was collected on July 25 from a small trickle which drained into a larger stream at 3000 feet on the south slope of Volcán Turrialba, Cartago Province, Costa Rica. Some individuals of the series were allowed to transform and the young frogs proved to be the distinctive *Hyla moraviensis*. No adults were taken with the tadpoles, but calling males of the same species were collected along the road from Turrialba to Peralta, 2.7 miles from the bridge over the Río Reventazón, on July 22, 24, and 29, and 4.6 miles west of Juan Viñas on August 4.



17



18

FIGS. 17 and 18. Lateral view and mouthparts of the tadpole of *Hyla moraviensis*.

DESCRIPTION OF TADPOLE.—UMMZ 118680 (5 specimens), Figures 17 and 18. Maximum total length before metamorphosis, 41 mm.; body somewhat depressed, greatest depth slightly less than width, which is about two-thirds of snout-vent length; tail length two and one-fourth times body length; greatest depth slightly more than one-fourth of length; musculature

not quite reaching rounded tip; dorsal fin rather low, does not extend onto body. Eyes situated dorsally, directed laterally; minimum interorbital width less than one-half body width. Spiracle sinistral, forming a long tube with the opening situated about three-fourths of the way back on body. Anal tube short, dextral. Dorsal color of body consisting of brown blotches; belly light; entire tail contrastingly marked with brown blotches on light background. Mouth ventral, slightly less than one-half of body width, entirely surrounded by wide lips bordered with multiple rows of papillae; triangular-shaped when lips are folded. Tooth rows $2/3$; anterior rows about same length, inner one with short median interruption; posterior rows complete, about equal in length; denticles quite long; beaks well developed and serrated.

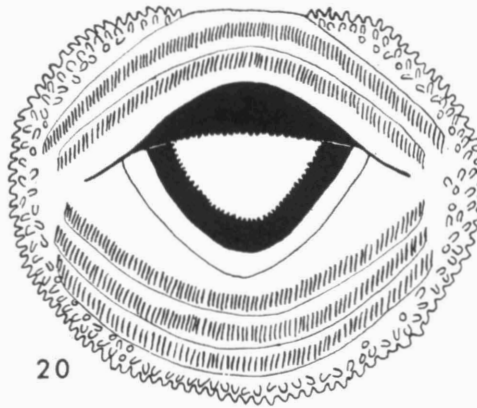
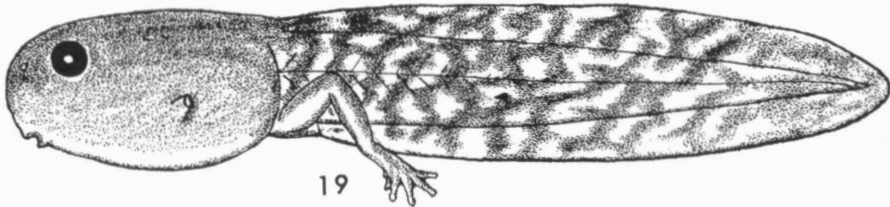
Hyla pseudopuma Günther

A series of tadpoles of *Hyla pseudopuma* was collected on July 28 in Heredia Province, Costa Rica, in a roadside rain puddle at about 6800 feet on the southwest slope of Volcán Barba. These tadpoles were nearing metamorphosis, and many which had forelegs already emerged were raised to froglets.

A second series of tadpoles was obtained from eggs laid by *H. pseudopuma* collected on August 6 in Alajuela Province, Costa Rica, at approximately 6400 feet on the southeast slope of Volcán Poás, 15.9 miles northwest of the town of Barba. Large numbers of these frogs were calling from muddy rain puddles along the side of the road, and many others were seen crossing the road in the rain. Both these localities are on the road leading from the town of Barba up onto Volcán Poás.

DESCRIPTION OF TADPOLE.—UMMZ 118682-83 (20 specimens), Figures 19 and 20. Maximum size before metamorphosis, 35 mm.; body oval, slightly depressed, greatest width slightly more than one-half body length; tail about twice as long as body; height slightly more than one-fourth length, rather uniform throughout length; musculature does not reach rounded tip; dorsal tail fin moderately high, extending onto body in young individuals, but not in older ones. Eyes dorsal; interorbital distance about two-fifths of body width; nostrils slightly closer to eyes than to snout. Spiracle sinistral, forming long tube with opening about seven-tenths of way back on body. Anal tube dextral. Color in formalin brown; body rather uniformly pigmented, belly light; darker brown reticulations present on both fins and musculature of tail. Mouth small, nearly terminal, less than one-third of body width; multiple rows of closely spaced papillae surround most of mouth except for anterior interruption; pigment present

among papillae. Tooth rows $2/3$; inner anterior row with short median break; posterior rows complete, about equal in size; beaks pigmented and serrated.



FIGS. 19 and 20. Lateral view and mouthparts of the tadpole of *Hyla pseudopuma*.

Hyla rivularis Taylor

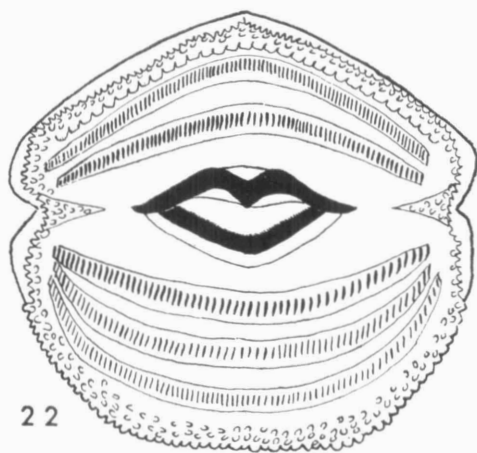
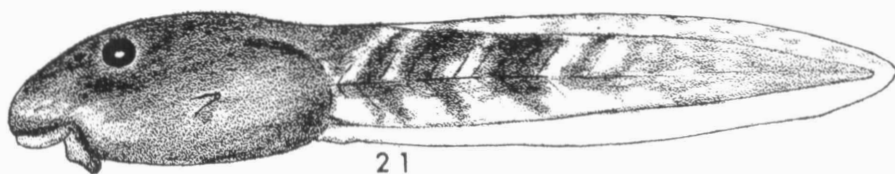
A series of tadpoles was collected on July 31 on the south side of Cerro de la Muerte, near the Pan American Highway, 11.7 miles north of San Isidro del General, San José Province, Costa Rica. They were taken from a fast-moving stream at approximately 6800 feet. When an attempt was made to catch them, the tadpoles sought refuge by clinging to the under-surfaces of rocks. An adult of *H. rivularis* was taken in the water, and calling males were collected along the stream at night. The call closely resembled that of a cricket.

Identical tadpoles were taken on August 6 near the American Cinchona Plantation on the east slope of Volcán Poás, at 4900 feet, Alajuela Province,

Costa Rica. These were found in a cool fast-moving stream and exhibited the same behavior as those of the first group. Some were reared to the stage of four well-developed legs. The foot characters matched very well those of adults of *H. rivularis*.

Calling frogs of this species were collected on July 25 along a stream at approximately 4500 feet on Volcán Turrialba, Cartago Province, Costa Rica.

DESCRIPTION OF TADPOLE.—UMMZ 118675–76 (31 specimens), Figures 21 and 22. Size before metamorphosis, 38 mm.; body depressed, greatest depth seven-tenths of greatest width which is about one-half body length;



FIGS. 21 and 22. Lateral view and mouthparts of the tadpole of *Hyla rivularis*.

tail twice as long as body; greatest height near tip, about one-sixth of length; musculature not extending to rounded tip; dorsal tail fin low, not extending onto body. Eyes dorsal; interorbital width about one-half body width; nostrils situated just anterior to eyes, very much closer to eyes than

to snout. Spiracle forms long narrow sinistral tube with opening seven-tenths of way back on body. Anal tube dextral. Body color very dark brown; most of viscera obscured by black pigmented tissue; area around mouth white; tail musculature strikingly blotched with dark brown on white; scattered pigment granules on fins. Mouth very large, ventral, nearly width of body; entirely surrounded by wide lips bordered with 3 or 4 rows of papillae; lips infolded laterally. Tooth rows $2/3$, complete, all extending to lateral edges of mouth; all denticles set on heavy folds of skin; those of innermost posterior row long and well developed; length of denticles decreasing gradually in two outer posterior rows; beaks pigmented and faintly serrated; upper beak distinctively bow-shaped.

Hyla uranochroa Cope

Two tadpoles of this species (UMMZ 118674) were collected in a small trickle along with those of *Anotheca coronata* and *Rana warschewitschii* (see below). One was preserved and the other was kept alive until it transformed into a small red-eyed *Hyla*. The froglet lived long enough to develop the enamel-white coloration around the anus which distinguishes *H. uranochroa* from the other red-eyed species of *Hyla* occurring in Costa Rica. The preserved tadpole (45 mm.) was very much like that described for this species by Dunn (1924). A few details of mouth structure not indicated by Dunn should be mentioned here. The wide mouth is completely surrounded by a double row of tiny papillae. Larger papillae occur scattered on the disk along with brown pigment splotches. There are two well-developed anterior rows of denticles and three posterior rows which decrease gradually in length. Broken ridges bearing irregularly placed denticles occur anterior to the first two rows and similar irregular ridges with very small scattered denticles are also present in the position of a fourth posterior row. The tooth formula of this species may then be considered as 2 or $3/3$ or 4. The anterior beak has a slight median notch.

A smaller tadpole (17 mm.) (UMMZ 118675), very similar to the one mentioned above, was collected in the same stream as were the *Hyla rivularis* tadpoles on Cerro de la Muerte (above).

Two other tadpoles, a 42-mm. one (UMMZ 118672) taken with the *Hyla moraviensis* tadpoles (above) and a 29-mm. individual (UMMZ 118673) collected in the stream with tadpoles of *Rana warschewitschii* (below) were also suggestive of those of *Hyla uranochroa*, but differed in having larger, more heavily pigmented lips, better developed first anterior and fourth posterior tooth rows, and posteriorly curved posterior rows.

Still another smaller tadpole (20 mm.) (UMMZ 118676) was collected

with the *Hyla rivularis* from Volcán Poás. This has characters intermediate between those of the first two and last two mentioned above. With the material at hand it is not possible to determine if these five tadpoles represent individual variation within the species or if some could represent another species. Some of them may belong to the closely related *Hyla alleei* Taylor or *H. rufioculis* Taylor.

An adult female of *H. uranochroa* was taken from a bush by the stream at the *Rana warschewitschii* locality. This frog had ovulated and large, uniformly white eggs were extruded upon handling her. No male was seen or heard at this time.

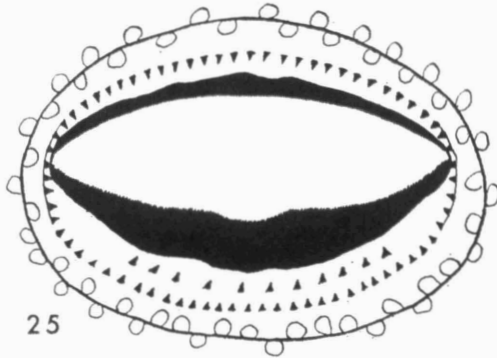
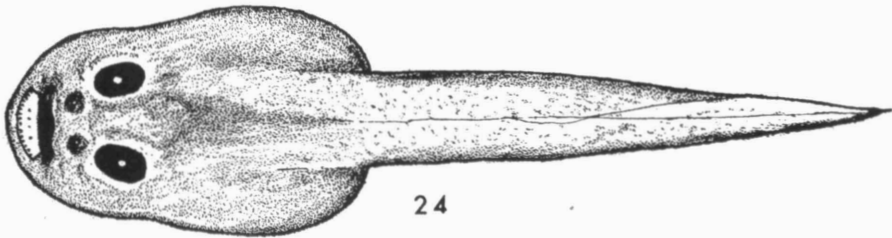
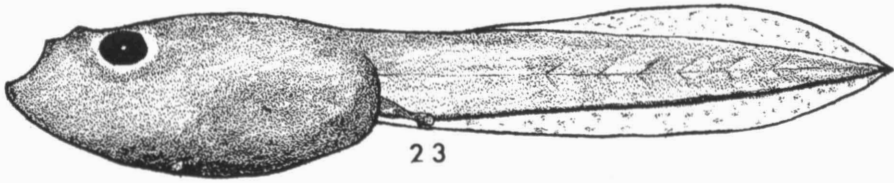
Dunn (1924) mentioned eggs, laid on a leaf above water, which he assumed to be of this species. These frogs may have peculiar breeding habits which are as yet unknown. It seems strange that the six tadpoles discussed above were mixed in with five different supposedly homogeneous collections. In every other case, a series of tadpoles of a particular species was collected at any one locality.

The tadpoles of *H. uranochroa* did not have red eyes in life. The eyes turned red upon preservation, but eventually lost the color. In the metamorphosing specimens the back began to turn green and the eyes turned red the day before emergence of the front legs. This early change in color contrasts with that in *Phyllomedusa helenae* (see below) in which the eyes did not turn red until several weeks after metamorphosis. This is evidence that the eye coloration of these two frogs probably results from convergence and does not indicate close relationship, such as was suggested by Noble (1927).

Hyla zeteki Gaige

In 1937, Dunn described a bromeliad tadpole of *Hyla zeteki*, from Costa Rica. His description is brief and no illustration is included. An examination of his specimens revealed tadpoles so striking and different from conventional types that an additional description and illustration are included in this paper.

DESCRIPTION OF TADPOLE.—ANSP 23822 (9 specimens), Figures 23, 24 and 25. Body quite depressed, guitar-shaped from dorsal view; greatest depth of body three-fifths of width which is three-fourths of length; tail short, greatest height one-fourth of length; musculature extends to pointed tip; dorsal tail fin very low, absent anteriorly. Eyes moderately large, dorsally situated; interorbital distance slightly more than one-fourth of body width. Spiracle located on left ventro-lateral edge of body about one-half way back. Anal tube long, dextral. Color in alcohol rather uniform brownish on body and tail; pigment flecks on dorsal and ventral tail fins. Mouth



FIGS. 23, 24 and 25. Lateral and dorsal views, and mouthparts (viewed anteriorly), of the tadpole of *Hyla zeteki*.

dorsal, nearly terminal, about one-third of body width, oval-shaped, without lips, surrounded by a single row of papillae; a single row of inwardly-pointing, heavy conical denticles forms a complete circle inside of papillary border; a few scattered denticles form an irregular row between lower

beak and the complete circle of denticles; beaks wide laterally, pigmented; lower beak serrated.

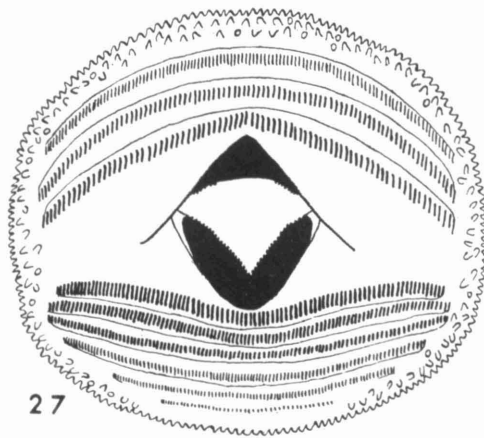
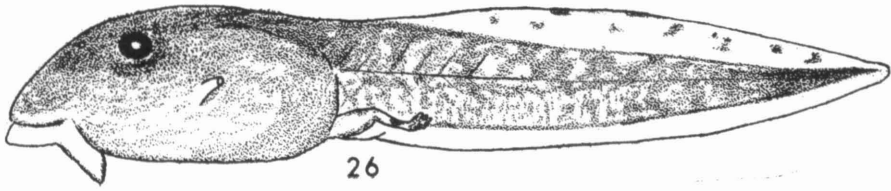
The beaks are situated inside the mouth, partially beneath its fleshy edges, and are not clearly visible from any view.

Hylella sumichrasti (Brocchi)

On June 27, adult males of this species were collected, while calling, in a rocky fast-moving stream at approximately 800 feet, 11.8 miles north of Arriaga, Chiapas, México. At this time eggs and 20-mm. tadpoles were collected from the same stream. The eggs, about 50 in number, were fastened in one layer to a piece of dead leaf wedged in among rocks in the water. They were uniform grayish white in color. Larvae with external gills hatched on June 29, and by July 3 they were heavily pigmented. They measured 10–12 mm., and their mouth discs were very large. At this time they closely resembled the 20-mm tadpoles. On August 22, the stream was revisited and larger tadpoles (40 mm.) with hind legs, were collected. A few of these were successfully reared and upon metamorphosis proved to be *Hylella sumichrasti*.

The tadpoles occurred in small pools where they were observed inching over the rocks with jerky movements, presumably in search of food. That the mouth is a powerful adhesive organ was evidenced by the behavior of the captive tadpoles which crawled out of water, up the side of the container, and out over the top edge whenever the container was left uncovered.

DESCRIPTION OF TADPOLE.—UMMZ 118670–71 (28 specimens), Figures 26 and 27. Body elongate, tapering, rather depressed; depth four-fifths of width which is one-half of length; tail twice as long as body, height about one-fourth of length; musculature not quite reaching slightly rounded tip; dorsal tail fin does not extend onto body. Eyes dorsal; interorbital distance about one-fourth of body width; nostrils much closer to eyes than to snout. Spiracle sinistral, forming tube with opening two-thirds of way back on body. Anal tube long, dextral. Color variable; in the field, tadpoles were observed to change color depending on color of background; the smaller tadpoles are rather uniformly dark brown on body and tail musculature; belly light; few spots of pigment on upper tail fin; older tadpoles considerably lighter with pigment scattered on body and tail musculature; few spots on upper tail fin, lower fin almost completely clear. Mouth ventral, large, nearly equal to width of body; lips wide, completely bordered by papillae surrounding mouth. Tooth rows $\frac{3}{6}$; anterior three about equal in length, denticles of innermost row heaviest; posterior rows complete, inner



FIGS. 26 and 27. Lateral view and mouthparts of the tadpole of *Hylella sumichrasti*.

four about equal, outer two decreasing in length, denticles gradually decreasing in length from row to row posteriorly; one specimen shows a very short posterior patch of denticles, indicating a rudimentary seventh row. The 20-mm. tadpoles have $3/6$ tooth rows whereas some of the 10–12-mm. tadpoles have only $3/4$ or $3/5$. Beaks well developed and serrated; anterior beak with angular apex; one specimen lacks pigment in the center of this ordinarily black triangle.

Phyllomedusa helenae (Cope)

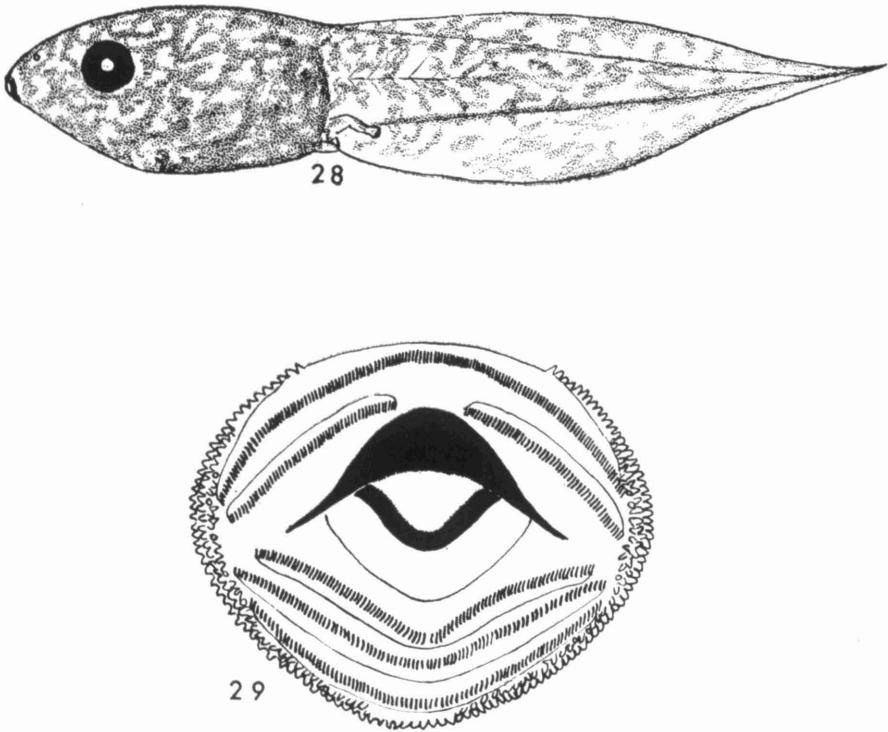
An amplexing pair of *P. helenae* was collected on July 16 at Hacienda La Cumplida, Nicaragua. Uniformly green eggs were deposited on the side of a plastic bag in which frogs were placed. The yellow developing embryos were coiled around the greenish yolk. Eggs that fell into the water in the bottom of the bag did not hatch, but those that adhered to the sides of the

bag above water continued to develop until the hatching tadpoles wriggled free and dropped into the water. An egg mass of *P. helenae*, collected on August 10 at Los Diamantes, Limón Province, Costa Rica, measured 50 mm. and contained approximately 75 eggs.

Older tadpoles were observed to suspend themselves in the water by rapid vibrations of their long tail tips, an action resembling that of tadpoles of *Xenopus*. Some of the tadpoles were reared through metamorphosis. The green adult coloration did not appear until resorption of the tail had begun. At about the time the tail disappeared the white lateral stripe was noticeable, but the vertical stripes and purple color on the lower sides did not appear for several weeks. The vertical pupil of the eye was noticed when the froglet crawled out of water, but the red color did not become apparent for two weeks. Then it took several days for the eye to become completely red as the coloration spread inward over the iris from the periphery where it first became evident. In contrast to *Hyla uranochroa* (see above), the eyes of the tadpoles of *P. helenae* did not turn red upon preservation.

DESCRIPTION OF TADPOLE.—UMMZ 118666 (2 specimens), Figures 28 and 29. Maximum size before metamorphosis, 48 mm.; body slightly compressed; width equal to greatest depth which is one-half of body length; tail slightly less than twice body length; maximum height nearly one-third of length, terminates in long filamentous tip; dorsal tail fin not extending onto body. Eyes lateral; interorbital distance two-thirds of body width; nostrils much closer to snout than to eyes. Spiracle ventral with opening just to left of the midline at a point five-eighths of the distance from snout to vent. Anal tube dextral. Entire body heavily pigmented with gray-brown reticulations; posterior belly lighter; pigment blotches present on tail musculature and fins; a younger larva (20 mm.) with no pattern, quite pale in color, with a few scattered melanophores. Mouth small, nearly terminal, less than one-half width of body; lips narrow; mouth surrounded by double row of papillae, except for wide anterior interruption. Tooth rows $2/3$; anterior rows about equal in length, inner one broken at midline; posterior rows of nearly the same length, the outermost slightly shorter; beaks well developed and serrated.

According to Lutz and Lutz (1939) *Phyllomedusa hypochondrialis* (Daudin), *P. rohdei* Mertens, and *P. fimbriata* (Miranda-Ribeiro) of Brazil have tadpoles which agree with those of *P. helenae* in having a spiracle near the midline of the venter, and mouthparts with $2/3$ tooth rows and an interrupted papillary border. Among Middle American species the same combination has been reported by Gaige (1936) in *P. callidryas* (Cope), by Stuart (1948) in *P. moreletii* (A. Duméril), and by Taylor (1942) in *P.*



FIGS. 28 and 29. Lateral view and mouthparts of the tadpole of *Phyllomedusa helenae*.

dacnicolor Cope. In the Brazilian *P. guttata* A. Lutz, the mouthparts are modified, but the position of the spiracle is the same as in other known tadpoles of *Phyllomedusa*. All four of these Brazilian species have been observed by Lutz and Lutz (*op. cit.*) to float in the water vibrating the tip of the tail in the manner described above for *P. helenae*. Ahl (1927) briefly described the tadpole of *Phyllomedusa burmeisteri*. He mentioned the pointed tail tip and $2/3$ tooth rows, but described a complete papillary border around the mouth.

The general shape and pigmentation of the tadpoles of *Phyllomedusa helenae* are very similar to those of the *P. callidryas* from Panamá, illustrated by Breder (1946). His illustration, however, shows a complete row of papillae around the mouth and what appears to be a lateral spiracle, although it is not labeled. An examination of Breder's specimens (AMNH 51769) revealed a ventral spiracle as in other species of *Phyllomedusa*. The sinistral mark on his illustration is apparently an elbow of the hidden front

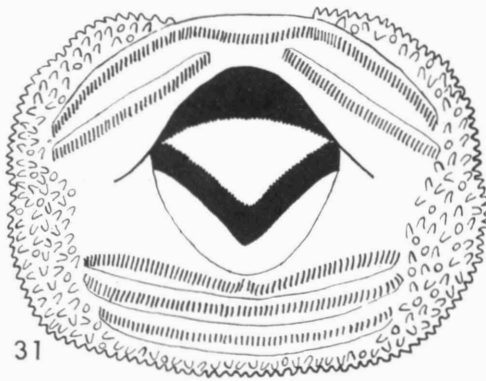
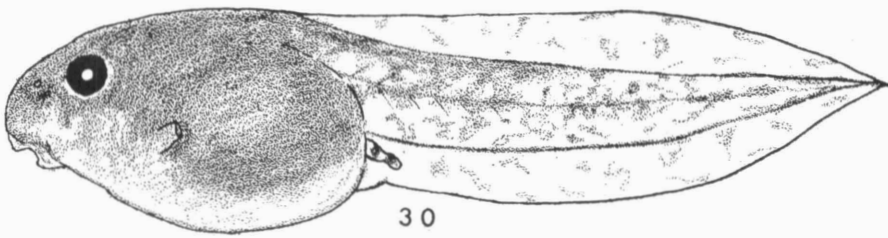
leg. The mouthparts of his tadpole were in rather poor condition, but none of the specimens appeared to have a complete row of papillae. Breder's tadpoles agree rather favorably with the specimens of *P. helenae* from Costa Rica.

Anothea coronata (Stejneger)

A series of tadpoles was collected on July 24 in a tiny tributary, 2.7 miles from the bridge over the Río Reventazón, along the road from Turrialba to Peralta, Cartago Province, Costa Rica. Some were preserved and the remainder allowed to transform. A froglet just losing its tail is extremely suggestive of *Anothea coronata*. It has a tarsal fold and a small amount of webbing on the hands and feet, which two characters in combination serve to distinguish this species from other Costa Rican hylids. It lacks the characteristic head spines of adults of *Anothea*, but these spines are known to be absent in young frogs of this species. This identification is further substantiated by black bars which are discernible on the hind legs of the large tadpoles and the froglet. These black markings were very noticeable on a larger frog of this series which, unfortunately, escaped.

Taylor (1954) described a bizarre egg-eating tadpole from Moravia, Costa Rica, as that of *A. coronata*. His specimens, none of which had hind legs, bore no resemblance to the tadpoles described below. His were taken from bromeliads, in one of which an adult *Anothea* was also found. Taylor assigned them to *Anothea coronata* because of a similarity in color of the tadpoles and adult, and because of the association of the tadpoles with an adult of this species. Dunn (1937) described the bromeliad tadpole of *Hyla zeteki* Gaige and discussed its peculiar egg-eating habits. A comparison of Taylor's specimens (UKMNH 35034) with Dunn's (ANSP 23822; see above) revealed certain similarities, but they obviously do not belong to the same species. The series of stages in Dunn's material is sufficiently complete to demonstrate the correctness of his identification beyond any reasonable doubt. The identity of Taylor's tadpoles, then, is still a question.

DESCRIPTION OF TADPOLE.—UMMZ 118664 (15 specimens), Figures 30 and 31. Maximum length before metamorphosis, 33.3 mm.; body robust, depth about as great as width which is three-fifths of length; tail one and two-thirds of body length; height one-third of length; musculature reaches to acuminate tip. Dorsal tail fin high, extending onto body. Eyes laterally directed; interorbital width about one-half of body width; nostrils midway between eyes and snout. Spiracle forms long tube, opening sinistrally about three-fifths of way back on body. Anal tube short, dextral. Color on body consisting of scattered black pigment; very little pigment on belly, viscera



FIGS. 30 and 31. Lateral view and mouthparts of the tadpole of *Anotheca coronata*.

clearly visible; tail musculature and fins with scattered gray blotches. Mouth ventral, nearly terminal; width about one-fourth that of body; lips rather wide, interrupted anteriorly, bordered with several rows of papillae; pigment spots scattered among papillae. Tooth rows 2/3; inner anterior row divided medially by arch of beak; posterior rows complete, decreasing slightly in length from inner to outer; denticles decreasing in length in posterior rows from inner row to outer; beaks well developed and serrated.

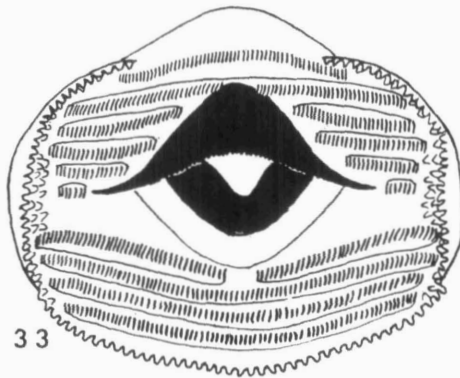
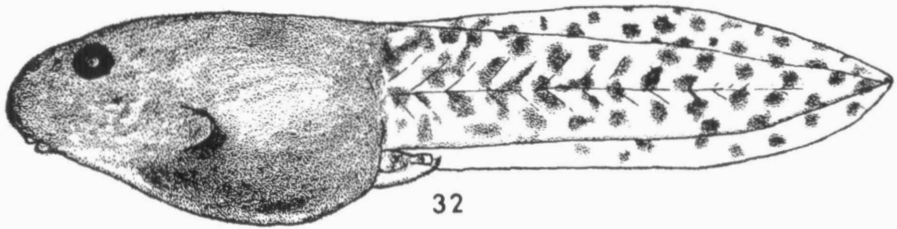
RANIDAE

Rana warschewitschii (Schmidt)

A large series of tadpoles, representing all stages through metamorphosis, was collected on July 24, 2.6 miles from the bridge over the Río Reventazón, near the road from Turrialba to Peralta, Cartago Province,

Costa Rica. They were taken from a small wooded stream and a few tributary trickles. No adults were collected at this locality.

DESCRIPTION OF TADPOLE.—UMMZ 118665 (15 specimens), Figures 32 and 33. Maximum size before metamorphosis, 115 mm.; body robust, width slightly greater than height and somewhat more than one-half of length; tail length a little more than one and one-half times the body length; height rather uniform, about one-third of length; musculature extends almost to slightly pointed tip; dorsal tail fin low, not extending onto body.



FIGS. 32 and 33. Lateral view and mouthparts of the tadpole of *Rana warschewitschii*.

Eyes dorso-lateral; minimum interorbital width about one-half of body width; nostrils nearer to eyes than to snout. Spiracle sinistral with opening approximately one-half way back on body. Anal tube dextral. Body color rather uniformly dark, slightly lighter ventrally; roundish spots of brownish pigment on tail musculature and fins. Mouth ventral, slightly less than

one-half body width; lips wide with papillate edge, surrounding mouth except for wide anterior interruption; not infolded laterally; lateral patches of papillae present. Tooth rows 6/4; outermost anterior row complete, the next with small median gap, the remaining four occurring lateral to beak and becoming gradually shorter posteriorly; posterior four rows about equal in length, inner one interrupted medially; beaks well developed, the upper serrated.

The tadpoles of *Rana warschewitschii* are very similar to those of *Rana macroglossa* Brocchi (Stuart, 1948 and 1951). Both have high numbers of tooth rows (6/4 or 5/4) and streamlined tails with similar melanophore patterns, and both are without lateral lip indentations. The high degree of similarity between the tadpoles of these two species suggests that they may be related. Volpe and Harvey (1958) compared the tadpoles of *R. macroglossa* and *R. palmipes* Spix, and believed the two species to be closely related.

Taylor (1952) has suggested that the affinities of *R. warschewitschii* may lie with Asian forms of the subgenus *Hylarana*. Tadpoles have been described for about 13 species of *Hylarana* (Flower, 1896; Kirtisinghe, 1957; Schijfsma, 1932; Van Kampen, 1923). The tooth row numbers vary from 1/2 to 8/10 and 11/5, with ten species having numbers greater than 2/3. Several of these tadpoles are mountain stream forms with very large mouth discs and increased numbers of tooth rows. However, one species, *Rana luctuosa* (Peters), is a pond-dwelling form with a mouth that suggests that of *R. warschewitschii* in that it has 6/4 tooth rows, but it differs in having indented lips and in the shape and coloration of the tail. In view of the variety of tadpoles in this subgenus, it would be difficult to substantiate a relationship to *warschewitschii* by this one similarity in the tooth rows of tadpoles.

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PLATE I

UPPER: Habitat of *Cochranella fleischmanni* and *Centrolene prosoblepon* at San José de la Montaña, Costa Rica. Four sets of eggs of *C. fleischmanni* were attached to the undersides of leaves on plants growing from the fallen tree across the stream.

LOWER LEFT: Plant with leaf turned back to show eggs of *Cochranella fleischmanni*.

LOWER RIGHT: Egg masses of *Cochranella fleischmanni* (above) and *Cochranella reticulata* (below), showing developing embryos.

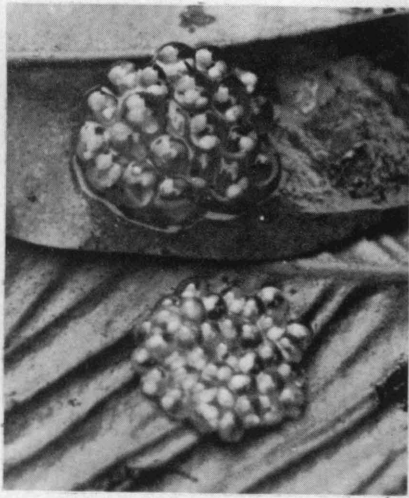
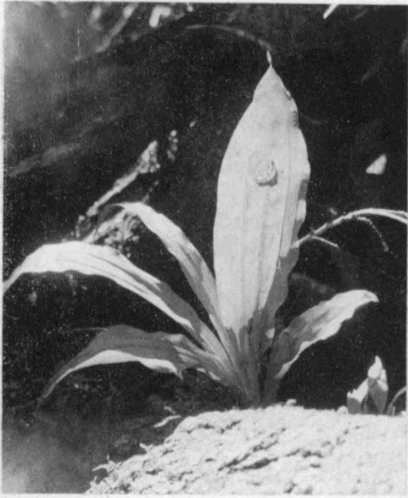


PLATE I

