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Larval Development of the Tree Frogs *Hyla arenicolor* and *Hyla wrightorum*

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As a by-product of a study of embryonic adaptation to temperature in anurans of the southwestern United States,¹ I have accumulated series of tadpoles of several species native to Arizona, New Mexico, and northwestern Mexico. Some of these species are poorly known or even unknown in the larval stage, and for none is there a description of the early larva. The present paper is the first of a projected series; others treating the genera *Scaphiopus* and *Bufo* will be prepared as opportunity permits.

In an account providing a detailed description of the early development of *Bufo valliceps*, Limbaugh and Volpe (1957, p. 1) state that "published descriptions of anuran tadpoles have been based principally on samples collected in the field. Larvae rarely have been reared through metamorphosis or obtained experimentally from known parents to insure positive identification." These authors also note the reluctance of most workers to treat any but "mature" tadpoles, thereby overlooking a significant part of the life history. The utility of larval stages in taxonomic work will be increased if characters can be traced through development and compared in related species, though as yet few authors have described other than "mature" tadpoles. Among papers treating *Hyla*, those of Orton (1947), Gosner and Black (1957), and Gosner and Rossman (1960) are notable exceptions.

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METHODS

Descriptions of color and pattern given here are based on specimens preserved in formalin unless otherwise stated. Small larvae were measured with an ocular grid and binocular dissecting microscope, and larger individuals were measured with a vernier caliper. Relative development of larvae is expressed in the numerical stages of Limbaugh and Volpe (1957). Gosner (1960) provides tables that correlate various staging systems. The conscientious use of staging tables by authors describing larvae would go far towards making descriptions by various authors more readily comparable and less subjective.

ACKNOWLEDGMENTS

The field work on which this work is based was conducted while I was a resident at the Southwestern Research Station of the American Museum of Natural History in the Chiricahua Mountains, Cochise County, Arizona, during the summers of 1958 and 1960. I wish to thank Dr. Mont A. Cazier, Resident Director of the Station, for helping make my time at the Station both pleasant and profitable. In 1958 I was assisted by Mr. William A. Wimsatt, and in 1960 by Mr. Charles Cole¹ and Mr. Harvey Pough, to whom go my sincere thanks. I am grateful to Mrs. Frances W. Zweifel for the carefully executed drawings in this paper. Dr. William J. Hamilton provided specimens from the Cornell University collection (abbreviated C.U.), and Dr. A. H. Wright gave me locality data for these specimens.

HYLA WRIGHTORUM TAYLOR

The Arizona Tree Frog is found in coniferous forests at high elevations in Arizona, New Mexico, and adjacent Mexico. It has been regarded as a species by most authors, though Schmidt (1953, p. 71) placed it as a subspecies of *H. eximia*, a form widespread on the Mexican Plateau that ranges northward in the Sierra Madre Occidental. Wright and Wright (1949, pp. 363–364) describe the color of tadpoles of *wrightorum*, but offer no illustrations or description of the mouth parts. Stebbins (1951, pp. 329–330) gives a detailed description of tadpoles thought to be those of *wrightorum*, but comparison of the tadpoles described by him (C.U. No. 4548, 12 specimens, six of which Stebbins examined) with specimens of certain identity reveals that he described and figured *Hyla arenicolor*.

On June 23, 1958, William A. Wimsatt and I found a spent female

¹ A participant in the Undergraduate Research Program sponsored by Special Projects in Science Education of the National Science Foundation, Grant EO/3/43-1606.

Hyla wrightorum during the day in a meadow in yellow pine forest 8 miles south-southwest of Alpine, Apache County, in Greenlee County, Arizona. That evening in a nearby dirt stock tank we encountered a large chorus of *wrightorum*, but found no females. The following morning we discovered several small, loose clusters of eggs attached to rushes in the shallow marginal water. The eggs were in stage 17 (tail bud) when examined in the laboratory late that afternoon; probably oviposition took place on the evening of June 22. The following description is based on larvae hatching from these eggs and reared in the laboratory. Their identity as *Hyla wrightorum* was confirmed by carrying several through metamorphosis.

MOUTH PARTS

The configuration of the mouth parts (fig. 4) is typical of North American *Hyla*. There are five rows of labial teeth, two upper and three lower. The second upper row is broken above the beak. The length of the rows decreases slightly from the first upper row to the second lower, but the third lower row is quite short, one-third to slightly less than one-half of the length of the second lower row. The papillary border is double and is continuous around the posterior and lateral margins of the oral disc but is interrupted on the anterior (upper) margin for a distance equal to approximately one-half of the length of the upper row of labial teeth. The margin of the oral disc is not infolded laterally. The mouth parts achieve essentially complete development in stage 26 and undergo no significant change other than multiplication of papillae and increase in size until the degeneration associated with metamorphosis begins in stage 40 or 41.

BODY PROPORTIONS

The tadpole of *Hyla wrightorum* agrees with Orton's (1952, p. 388) characterization of *Hyla* larvae of the United States and Canada: "with deep, globose belly, wide head, very blunt snout, lateral eyes (visible from ventral as well as dorsal view), lips folding into a subtriangular shape with apex forward . . .," though the eyes are not always visible from the ventral view. The length of the tail ranges from slightly more than half to more than two-thirds of the total length, with the relative length of the tail increasing as the tadpole grows. Eleven tadpoles in stages 26 to 29 (body lengths, approximately 4 to 7 mm.) have an average tail length/total length ratio of 0.584 (0.56–0.60), compared to an average of 0.644 (0.60–0.71) for 19 tadpoles in stages 33 to 40 (body lengths, about 9 to 13 mm.). The depth of the tail fin decreases relative to increasing body size. In 10 tadpoles in stages 26 to 29 the maximum distance from

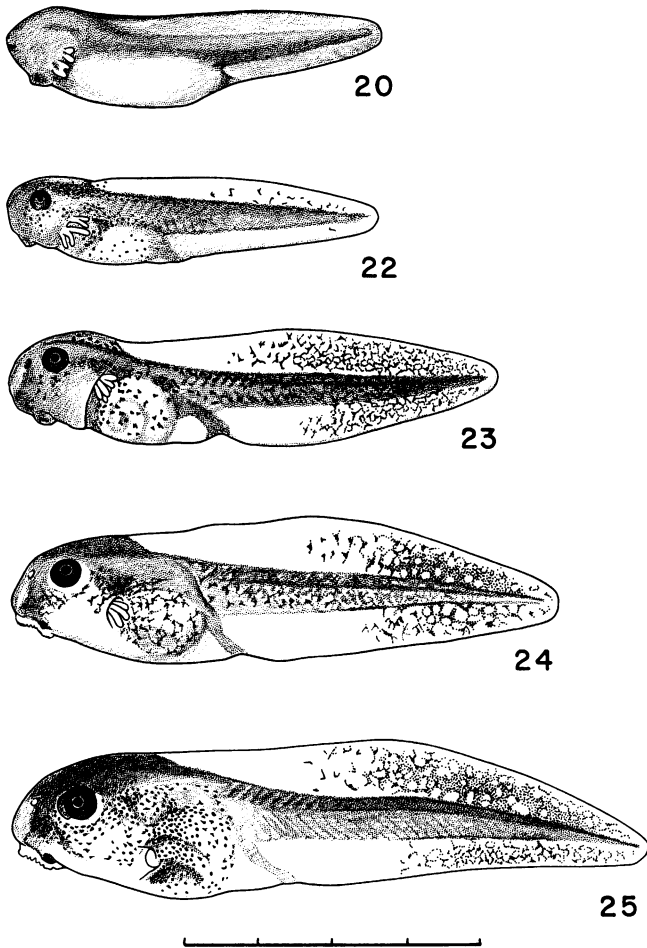


FIG. 1. Early larval stages of *Hyla wrightorum*. Number beside each drawing indicates stage of development. Scale bar at bottom of figure represents a relative length of 4 mm.

upper edge of dorsal fin to lower edge of ventral fin averages 0.603 of the body length, range 0.55–0.64. Nineteen tadpoles in stages 33–40 have a lower average, 0.561 (0.49–0.65).

The tadpole of *wrightorum* hatches in stage 20. Five specimens preserved immediately after hatching are 4.9 to 5.2 mm. in total length. The maximum total length attained by any of my tadpoles was 38 mm., and the maximum body length was 12.7 mm. Wright and Wright (1949, p.

363) record maximum total and body length, respectively, as 40 and 17 mm., but these records probably were based on misidentified tadpoles of *Hyla arenicolor*.

PIGMENTATION

The newly hatched tadpole is pale yellow in the abdominal region where the yolk shows through, yellowish brown on the rest of the body and tail. Possibly a characteristic feature of *wrightorum* is the early development of melanophores both on the body and in the tail fin. As early as stage 22 (fig. 1), there are easily discernible melanophores scattered over the body and base of the tail, and several of these cells are evident in

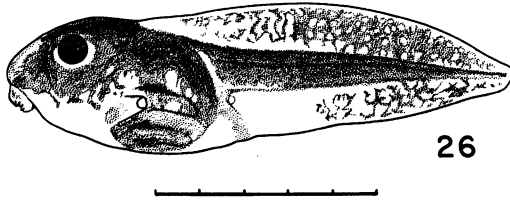


FIG. 2. Larva of *Hyla wrightorum* in stage 26. Scale bar measures 5 mm.

the distal half of the upper tail fin. Before opercular closure is complete (stages 23–24; fig. 1) there is a heavy, dendritic network of melanophores in the posterior half of the dorsal and ventral fins. In the living tadpole the blackness of this network stands in striking contrast to the transparency of the anterior parts of the tail fins.

The intensity of the melanophore network in the tail fins decreases as the tadpole grows, but the area in which melanophores are present increases. The largest tadpoles have at least a stippling of dark brown pigment in the anteriormost parts of the tail fins. The aspect of the fin pigmentation changes from a network to a stipple through which run a few dark, dendritic lines formed by the accumulation of melanin along blood vessels.

Melanophore coverage of the abdominal region, incomplete in early stage 25 (fig. 1), is well advanced by stage 26 (fig. 2). Tadpoles in this and later stages have a dense coverage of deep melanophores over the abdomen; the viscera can be seen only if the melanophores are quite contracted. Ventral surfaces anterior to the abdomen are largely free of melanophores and are transparent in the preserved tadpole. No pattern is evident in the pigmentation of the body at any stage. In larger tadpoles (fig. 3), the formerly rather uniform brown of the tail musculature be-

comes splotchy, with irregular lateral areas free of melanin. The dorsal edge of the tail musculature is more densely and more uniformly pigmented than the lower lateral surface, and there is a faint tendency to the formation of a dark lateral line.

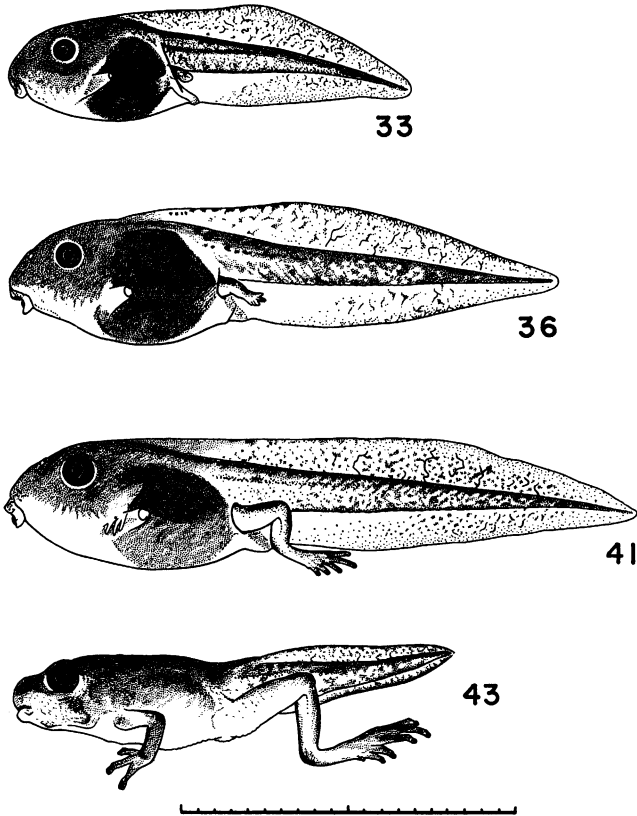


FIG. 3. Advanced larvae of *Hyla wrightorum*. Number beside each drawing indicates stage of development. Scale bar represents a relative length of 20 mm.

At about stage 26, after the yolk is absorbed or masked by the development of melanophores, the over-all appearance of the tadpole in life is brown. By stage 28 a scattering of golden chromatophores is present over the body, and a few of these cells are seen on the base of the tail. At this stage the abdomen is dark, but superficial golden and silver cells mask some of the melanin. With the appearance of increasing numbers of golden cells, the larger tadpoles assume a golden brown hue to gross ex-

amination. Wright and Wright (1949, p. 363) report that their specimens were green at transformation, but mine did not change from brown to green until a day or two after the tail was resorbed. It should be noted that *Hyla wrightorum* is always a green frog, whereas the related species *H. eximia* and *H. regilla* have both green and brown phases as well as mixtures of the two colors.

COMPARISON WITH RELATED FORMS

The species closest morphologically to *H. wrightorum* are *Hyla eximia* of Mexico and *Hyla regilla* of the Pacific coast region. Taylor (1938) regards a number of other species in Mexico as belonging to the same species group, and Blair ("1958" [1959], and 1960) suggests that *H. squirella* of the southeastern United States may belong with *eximia* and its relatives. So far as is known, the tadpoles of Nearctic species of *Hyla* are relatively similar in mouth parts and general morphology. Differentiation of species groups on the basis of larval characteristics may be possible but will require more detailed knowledge.

Hyla regilla apparently differs from *wrightorum* in having only a single row of labial papillae below the third lower row of teeth (Wright, 1929, p. 60, pl. 4, fig. 5; Stebbins, 1951, p. 326, pl. 32), whereas there are two rows in *wrightorum* and other hylas. Both Wright and Stebbins illustrate *regilla* with the first lower row of labial teeth interrupted medially. If typical, such difference may be another from *wrightorum*, in which this row is continuous. Differences in the pigmentation of the early larva may distinguish these two species, for Eakin's (1947, pl. 24) illustrations of *regilla* in stages 22 through 24 show only a scattering of melanophores.

Aside from generalized observations by Rabb and Mosimann (1955, pp. 4-5), the tadpole of *H. eximia* has not been described. These authors note that the tadpoles they refer to *eximia* are of the pond type, with the tail fin well elevated just posterior to the body, the tail having a pointed tip, and the upper lip lacking a complete row of papillae. Tadpoles collected at Chapala, Jalisco, by C. M. Bogert probably belong to *eximia*, though the presence at that locality of both *Pternohyla fodiens* (the tadpole of which is undescribed) and *eximia* makes the identification uncertain. The mouth parts are identical to those of *wrightorum*, but the tail fin is much higher. In nine tadpoles with body lengths ranging from 9.8 to 13.4 mm. (stages 35 to 41), the fin height averages 0.728 of the body length, as against 0.558 for 14 *wrightorum* of approximately the same size range and stage of development. Pigmentation of the tail fin is similar in the two lots, but the slight tendency to the formation of a lateral line on the tail musculature of *wrightorum* is considerably emphasized in the tadpoles

WRIGHTORUM

ARENICOLOR

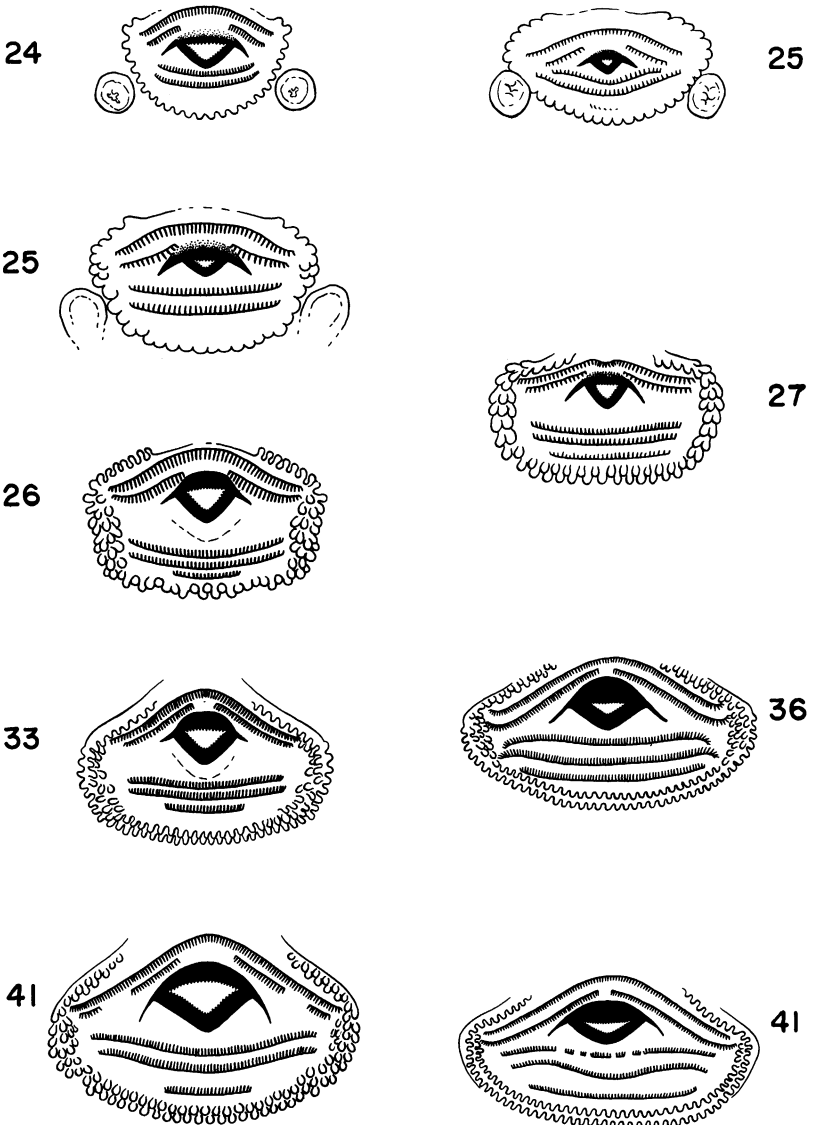


FIG. 4. Mouth parts of larvae of *Hyla wrightorum* and *Hyla arenicolor*. Numbers indicate stage of development; drawings are semi-diagrammatic and not to scale, and are based on same specimens as are illustrated in figures 1-3 and 5-7.

from Chapala. As I am not certain of the identity of the tadpoles from Chapala, I have not drawn up a detailed description. A further complication is introduced by Maslin's (1957) description of *Hyla microeximia* and Blair's (1960) suggestion that *Hyla eximia* of authors includes two cryptic species.

HYLA ARENICOLOR COPE

Wright (1929, pp. 63-64) and Stebbins (1951, p. 321) give descriptions of tadpoles of *arenicolor* from Texas and Arizona, respectively. The early larval stages have not been described, however, and considerable geographic variation makes desirable the description of larvae from other regions. Except where specified to the contrary, the following description of larval development of *arenicolor* is based on specimens collected in the Chiricahua Mountains, Cochise County, Arizona, or on tadpoles bred in the laboratory from parents collected in this region. Where measurements or proportions are given, the specimens used were collected in the field and preserved immediately or within a day or two. Specimens reared in the laboratory were not used in the calculation of proportions because of the possibility that laboratory conditions might have altered their growth. There is no doubt that the specimens collected in the field are *Hyla arenicolor*, as this is the only member of its family in the Chiricahua region, and the specimens agree in all pertinent respects with those bred and reared in the laboratory.

MOUTH PARTS

The familiar *Hyla* pattern (fig. 4) of two upper and three lower rows of labial teeth, the oral disc fringed by papillae except for the median anterior edge, and the oral disc not indented laterally is seen in *arenicolor*. The second upper row of teeth is narrowly interrupted along the midline. The two upper rows and first two lower rows are similar in length, and the third lower row is only slightly shorter than the others. The papillary border is double, and additional papillae develop in the corners of the disc. All rows of labial teeth are well developed by the completion of stage 26. The only significant change before the commencement of metamorphosis is the increase in the number of marginal papillae.

BODY PROPORTIONS

The tadpole shows no striking departure from that of other North American hylas, though the eyes are displaced slightly dorsally in comparison to those in some other species. As a result, the eyes cannot be seen from the ventral view. The relative length of the tail apparently increases

with growth. Fourteen specimens in stages 26 to 28 (body length, 5.5–7.0 mm.) have an average tail length/total length ratio of 0.570 (0.53–0.60), whereas seven individuals in stages 31 to 39 (body length, 9–13 mm.) average 0.606 (0.58–0.65). The relative height of the tail fin may increase slightly with growth, though variation in the small sample is extensive. Fifteen tadpoles in stages 26 to 28 (body lengths, 5.5–7.0 mm.) have an average fin height/body length ratio of 0.549 (0.48–0.62), whereas nine tadpoles in stages 32 to 39 (9–13 mm.) average 0.600 (0.54–0.68).

Hatching takes place in stage 20, in some instances late in that stage. I preserved no hatchlings so cannot give dimensions. The largest tadpole

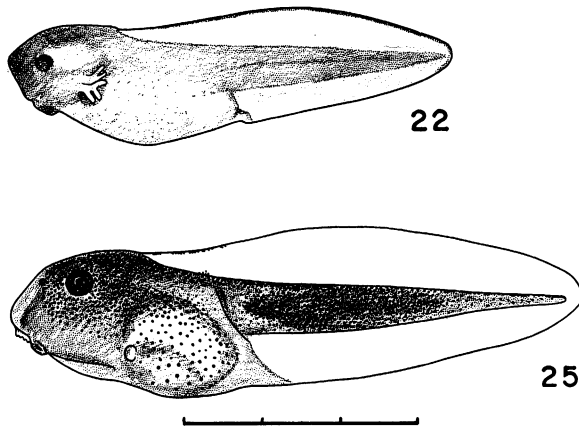


FIG. 5. Early larvae of *Hyla arenicolor* from Chiricahua Mountains, Arizona. Scale bar measures 3 mm. Number indicates stage of development.

(stage 41) in the Chiricahua series is 38.3 mm. in total length and has a body length of 14.1 mm. The snout-vent length of the newly metamorphosed frog is about 15 mm.

PIGMENTATION

At hatching the tadpole is yellowish brown, yellower in the abdominal region than dorsally. By stage 22 (fig. 5) a few melanophores can faintly be seen on the body. Melanophores are abundant on the body and tail musculature in stage 25 (fig. 5), though the yellow of the yolk-filled gut still is the dominant color of the abdomen. A very few melanophores are present in the anterior edge of the dorsal fin, but the fin is otherwise clear.

By stage 27 or 28 (fig. 6) the melanophore development is such that the ground color of the dorsal surface of the body and all but the ventral

edge of the tail musculature are dark brown. The abdomen is darker than the dorsal surface of the body and appears black in life. (The individual illustrated in fig. 6 has the melanophores somewhat more contracted than is usual in life.) A scattering of melanophores is present in the dorsal fin, but the ventral fin is still immaculate or at the most has a few brown flecks. There is yet relatively little development of golden cells. These are present over the body, including the abdomen, but do not detract from the general dark brown aspect afforded by the melanophores. There are very few golden cells on the lateral surface of the tail, but some patchy aggregations are present along the dorsal edge. No pattern is evident in melanophores or xanthophores. The ventral surfaces anterior to the abdomen are free of pigment.

Two principal changes take place through stages 30 and 31: melanin increases in the dorsal fin and may become evident in the ventral fin; xanthophores become much more abundant on the body and tail, and almost obscure the underlying black of the abdomen. The ventral tho-

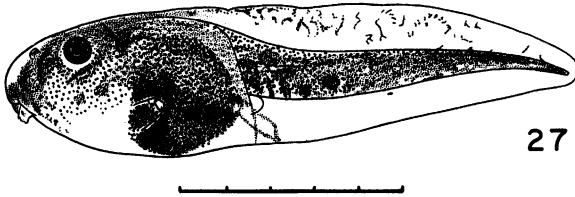


FIG. 6. Larva of *Hyla arenicolor* from Chiricahua Mountains, Arizona, in stage 27. Scale bar represents a relative length of 5 mm.

racic region remains unpigmented by melanin, though xanthophores are present. Because of the locally greater increase in xanthic pigmentation on the abdomen, a fairly sharp line of demarcation develops between dorsal and ventral surfaces.

Larger tadpoles (fig. 7, stages 36 and 41) show increasing development of melanin in the tail fin and widespread multiplication of xanthic cells. The appearance of the tadpole in life has changed from dark brown to golden brown. No pattern is evident on the body, but patchy distribution of superficial xanthophores on the tail musculature may give a mottled appearance to this area. The abdominal surfaces are dense silver (with a golden sheen when seen at the right angle) which gives way abruptly to the golden brown of the dorsum about midway up the side of the body.

One of the characteristics of the tadpoles from the Chiricahua region is the lack of distinct pattern on the tail musculature and the weak development of melanin in the tail fins. Some individuals show a more dendritic

pattern in the fin than is illustrated in figure 7, but large accumulations of intensely dark cells are absent. Similarly, though there may in life be some contrast between golden and brown areas on the tail musculature, the contrast is not at all striking and largely disappears in preservative.

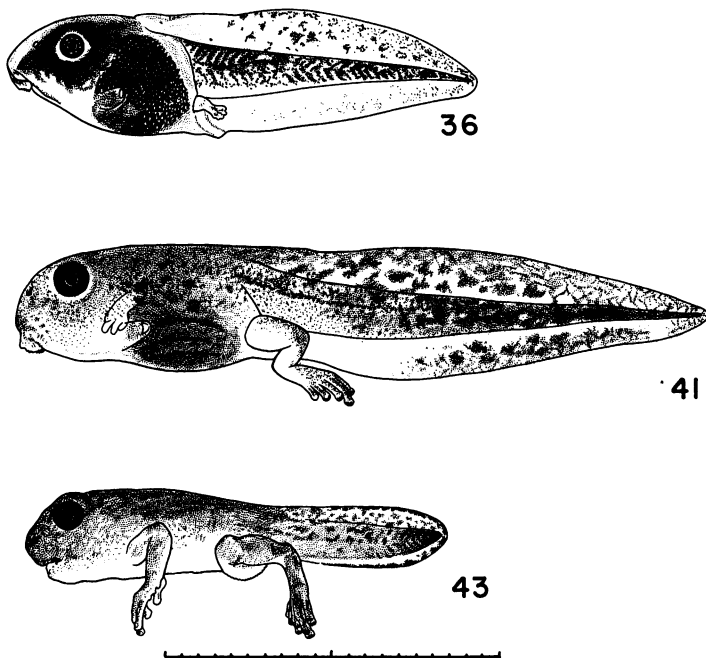


FIG. 7. Advanced larvae of *Hyla arenicolor* from Chiricahua Mountains, Arizona. Numbers indicate stage of development. Scale bar represents a length of 20 mm. Specimen in stage 36 shows appearance in life, with golden cells contrasting with black of abdomen.

GEOGRAPHIC VARIATION IN *Hyla arenicolor*

The few data available indicate considerable variation in pigmentation and maximum size. Wright (1929, pp. 63-64, pl. 9, fig. 2) describes and illustrates the larvae of this species from Alpine, Texas. The dorsal and ventral tail fins are heavily marked with black in large, intense blotches, unlike any specimens I have seen from farther west. Wright also mentions that in some tadpoles the tail fins are "suffused with some 'reddish' or orange pink, coral pink, or coral red, as in *H. versicolor*." No such color is evident in Chiricahua specimens. Wright's largest specimen was 50.0 mm. in total length and 15.4 mm. in body length, or about 30 per cent longer than the largest specimen from the Chiricahuas.

A tadpole (stage 41) from Montezuma Canyon, Huachuca Mountains, Cochise County, Arizona, differs from the specimens from the Chiricahua Mountains in size and pigmentation. Melanophores in the tail fins are aggregated into spots rather than being more or less dispersed or dendritic as in the Chiricahua specimens. The tail musculature in life was strikingly mottled with black and gold, and the mottling (though not the gold) persists in the preserved specimen and contrasts with the relatively uniform pigmentation of Chiricahua specimens (fig. 7). This individual is 43.5 mm. in total length and has a body length of 15.5 mm. and thus is about 13 per cent longer over all than the largest Chiricahua tadpole. The specific identity of the Huachuca specimen was confirmed by the rearing through metamorphosis of a second, virtually identical specimen collected with it.

A series of tadpoles again differing in size and pigmentation from the specimens from the Chiricahua Mountains was collected along with adult *arenicolor* in the Virgin River near Virgin, Washington County, Utah. Although it was not possible to confirm identity by rearing the tadpoles, there is little doubt that they are *arenicolor*. The mouth parts and proportions are those of *arenicolor* and differ significantly from those of the only other hylid occurring in southwestern Utah, *Pseudacris nigrata* (see Stebbins, 1951, pls. 31, 32, and 59).

The largest Utah tadpole is 47.3 mm. in total length and has a body length of 17.2 mm., though only in stage 36. The greater size of the individuals in the Utah series is shown graphically in figure 8. A heavier and earlier accumulation of melanin in the tail fin characterizes the specimens. A specimen in stage 28 (fig. 9) has almost as much melanin in the lower fin as a Chiricahua specimen in stage 41 (fig. 7). The pattern of the fin is a diffuse scattering of melanophores through which pass darker dendritic lines following blood vessels. The impression given is of an intensification of the Chiricahua pattern, in contrast to the spotted or blotched pattern of the Huachuca and Texas tadpoles.

The relative uniformity in pigmentary development and maximum size of specimens in the samples from the Chiricahua Mountains and the Virgin River is worthy of note, but in the absence of a more satisfactory geographic coverage we cannot know if these specimens are typical of areas greater than those inhabited by the local populations sampled.

COMPARISON WITH RELATED FORMS

Hyla arenicolor was previously considered to range from California to Texas, with the coastal population separated from that in Arizona by an uninhabited area in the desert region (Stebbins, 1951, pl. 59). Recently,

however, Gorman (1960) described the disjunct western population as *Hyla californiae*. The larva of this western form has not been described in detail, though Stebbins (*op. cit.*, pl. 31) figures both *californiae* and *arenicolor*. Stebbins' illustration (*op. cit.*, pl. 32) of the mouth parts of "*arenicolor*"

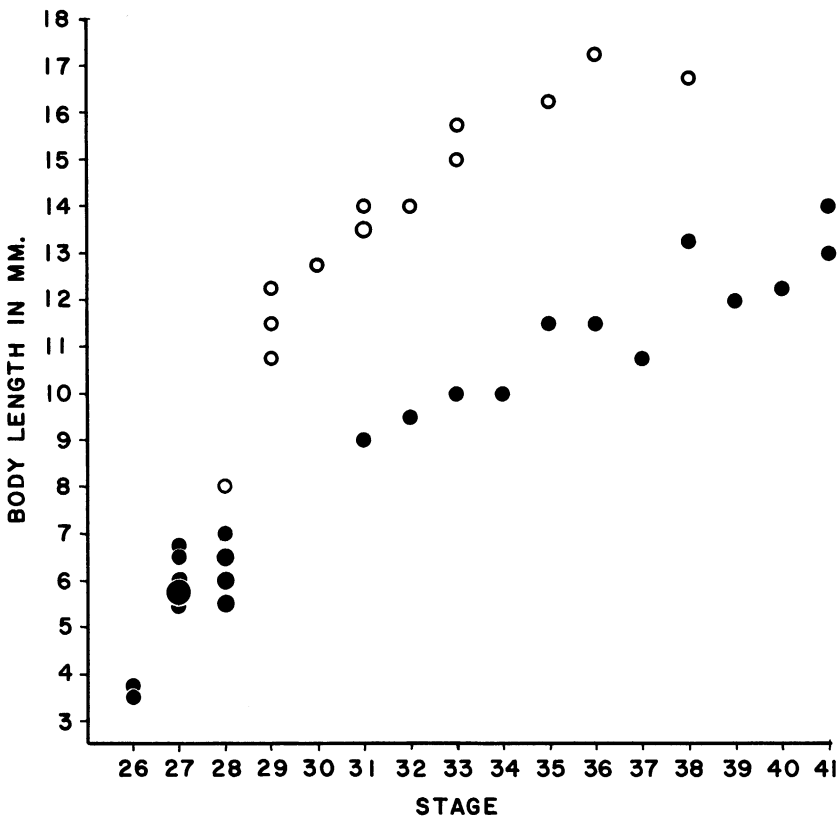


FIG. 8. Comparison of size in tadpoles of *Hyla arenicolor* from Virgin River, Utah (○), and Chiricahua Mountains, Arizona (●). Three sizes of spots indicate one, two, and three specimens falling at a particular point on the diagram.

shows the third lower row of labial teeth as being shorter than in true *arenicolor*. If the specimen illustrated is *californiae* (no locality data are given), there may be a significant difference in mouth parts. Because of the wide variation in pigmentation seen in *arenicolor*, any apparent differences between this species and *californiae* will have to be interpreted with caution.

Wright (1929, p. 64) includes *H. versicolor*, *H. femoralis*, and *H. squirella* in the same group as *arenicolor*, presumably on morphological criteria. Blair ("1958" [1959]), using structure of the mating call as the principle criterion, adds *H. phaeocrypta* and *H. baudini* to this group, but eliminates *squirella* which he (1960) regards as related to *eximia*. A further complication is that *versicolor* is a composite of two sibling species (Johnson, 1959).

Hyla versicolor as illustrated by Wright (1929, pl. 4, fig. 8) has mouth parts similar to those of *arenicolor* in that the third lower row of labial

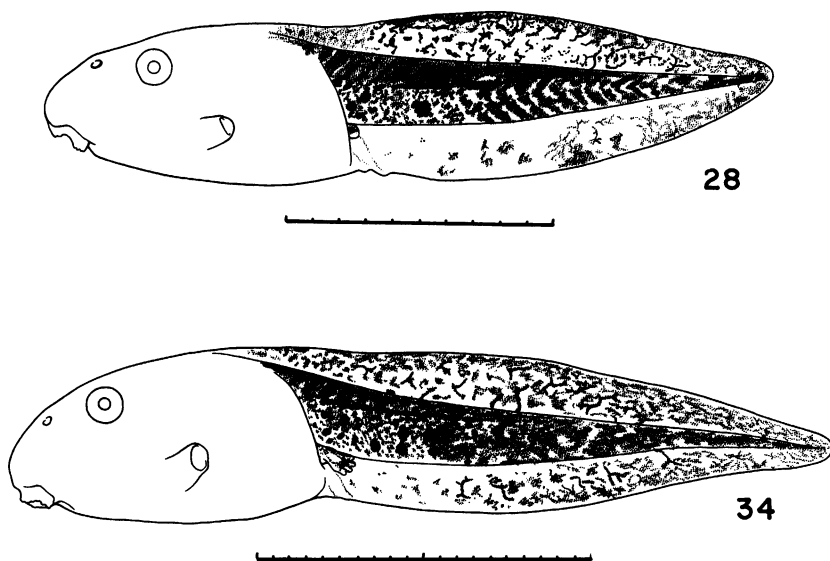


FIG. 9. Larvae of *Hyla arenicolor* from Virgin River, Utah, with color pattern of tail only indicated. Numbers indicate stage of development. Scale bars represent lengths of 10 (upper) and 20 (lower) mm.

teeth is relatively long. Hellman's (1953) description of *versicolor* and *phaeocrypta* in Florida notes that the third lower row in *versicolor* is shorter than in *phaeocrypta*, in which species it is about two-thirds of the length of the second lower row. The discrepancy between the description of *versicolor* given by Wright and that by Hellman suggests that the tadpoles of the two species presently confused under *versicolor* may differ slightly in the structure of the mouth parts. Among the remaining species, the third lower row is relatively long in both *H. femoralis* and *H. squirella* (slightly longer in *femoralis*), and the tadpole of *H. baudini* has not been described. The inclusion of *baudini* in this species group is not well established; it is

sufficiently different morphologically for some authors to assign it to another genus, *Smilisca* (Starrett, 1960).

Many species of *Hyla* (e.g., *wrightorum*) differ from those discussed in the preceding paragraph in having the third lower labial row quite short, less than one-half of the length of the second row. A single character such as this should not be given too much weight, but in conjunction with adult morphology and breeding call may help define the species group.

COMPARISON OF LARVAE OF *Hyla arenicolor* AND *Hyla wrightorum*

Because of confusion in the literature regarding the larvae of these species, I note here the distinctive features of the tadpoles. Almost all specimens from stage 26 on are distinguishable in the configuration of the mouth parts, specifically the relative length of the third lower row of teeth. This row rarely attains a length as great as half of the length of the preceding row in *wrightorum*, whereas it is always longer than one-half of the preceding row in *arenicolor* (fig. 4). Possibly some specimens undergoing metamorphosis attain a transient similarity of mouth parts. An *arenicolor* tadpole with the third lower row just beginning to develop (fig. 4; stage 25) might be mistaken for *wrightorum*, but in the early stages differences in pigmentation are sufficient to assure proper identification (figs. 1, 5).

There is sufficient overlap in ranges of variation for the ratios tail length/total length and fin height/body length to be of no use in separating the species. Similarly, the variation in color pattern of *arenicolor* limits the usefulness of this character.

NOTES ON THE BREEDING SEASON AND LARVAL ECOLOGY OF *Hyla arenicolor*

Observations in the Chiricahua Mountains suggest that most breeding activity takes place in the spring or very early summer. In 1958 there were larvae in potholes in the South Fork of Cave Creek when I first investigated the area on June 22. Judging from the size of some individuals, breeding must have commenced at least a month earlier in the midst of the dry season. Although there is no rain in May, stream flow may be high owing to melting snow at higher elevations. The amount of surface water rapidly diminishes, until in late June, just prior to the first summer rains, water remains in only a few potholes. Summer rains are usually sufficient to keep the pools filled, though surface flow disappears at times.

Some breeding probably took place along South Fork in late June and early July, 1958, though direct evidence is lacking. The largest chorus we encountered was on July 1, following approximately one-half inch of rain

that day. A gravid female was found on this date. Although this chorus followed a fairly heavy rain, other rains before and after this date elicited no such mass response from the frogs, and calling on dry nights was not infrequent. Only one other gravid female was found in 1958 (June 28), and vocal activity decreased greatly after the first week in July.

The situation was somewhat different in 1960. When we first investigated the pools in South Fork in late June, no tadpoles were present. None was seen despite intensive search, and operation of electrical fish-shocking gear by Kenneth John also failed to disclose tadpoles. If there was a spring breeding, all tadpoles had metamorphosed and left the water by late June.

On July 17, 1960, in South Fork, Charles Cole collected small tadpoles and an egg almost ready to hatch. A sample of tadpoles taken there on July 20 includes individuals in stages 26 through 31. The first summer rain at the nearby Southwestern Research Station in 1960, 0.70 inches, fell on July 3, and a total of slightly more than 4 inches fell by July 10. Probably most breeding this year took place during this period, for there was little calling later, and no females were found after July 8 despite several attempts.

An estimate of the duration of larval life can be made from observations made on the population in a narrow draw immediately adjacent to the Southwestern Research Station. This little canyon was dry until the heavy rains of early July, but after the rains commenced there was water in some potholes through much of the summer, and one still contained water in early September despite an unusually dry August in which scarcely an inch of rain fell.

Hyla arenicolor began calling from this canyon after the rains commenced, and on July 18 we found newly hatched tadpoles in one of the potholes. Oviposition probably took place on July 12 or 13, after three or four days with little or no rain. Subsequent checks revealed no new increment to the tadpole population, nor were there tadpoles in any other pool. Presumably breeding took place only once, though several males and more than one female were known to be in the local population. By August 27 most tadpoles were in stage 41, though none with front legs protruding was seen. On September 2 many with all four legs but still with long tails were found. The period from oviposition to metamorphosis was probably between 50 and 60 days, agreeing with the range of 40 to 75 days given by Stebbins (1951, p. 322).

It is curious that the pool in which the eggs were laid was the only one of several in the canyon that did not go dry later in the summer. At the time oviposition took place all pools were full and connected by a slight

surface flow, and to the herpetologist's eye (if not to the frog's) no one of the larger pools had better potential for retaining water than any other. Indeed, adult frogs were rarely seen around the breeding pool but could be found with fair regularity around another pool up the canyon.

SPECIMENS EXAMINED

Hyla eximia (?): Chapala, Jalisco, A.M.N.H. Nos. 64669, 64670 (series of tadpoles of two size groups).

Hyla wrightorum: Eight miles south-southwest of Alpine, Apache County, Arizona, in Greenlee County, A.M.N.H. No. 64675 (series of tadpoles reared in captivity from eggs collected at this locality).

Hyla arenicolor: Virgin River near Virgin, Washington County, Utah, A.M.N.H. No. 64683 (series of tadpoles). Montezuma Canyon, Huachuca Mountains, Cochise County, Arizona, A.M.N.H. No. 64677 (one tadpole and one newly metamorphosed frog). Southwestern Research Station, Chiricahua Mountains, Cochise County, Arizona, A.M.N.H. No. 64678 (series of tadpoles). South Fork of Cave Creek, Chiricahua Mountains, Cochise County, Arizona, A.M.N.H. Nos. 64679-64681 (tadpoles collected here or bred from frogs from this locality). South Fork of Cave Creek and Rucker Canyon, Chiricahua Mountains, Cochise County, Arizona, A.M.N.H. No. 64682 (tadpoles from mating of male frog from South Fork with female from Rucker Canyon). Lake-o-Woods Lodge, Navajo County, Arizona, C.U. No. 4548 (series of tadpoles).

BIBLIOGRAPHY

BLAIR, W. FRANK

"1958" [1959]. Call structure and species groups in U. S. treefrogs (*Hyla*). *Southwestern Nat.*, vol. 3, pp. 77-89, figs. 1-4, tables 1-2.

1960. Mating call as evidence of relations in the *Hyla eximia* group. *Ibid.*, vol. 5, pp. 129-135, fig. 1, tables 1-2.

EAKIN, RICHARD M.

1947. Determination and regulation of polarity in the retina of *Hyla regilla*. *Univ. California Publ. Zool.*, vol. 51, pp. 245-272, figs. A-B, pls. 22-28, tables 1-4.

GORMAN, JOE

1960. Treetoad studies, 1. *Hyla californiae*, new species. *Herpetologica*, vol. 16, pp. 214-222, figs. 1-4.

GOSNER, KENNETH L.

1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, vol. 16, pp. 183-190, tables 1-3.

GOSNER, KENNETH L., AND IRVING H. BLACK

1957. Larval development in New Jersey Hylidae. *Copeia*, pp. 31-36, figs. 1-4.

GOSNER, KENNETH L., AND DOUGLAS A. ROSSMAN

1960. Eggs and larval development of the treefrogs *Hyla crucifer* and *Hyla ocularis*. *Herpetologica*, vol. 16, pp. 225-232, 1 fig.

HELLMAN, ROBERT E.

1953. A comparative study of the eggs and tadpoles of *Hyla phaeocrypta* and *Hyla versicolor* in Florida. Publ. Res. Div. Ross Allen's Reptile Inst., vol. 1, pp. 61-74, fig. 1.

JOHNSON, CLIFFORD

1959. Genetic incompatibility in the call races of *Hyla versicolor* LeConte in Texas. Copeia, pp. 327-335, figs. 1-3, tables 1-4.

LIMBAUGH, BEVERLY A., AND E. PETER VOLPE

1957. Early development of the Gulf coast toad, *Bufo valliceps* Wiegmann. Amer. Mus. Novitates, no. 1842, pp. 1-32, figs. 1-10, tables 1-2.

MASLIN, T. PAUL

1957. *Hyla microeximia* sp. n., Hylidae, Amphibia, from Jalisco, Mexico. Herpetologica, vol. 13, pp. 81-86, fig. 1, table 1.

ORTON, GRACE L.

1947. Notes on some hylid tadpoles in Louisiana. Ann. Carnegie Mus., vol. 30, pp. 363-379, pls. 1-2, tables 1-4.

1952. Key to the genera of tadpoles in the United States and Canada. Amer. Midland Nat., vol. 47, pp. 382-395, figs. 1-21.

RABB, GEORGE B., AND JAMES E. MOSIMANN

1955. The tadpole of *Hyla robertsonum*, with comments on the affinities of the species. Occas. Papers Mus. Zool., Univ. Michigan, no. 563, pp. 1-9, figs. 1-3, table 1.

SCHMIDT, KARL P.

1953. A check list of North American amphibians and reptiles. Sixth edition. [Chicago], American Society of Ichthyologists and Herpetologists, pp. i-viii, 1-280.

STARRETT, PRISCILLA

1960. A redefinition of the genus *Smilisca*. Copeia, pp. 300-304, figs. 1-3.

STEBBINS, ROBERT C.

1951. Amphibians of western North America. Berkeley and Los Angeles, University of California Press, pp. i-xvii, 1-539, figs., pls.

TAYLOR, E. H.

1938. Frogs of the *Hyla eximia* group in Mexico, with descriptions of two new species. Univ. Kansas Sci. Bull., vol. 25, pp. 421-439, pls. 46-48.

WRIGHT, A. H.

1929. Synopsis and description of North American tadpoles. Proc. U. S. Natl. Mus., vol. 74, pp. 1-70, pls. 1-9.

WRIGHT, A. H., AND A. A. WRIGHT

1949. Handbook of frogs and toads of the United States and Canada. Third edition. Ithaca, New York, Comstock Publishing Co., Inc., pp. i-xii, 1-640, pls., maps.

