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The Tadpoles of Five Species of New Mexican Leopard Frogs

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Abstract

Large tadpoles of five New Mexican species of leopard frogs, *Rana berlandieri*, *R. blairi*, *R. chiricahuensis*, *R. pipiens*, and *R. yavapaiensis* can be distinguished using a suite of 10 morphological variables and color patterns. The tadpoles of *R. chiricahuensis* tend to be the darkest with the boldest pattern. *Rana berlandieri* and *R. yavapaiensis* are less dark and less boldly patterned. The patterns of *R. pipiens* and *R. blairi* tadpoles are relatively pale and not heavily patterned. *Rana berlandieri* is a relatively long, slim tadpole with a moderately deep tail and narrow tail muscle; *R. blairi* has an oval body shape, a deep, long, and wide tail, and a filmy tail fin; *R. chiricahuensis* is relatively small-bodied with a deep, wide tail and thick tail fin; *R. pipiens* has a deep, heart-shaped body, a moderately deep, narrow tail, and a filmy tail fin; *R. yavapaiensis* is similar to *R. chiricahuensis* in body shape, but has a shallower tail. Other characters including numbers of labial tooth rows, condition of oral papillae, mouth shape, visibility of the lateral line system, iris pattern, peritoneal coloration, and visibility of ventral muscle sheath myomeres are less diagnostic, but proved useful when series of tadpoles were examined. *Rana* tadpoles are differentiated from other New Mexican anurans and a key to New Mexican larval *Rana* is provided.

Patterns in the dates of occurrence of eggs and tadpole size classes suggest that breeding is most common in the spring; a second peak may occur in the fall, but detailed patterns require verification. *Rana chiricahuensis* may be reproductively active year-round in some warm springs. According to the habitat descriptions accompanying the collections in New Mexico, tadpoles of *R. berlandieri* and *R. chiricahuensis* are found primarily in flowing waters, and *R. blairi* and *R. pipiens* are found in both still and flowing waters. *Rana yavapaiensis* was not included in the habitat and breeding season analysis.

INTRODUCTION

Study of the systematics of the leopard frog complex (*Rana pipiens* and allies) has shown an explosive development ever since suspected specific differences were confirmed by careful studies of morphology, mating calls, chromosomal compatibility, electrophoretic patterns, and hybridization studies (Littlejohn and Oldham 1968; Mecham 1968; Platz 1972, 1976; Pace 1974; Frost and Bagnara 1977; Sage and Selander 1979; Frost and Platz 1983; Hillis et al. 1983). Nowhere north of Mexico does the complex reach a greater di-

versity than in New Mexico with its five species (Fritts et al. 1984). *Rana pipiens* Schreber, 1782, is found in the northwestern and north-central part of the state and throughout the Rio Grande Valley. *Rana blairi* Mecham, Littlejohn, Oldham, Brown, and Brown, 1973, is an inhabitant of the eastern plains, and *R. berlandieri* Baird, 1859, occurs in southeastern New Mexico west of the lower Pecos River. *Rana chiricahuensis* Platz and Mecham, 1979, is found in the mountains and playa valleys of the southwestern part of the state. *Rana yavapaiensis* Platz and Frost, 1984, barely enters

the state along the Arizona border where it overlaps the range of *Rana chiricahuensis*.

Although adults of each species have been well characterized on the basis of genetical, morphological, and reproductive traits, the important tadpole stage has been largely neglected. This is somewhat surprising because our studies indicate that fresh samples of large tadpoles are as easy to identify as samples of adults. Also, tadpoles are often easier to find, especially during summer months when adults become more terrestrial and widely dispersed. In fact, persons surveying leopard frog distributions are much more efficient if they concentrate on sampling eggs and tadpoles than if they search for the elusive adults (Lynch 1978).

The last comprehensive guide to tadpole identification (Altig 1970) explicitly recognizes only one of the New Mexican leopard frogs, *R. pipiens*, although it recognizes differences between tadpoles from east and west of the 100th meridian. In spite of Wassersug's (1976) recognition of a real need for more precise descriptions and comparisons of leopard frog tadpoles, two species found in New Mexico remain undiagnosed as larvae. Only recently, Korky (1978) described and compared *R. pipiens* and *R. blairi* tadpoles in Nebraska and Hillis (1982) described *R. berlandieri* and *R. sphenoccephala* (which is not found in New Mexico) tadpoles from Texas.

Older illustrations and descriptions of leopard frog tadpoles almost always represented material that still would be assigned to *R. pipiens* (Dickerson 1906; Wright 1914; Wright and Wright 1949; Stebbins 1962, 1966) although a photograph in Wright and Wright (1949, plate CXV) is a tadpole of *R. chiricahuensis*. This paper provides detailed descriptions and comparisons and a key to the tadpoles of the *Rana* known from New Mexico.

MATERIALS AND METHODS

Live, freshly-preserved, and old collections of tadpoles were available in the Museum of Southwestern Biology, University of New Mexico (MSB) for all species. Numbers in the "Specimens Examined" section refer to lots (one to many) of tadpoles examined. For this paper, we used fully grown tadpoles in stages 38–42 of Gosner (1960) unless otherwise noted. In Gosner's system, tadpoles with tiny hind limb buds are stage 25, all

five toes can be distinguished at stage 36, tail fin resorption starts in stage 40, and forelimbs erupt in stage 42. Growth in body and tail length almost cease by stage 38.

As far as we know, all the MSB tadpole samples came from areas that harbor only one species of leopard frogs (Fritts et al. 1984). In addition, identifications were confirmed for all of the recent material by rearing a few individuals through metamorphosis. The color pattern and lateral line descriptions are all from these recent collections.

The following terms are used in the color pattern descriptions. *Dots* and *punctations* are small, discrete, dark marks less than about 0.75 mm in diameter in large tadpoles. *Spots* and *flecks* are a little larger (approximately 1–2 mm); they may be dark or pale and are often more blurred and less discrete than dots. They may coalesce and form a fine *mottling*. *Blotches* are greater than 2 mm in diameter and may be dark (melanic) or pale (guanic); they sometimes coalesce into a striking *reticulation*.

Descriptions of color pattern are taken from series of large tadpoles (stages 36–42) which have the best developed, most distinctive color patterns. Younger tadpoles of all species tend to have clear, patternless tail fins and uniformly olive to black tail muscle and body coloration. The distribution and intensity of melanin in the parietal peritoneum were examined by making incisions and reflecting a flap of the body wall. In general, melanin in the lateral body wall was darker dorsally and paler or absent ventrally. Melanin was also present in the peritoneum covering the dorsal body muscle and lungs.

Tadpole proportions remain relatively constant throughout the latter stages of ontogeny. In a principal components analysis, 93% or more of the variance in the chosen morphometric characters was explained by differences in overall size, leaving little variance due to allometry or other sources of variation. However, only the largest tadpoles (body length 26–33 mm) in stages 38–42 were used for morphometric analyses. Measurements were made either to 1 mm with a ruler or to 0.1 mm with dial calipers (Fig. 1); and included body length, tail length, depth of the tail at the deepest point, width of the tail muscle (not illustrated, but taken across the back near the body), depth of the tail muscle, eye (corneal) diameter, and mouth width. The latter was taken under the mar-

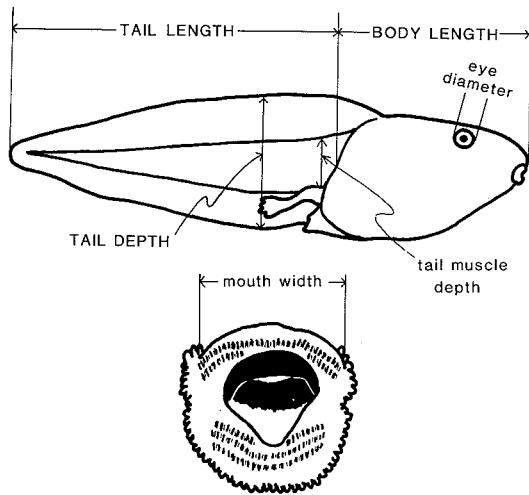


Figure 1. Morphometric characters of leopard frog tadpoles. Tail muscle width was measured across the back at the same point the tail depth measurement was taken.

ginal papillae at the corners of the mouth; at this point, the mouthparts are more solid and less subject to curling.

The lateral line systems (the "muciferous crypts" of some older literature) and orbitonasal canals were examined under water and $6\times$ magnification and the percent of each branch visible was scored for a sample of each species (Fig. 2). The samples were composed of large tadpoles (stages 39–42). Each species' sample was taken at the same time and place and all samples had been preserved 5–6 months.

Mouthparts of tadpoles are quite complex and useful in identifications. The number, distribution, and sizes of the oral papillae and labial tooth rows are variable within and among species. Labial teeth are arranged in rows on the upper and lower labium and some rows may be divided. We use the descriptive system presented in Altig (1970). A typical ranid tadpole would have a labial tooth formula of $2(2)/3(1)$, which means that there are two rows on the upper labium and three on the lower. Numbers in parentheses indicated which rows are divided: row number two (counting from the anteriormost) on the upper labium and row number one on the posterior labium.

The final morphological trait examined was the

thickness of the rectus abdominis muscle. After a few weeks in formalin, the guanine coloring that covers the abdomen dissolves and the skin becomes almost clear. In some tadpoles, the intestines can then be seen clearly, but in others, the myomeres of the rectus abdominis muscle are thick enough to obstruct a view of the digestive tract.

The parametric analysis of variance and Duncan's Multiple-range Test were used for comparing sample means. We have concentrated on key characters in our discussions and we were most interested in those means, or pairs of means, that are statistically distinct from all others. The distributions of ratios of measurements were tested and all but one were not significantly different from normal, and parametric tests were justified. Statistical significance was $P < 0.05$ in all tests.

The collections of the MSB provided the base for an analysis of the breeding seasons of four of the five species. Each collection was sorted into five developmental stages: eggs and four tadpole stages, small (less than 25 mm total length), medium (25–50 mm), large (greater than 50 mm), and transforming (Gosner stages 40–42). The presence of each stage was plotted on a calendar.

The characteristics used to define these tadpoles are valid for all New Mexican material that we have seen. Populations in other areas may not show the same characteristics or display the same relationships between species, just as adult characters vary geographically.

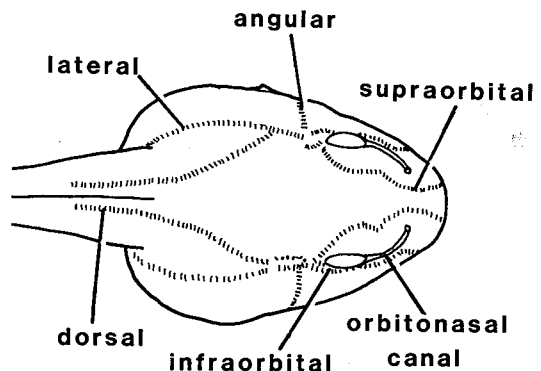


Figure 2. Dorsal view of a *Rana yavapaiensis* tadpole showing the branches of the lateral line system and the orbitonasal canal (after Noble 1931).

RESULTS

Color Pattern

The colors and patterns of live tadpoles of the same species vary considerably. Besides color variation within a cohort, which presumably has a genetic basis, tadpoles differ at various stages of ontogeny and under different environmental conditions. Camera lucida drawings of freshly preserved tadpoles and photographs of living tadpoles are shown in Figs. 3 and 4 and eye diagrams are shown in Fig. 5.

Color Changes during Ontogeny

In our collections, we have a sufficiently broad range of tadpole sizes of two species, *R. berlandieri* and *R. chiricahuensis*, to be able to describe the general developmental trends in pigmentation. Ontogenetic color changes were consistent

between localities; however, the descriptions in this section were made from different-sized tadpoles taken at the same time and place.

Rana chiricahuensis is darker colored than *R. berlandieri* at all stages. In early development (about stage 25), the tadpoles' bodies and tail muscles are black with tiny gold dots. The overall dorsal effect is velvety dark olive in *R. chiricahuensis* or dark grayish black in *R. berlandieri*. The venter is opaque white to pale gray with large bronze blotches in both species. The tail musculature is clear to olive with scattered black dots. Golden spots are present on the dorsal tail muscle in *R. berlandieri*. Tail fins are clear to translucent yellow-olive with black dots denser on the dorsal fin. A few bronze flecks may be present on the ventral fin near its base. As the tadpoles grow, more pigment is produced and a pattern becomes evident. Apparently, patterns are formed by the coalescence of discrete dots into spots and blotches,

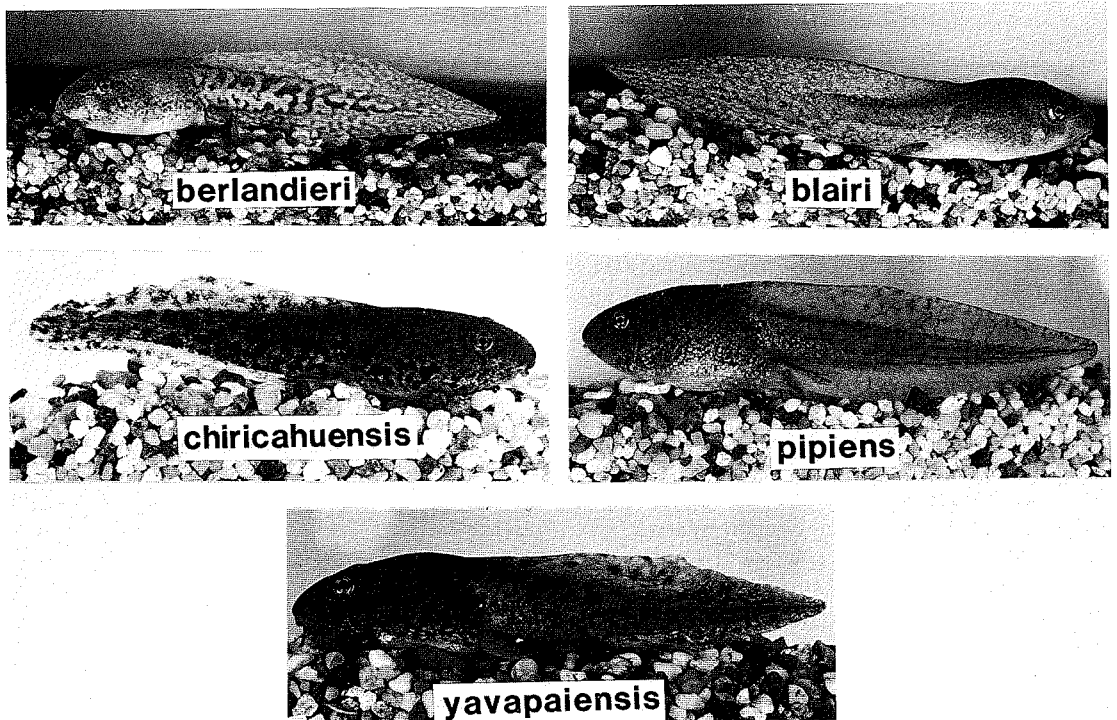
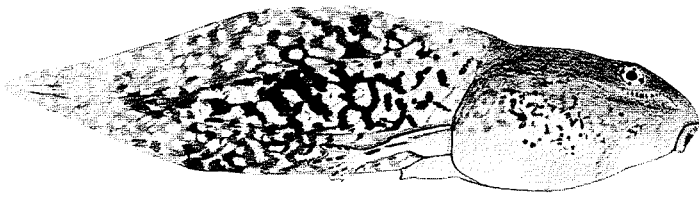
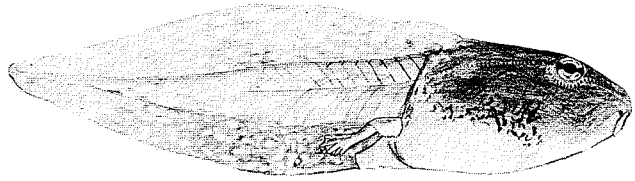


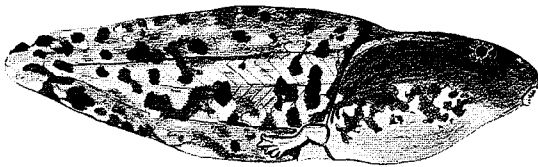
Figure 3. Photographs of live *Rana* tadpoles. *R. berlandieri* stage 39, New Mexico: Eddy County, near McKittrick Spring. *R. blairi* stage 39, New Mexico: Lea County, about 10 km W Crossroads. *R. chiricahuensis* stage 38, New Mexico: Catron County, Tularosa River 2 km E Aragon. *R. pipiens* stage 39, New Mexico: Sandoval County, 5.6 km S Cuba. *R. yavapaiensis* stage 41, Arizona: Greenlee County, Turkey Creek 9 km W Juan Miller crossing of Blue River.



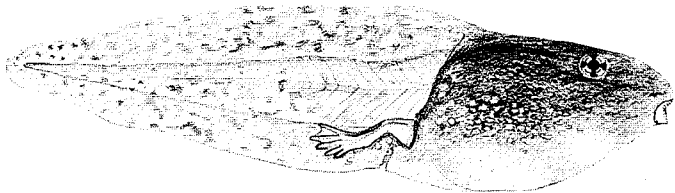
berlandieri



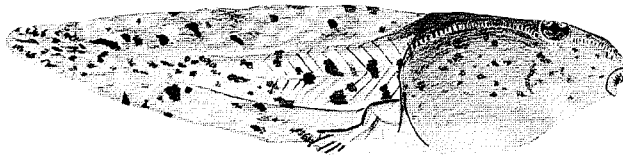
blairi



chiricahuensis



pipiens



yavapaiensis



Figure 4. Camera lucida drawings of leopard frog tadpoles showing shapes and color patterns. The following numbers are the total length and body length in mm and Gosner stage for each species: *Rana berlandieri* 90, 30, 40; *R. blairi* 81, 28, 38; *R. chiricahuensis* 72, 27, 39; *R. pipiens* 83, 29, 40; *R. yavapaiensis* 81, 28, 39. Localities as in Fig. 3.

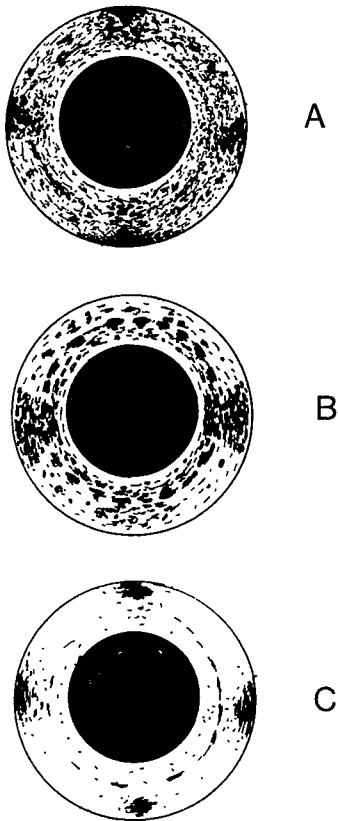


Figure 5. Diagrams of leopard frog tadpole iris patterns. A = *Rana chiricahuensis*, B = *R. blairi*, C = *R. berlandieri*. Localities as in Fig. 3.

and further into mottling and reticulations. The most striking and bold patterns occur in tadpoles immediately prior to the eruption of the forelimbs. In *R. blairi* and *R. pipiens*, and to a slight degree in *R. berlandieri*, melanic patterns in the posterior half of the tail may become quite black beginning at about stage 39 (large hind limbs). This does not happen in all tadpoles of a population however.

Generally, tadpoles kept in the dark are darker; an exception is when young tadpoles turn black upon exposure to sunlight. Dark substrates and cool water also tend to darken tadpoles.

Color and Pattern in Life

The following color descriptions are taken from living tadpoles in stages 39–41 and relaxed in

chloretone. We usually only had live tadpoles from one locality and a single representative specimen was chosen from each series. We have limited experience with the variation in color between different sites and habitats, but we do not believe that it is enough to obscure the observed specific differences.

Rana berlandieri stage 40; body length 32 mm; total length 95 mm: body dorsum and sides olive with a yellowish cast; spots on sides gray; belly and throat white. Tail musculature pale gray with dark olive vermiculate reticulations; large bronze blotches on base, yellowish distally; tail fins translucent with large pale blotches; some bronze blotches on base. Peritoneum of lateral body wall black dorsally, shading to gray midlaterally, and white ventrally; peritoneum covering the dorsal body musculature dark gray; lungs black. Iris essentially gold with black flecks, with black showing through in four spots.

Rana blairi stage 40; body length 27 mm; total length 81 mm: body dorsum and sides olive with numerous obscure dark dots giving a gray-brown effect; belly and throat shiny white with pinkish-bronze reflections ventrolaterally. Tail musculature pale olive with large bronze blotches; tail fins clear olive with indistinct bronze blotches giving an appearance of pale spots; entire tail covered with indistinct dark smudges and blotches. Peritoneum of lateral body wall black dorsally shading to gray laterally and white ventrally; peritoneum covering dorsal body muscle black; lungs dark gray. Iris black with gold flecks; flecks densest around pupil. No cross-like pattern in iris.

Rana chiricahuensis stage 41; body length 27 mm; total length 80 mm: body dorsum dusky olive-gray with very faint dark spots; lateral field olive with large black spots tending to be fused; large bronze blotches ventrally; venter grayish white with a pinkish-bronze sheen. Tail muscle dark olive-gray with large dull olive blotches, tending to coalesce, and bronze dots; tail fins yellow-olive with gray spots; bronze dots on ventral fin and tail tip. Lateral body wall peritoneum black dorsally, shading to gray laterally and pale gray ventrally; peritoneum covering body muscle black; lungs black. Iris bronze with black crossbar and black spots dorsally and ventrally forming a cross-like pattern.

Rana pipiens stage 39; body length 28 mm; total length 83 mm: body dorsum dark olive-gray

with obscure charcoal spots; midlateral field a mix of poorly defined charcoal, olive, and pinkish-bronze blotches, large obscure bronzy-olive pale spots on sides of head; venter white with pink-bronze sheen; yellowish cast to clear tissue around anus. Tail muscle gray with obscure dark flecks evenly scattered; some obscure light spots on ventral muscle especially near body; tail fins clear gray-olive with numerous evenly dispersed charcoal spots. Lateral body wall peritoneum dark gray dorsally, gray laterally, and white ventrally; peritoneum over body muscle pale gray; lungs gray. Iris gold with black cross-like pattern similar to that of *R. chiricahuensis*.

Rana yavapaiensis stage 39; body length 25 mm; total length 77 mm: body dorsum dusky yellow-olive; laterally paler with obscure dark spots; venter white with yellowish cast to throat. Tail muscle olive-gray with scattered dark gray spots; tail fins dusky yellowish white with discrete gray spots. Peritoneum of body wall black dorsally, dark gray laterally, and white ventrally; peritoneum over body muscle medium gray; lungs black. Iris bronze with crossbar and dorsal and ventral spots forming a black cross-like pattern similar to that of *R. chiricahuensis*.

Color and Pattern in Formalin

When a tadpole is placed in formalin, much of its color is leached out within about a week. The lipophores, responsible for the yellow and green tones, and guanophores, which produce the bronze and white colors, lose their color, leaving a tadpole in which the melanin pattern is distinct. In some species, most notably *R. blairi* and *R. pipiens*, much of the body wall becomes transparent, thereby exposing either the melanin in the sheathing parietal peritoneum, the rectus abdominis muscle, or the intestine itself.

Rana berlandieri: body dorsum dark gray with numerous poorly defined black punctations, dorsolateral white muscle bundles somewhat obscure; venter grayish white or clear with faint trace of muscle bands posteriorly. Tail musculature white for about one-half of its length, remainder gray, all overlain by discrete black spots or a thick black reticulation; pattern obscure at the tail base, becoming darker distally; fins with a coarse mottle composed of about equal proportions of dark gray, light gray, and clear spots.

Rana blairi: body dorsum light gray with black patches over dorsolateral part of intestinal cavity, dorsolateral white muscle bundles clearly visible; venter pale gray or clear, intestines clearly visible; tail musculature white, mottled with gray on posterior one-half; fins covered with a mottle of gray and clear spots, lower fin darker.

Rana chiricahuensis: body dorsum dark gray with numerous black blotches becoming more conspicuous laterally, dorsolateral white muscle bundles appear as white dorsolateral stripes; venter gray with white transverse bands of muscle posteriorly; tail musculature gray with large dark gray blotches tending to coalesce; fins clear gray with large dark gray blotches tending to coalesce.

Rana pipiens: body dorsum light gray with indistinct dark spots, dorsolateral white muscle bundles clearly visible, black patches over lateral body wall; venter clear, intestines clearly visible; tail musculature white, mottled with gray on posterior one-half, with tendency to form reticulations; fins with a fine mottle of clear and gray, lower fin somewhat darker.

Rana yavapaiensis: body dorsum and sides dark gray with faint darker mottling, dorsolateral white body muscles scarcely visible; venter dark gray with intestines faintly visible anteriorly but covered with white transverse bands of muscles posteriorly, throat and region around cloaca paler; tail musculature gray with evenly spaced discrete dark spots; fins gray with sparse dark and clear spots.

Differences Among the Species

The most striking differences among the species occur in the color patterns of the tails of large larvae (Figs. 3 and 4). Most of these patterns consist of melanin and are visible, although to differing degrees, in live and preserved material.

A progression of sorts exists in the dispersion and intensity of the tail pattern in the various species. *Rana blairi* has the palest and most uniform coloration. On close inspection, a large number of clear dots and spots spatter the tail fins, but the intervening melanic spots are so pale that the contrast is slight. *Rana pipiens* is slightly less pale and has a less uniform color pattern. However, the tail of *R. pipiens* has large clear spots and darker melanic patches, so the effect is a less uniform mottle than in *R. blairi*. These two

species are the most difficult to distinguish, especially in faded or young material. *Rana berlandieri* is intermediate, but even in medium-sized tadpoles, a dark spotted or reticulated pattern is evident between the large, pale-bronze or clear blotches on the tail. *Rana yavapaiensis* and *R. chiricahuensis* are dark tadpoles, especially when first caught. Their color patterns differ in the size and number of charcoal-colored spots on the tail. *Rana yavapaiensis* has fewer, more discrete spots measuring 1–2 mm; *R. chiricahuensis* has more and larger blotches, up to 3 mm in diameter, which tend to coalesce or become blurred.

Body color patterns are less distinct and the differences tend to disappear in preservative. The most striking are the black and bronze blotches on the side of *R. chiricahuensis*. These are retained as discrete spots on the body in faded material. *Rana yavapaiensis*, the most similar tadpole in overall color and pattern, lacks the prominent bronze blotches and the dark spots are smaller and more obscure. The sides of the body in *R. pipiens* bear a salt-and-pepper pattern of a dark

ground color, melanic spots, and pale guanic spots. The bodies of *R. berlandieri* and *R. blairi* are relatively unpatterned.

Analysis of Shape

Studying tadpole shapes is an elusive exercise. Soft tissue measurements are difficult to replicate precisely and accidents during development are reflected in tail measurements, possibly without an obvious trace. However, analyses of large samples enabled us to characterize the shapes of the five species. Lateral views of the tadpoles are shown in Figs. 3 and 4 and dorsal body outlines are shown in Fig. 6.

Summary statistics and a Duncan's Multiple-range Test of selected ratios for tadpoles in stages 38–42 are given in Tables 1 and 2. Tadpoles in these stages have almost ceased to grow, and we believe that lumping these stages in a single analysis of tadpole shape is justified.

Rana berlandieri: this tadpole is intermediate in most shape characters. In side view, it has a

Table 1. Means (mm) and standard deviations (in parentheses) of measurements and ratios of measurements of five species of leopard frog tadpoles in Gosner stages 38–42 with a body length range of 26–33 mm. * = significantly different from all other species by Duncan's Multiple-range Test.

	<i>berlandieri</i>	<i>blairi</i>	<i>Rana chiricahuensis</i>	<i>pipiens</i>	<i>yavapaiensis</i>
N	11	24	20	39	4
MEASUREMENTS					
Body length (BL)	29.8 (1.0)	29.1 (1.9)	29.0 (1.5)	29.5 (1.2)	27.5 (0.6)*
Tail length (TAL)	58.1 (3.1)	58.5 (4.1)	51.6 (4.6)	59.4 (3.2)	50.8 (4.2)
Tail depth (TD)	21.6 (1.8)	23.1 (1.8)	20.6 (1.8)	21.4 (1.7)	16.0 (2.8)
Eye diameter (ED)	4.1 (0.2)	4.3 (0.3)	4.3 (0.2)	3.9 (0.2)	3.7 (0.2)
Mouth width (MW)	5.6 (0.3)	5.3 (0.4)	5.5 (0.5)	5.3 (0.3)	6.2 (0.4)
Tail muscle width (TMW)	8.7 (0.5)	9.2 (0.7)	9.7 (0.7)	8.4 (0.7)	8.7 (0.4)
Tail muscle depth (TMD)	9.6 (0.7)	9.9 (0.6)	11.4 (1.0)	10.2 (0.7)	9.3 (0.2)
RATIOS					
TAL/BL	1.95 (0.09)	2.01 (0.09)	1.77 (0.11)	2.01 (0.10)	1.84 (0.13)
TD/BL	0.72 (0.06)	0.79 (0.05)*	0.72 (0.03)	0.73 (0.04)	0.58 (0.09)*
ED/BL	0.14 (0.01)	0.15 (0.01)	0.15 (0.01)	0.13 (0.01)	0.13 (0.00)
MW/BL	0.19 (0.01)	0.18 (0.01)	0.19 (0.01)	0.18 (0.01)	0.23 (0.01)*
TMW/BL	0.29 (0.01)	0.32 (0.02)	0.33 (0.02)*	0.28 (0.02)	0.32 (0.01)
TMD/BL	0.32 (0.02)	0.34 (0.02)	0.39 (0.02)*	0.34 (0.02)	0.34 (0.00)

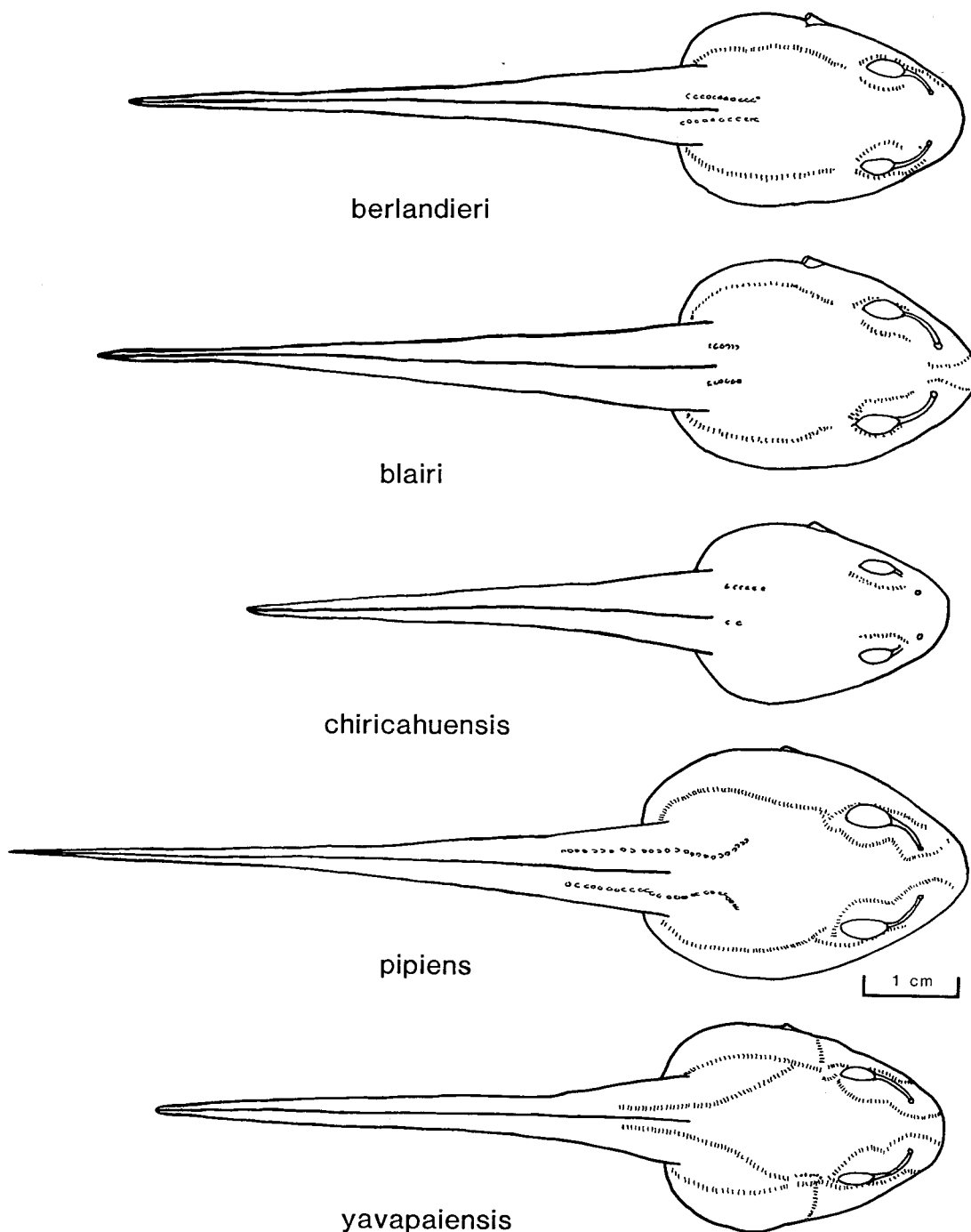


Figure 6. Camera lucida diagrams showing dorsal body shape, the orbitonasal canal, and the parts of the lateral line system usually visible underwater at $6\times$ magnification. Differences in tadpole shapes are seen best in healthy, well-fed, large specimens. Localities as in Fig. 3.

Table 2. Summary of statistical differences among selected measurements and ratios of measurements of tadpoles of five species of leopard frogs in Gosner stages 38–42. Species sharing the same line are not significantly distinct ($P > 0.05$) by Duncan's Multiple-range Test. BER = *berlandieri*, BLA = *blairi*, CHI = *chiricahuensis*, PIP = *pipiens*, and YAV = *yavapaiensis*. See Table 1 for actual measurements and sample sizes.

BODY LENGTH (BL)				
Short YAV	CHI	BLA	PIP	Long BER
TAIL LENGTH/BL				
Short-tailed CHI	YAV	BER	BLA	Long-tailed PIP
TAIL DEPTH/BL				
Shallow tail YAV	CHI	BER	PIP	Deep tail BLA
EYE DIAMETER/BL				
Small eye PIP	YAV	BER	BLA	Large eye CHI
MOUTH WIDTH/BL				
Narrow mouth PIP	BLA	BER	CHI	Wide mouth YAV
TAIL MUSCLE WIDTH/BL				
Narrow muscle PIP	BER	YAV	BLA	Wide muscle CHI
TAIL MUSCLE DEPTH/BL				
Shallow muscle BER	YAV	BLA	PIP	Deep muscle CHI

long, slim body, and relative tail muscle depth is smallest but not significantly so. The body shape viewed from above is the slimmest and most elongate of any species. This gives the appearance of a tadpole with an exceptionally long tail, but this is not reflected in the measurements. The tail fin is moderately thick, not as thick as that of *chiricahuensis* and *yavapaiensis*, but not as thin as that of *blairi* and *pipiens*.

Rana blairi: this species has the deepest tail; the ratio of tail depth to body length is significantly larger than in the other species. Like *R. berlandieri*, it has a long, slim body when viewed from the side. Body shape viewed dorsally is oval. It is the only species that is wider at midbody than it is further back. The tail fin membrane is thin.

Rana chiricahuensis: this species is characterized by a small body, small outer tail dimensions, and a relatively large tail muscle, eye, and mouth. Proportionate to the body length, the tail muscle is significantly wider and deeper than any other species and the body is relatively deep. The body in dorsal view is triangular with slight indentations at the level of the eye that tend to separate the head from the abdomen. When viewed from above, the wide tail muscle is apparent and the tail fin membrane appears thick and sturdy.

Rana pipiens: this tadpole is average in most body and outer tail dimensions, but it has a relatively narrow tail muscle, eye, and mouth, and a deep body. Seen from above the body is heart-shaped and the snout is unusually pointed. The tail muscle is quite narrow and the tail fin membrane is filmy.

Rana yavapaiensis: these tadpoles resemble *R. chiricahuensis* in most characters. However, they have significantly shallower tails and wider mouths

than any of the other species. Body shape is similar to that of *R. chiricahuensis*, with a slight distinction between the head and body, but the snout is blunter. The tail fin is thick.

Lateral Line Organs and Orbitonasal Canal

New Mexican leopard frog tadpoles show the basic ranid pattern (Noble 1931) in the lateral line system, which is expressed as rows of pellucid dots or "stitch" marks on the head, body, and tail base (Fig. 6). An orbitonasal canal is present as a clear streak from eye to nostril on each side. The species vary in the degree of expression of these systems and this variation can be used for identification. The following descriptions are based on Table 3. All species probably have the same lateral line pattern, but the size of the individual organs and the distribution of the surrounding skin pigmentation determines the relative visibility of the system.

Rana berlandieri: the orbitonasal canal is very clear. The lateral line system on the head is usually only partly visible and the supraorbital branch is significantly less apparent than in other species.

Rana blairi: the two systems are usually fairly obvious. The dorsal branch of the lateral line system tends to be obscure, but all other branches except the angular are usually mostly visible.

Rana chiricahuensis: the lateral line system and orbitonasal canals are largely obscured by pigment. The lateral branch is significantly less distinct than in all other species and usually cannot be detected.

Rana pipiens: the systems are fairly distinct and all branches, except the angular, are usually visible. The anterior sections of the dorsal branch were most obvious in this species and the next.

Table 3. Mean (standard deviation) percent of each branch of the lateral line system easily visible under 6× magnification in five species of New Mexican leopard frogs. * = mean significantly distinct by Duncan's Multiple-range Test.

<i>Rana</i>	N	Supraorbital	Infraorbital	Angular	Lateral	Dorsal
<i>berlandieri</i>	6	35 (41)*	22 (39)	0	62 (34)	42 (31)*
<i>blairi</i>	10	98 (6)	78 (37)	0	94 (7)	17 (19)
<i>chiricahuensis</i>	10	65 (24)	8 (18)	0	8 (19)*	1 (3)
<i>pipiens</i>	10	78 (30)	49 (40)	0	51 (37)	71 (25)*
<i>yavapaiensis</i>	4	100 (0)	100 (0)	88 (25)*	100 (0)	100 (0)*

Rana yavapaiensis: these tadpoles are best distinguished from the other species by their prominent lateral line system. They were the only species in which the angular branch could be seen, and almost all parts of the other branches were obvious.

Mouthparts

The modal mouthparts of all five species are similar, only differing statistically. The oral disc is fringed with papillae along its ventral (or posterior) and lateral borders; the dorsal (or anterior) border along the the upper labium is unornamented. Species differ somewhat in the relative size, number, and pigmentation of the papillae (Fig. 7).

The basic tooth row pattern is the same in all species, with an undivided row on the upper labium and a divided row beneath; there are three rows on the lower labium, the first row is divided and the other two are not. The horny beak is similar in all species and differs only in the extent of wear on its cutting margins. However, ecological conditions and variations in develop-

mental patterns produce a rather wide variety of tooth row patterns, especially on the upper labium. This variation can help identify a given tadpole population and is described for each species (Table 4).

Rana berlandieri: the oral disc has a single, marginal row of relatively long, clear papillae, with a second and partial third row on the lateral fields of the disc. There is a marked tendency to form a third split tooth row on the upper labium. As a tadpole cohort grows, more individuals develop at least a partial third tooth row, reaching a maximum frequency of 65% in tadpoles approaching metamorphosis. Third tooth row development can be quite asymmetric; 20% of the large, premetamorphic tadpoles had a third row on only one side of the upper labium.

Rana blairi: the papillae are relatively small and clear and more numerous than in *R. berlandieri*, and the area of the oral disc lateral to the beak tends to become filled with papillae. There is a tendency to form a third tooth row on the upper labium, but not to the same degree as in *R. berlandieri*. In our series of large tadpoles (Gosner stages 37–41), this third row was often

Table 4. Percent of tadpoles having indicated number of tooth rows on upper labium of five species of leopard frogs. Stages are according to Gosner (1960). Half tooth rows, indicated by .5, are those normally divided rows that have teeth on only one side of the labium.

<i>Rana</i>	N	Number of Tooth Rows				
		1	1.5	2	2.5	3
<i>berlandieri</i>						
Stages 25–26	35	3	3	69	20	6
Stages 27–32	78	0	0	42	28	29
Stages 38–41	20	0	0	35	20	45
<i>blairi</i>						
Stages 25–31	33	6	0	94	0	0
Stages 37–41	25	0	0	40	36	24
<i>chiricahuensis</i>						
Stages 25–26	25	60	28	12	0	0
Stages 28–32	19	26	32	42	0	0
Stages 36–40	28	7	39	54	0	0
<i>pipiens</i>						
Stages 26–33	10	0	0	100	0	0
Stages 39–41	35	0	3	89	9	0
<i>yavapaiensis</i>						
Stages 39–42	4	0	0	75	0	25

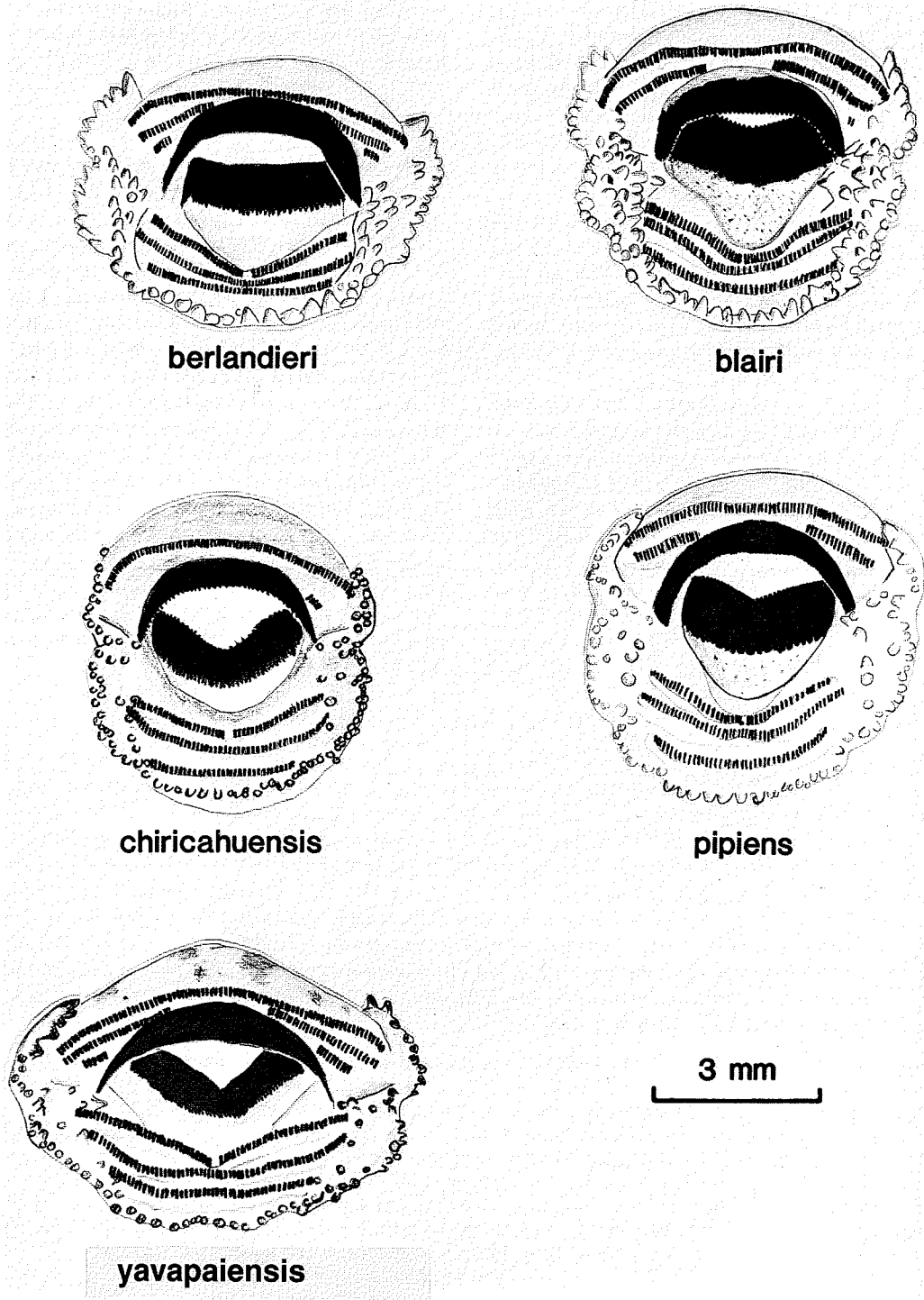


Figure 7. Camera lucida diagrams of mouthparts of leopard frog tadpoles (*Rana*). Localities as in Fig. 3.

expressed by only one or two teeth; the most third-row labial teeth present in any specimen was 8, 2 on one side and 6 on the other. The tooth rows of *R. blairi* in our samples tended to be more ragged than those of other tadpoles both because of missing teeth and teeth of different lengths. This species also tends to lose labial teeth earlier in metamorphosis.

Rana chiricahuensis: the oral papillae are relatively small and sparse inside the margin of the oral disc and may be pigmented or clear. In contrast to the other species, *R. chiricahuensis* never has a third tooth row on the upper labium; on the contrary, some individuals never even develop a second row.

Rana pipiens: in this species, the colorless, medium-sized oral papillae are sparse inside of the marginal row. Most *R. pipiens* tadpoles have the standard tooth row formula, but a few have some teeth on one side or another of the third row. None of the specimens we examined had teeth on both halves of this row.

Rana yavapaiensis: our small sample shows that it has the fewest papillae inside the oral margin of any of the five species and that a well-developed third tooth row may be present. The

marginal papillae are usually well pigmented in contrast to those of the other species which tend to have little or no pigment.

Ventral Muscle Sheath

When tadpoles are first preserved, the abdominal body wall is opaque, largely because of guanophores and lipophores. The pigments are mostly dissolved within a few weeks time, leaving much of the abdominal wall clear and the intestines visible. The posterior half of the abdominal cavity is covered by sheaths of the rectus abdominis muscle. In *R. chiricahuensis*, muscles pertaining to at least the four most posterior myomeres are so thick that, in preservative, they may obscure the intestine (Fig. 8A). In *R. pipiens*, on the other hand, the rectus abdominis is nothing more than a thin transparent sheet, and only a shadow of the most posterior myomere can be distinguished (Fig. 8B). The other three species form a graded series between these extremes. *Rana blairi* usually shows signs of three translucent posterior myomeres, *R. yavapaiensis* two or three myomeres, and *R. berlandieri* two almost clear muscle bundles.

Key to the *Rana* Tadpoles of New Mexico

In New Mexico, ranid tadpoles differ from hylids (*Acris*, *Hyla*, *Pseudacris*) by having a lateral infolding of the oral disc at each corner of the mouth (Fig. 7); hylids lack this emargination. Tadpoles of the genus *Bufo* (Bufonidae) lack marginal papillae on the lower labium for a distance at least as long as the lowermost tooth row. The third anuran family with tadpoles in New Mexico, the Pelobatidae (*Scaphiopus*) has at least four tooth rows on the lower labium; ranids never have more than three.

The following key includes the bullfrog (*Rana catesbeiana*), the only non-leopard frog member of the genus *Rana* known from New Mexico. The key is based on large tadpoles (stages 36-42), either live or well-preserved. The iris characters can be seen only in live or freshly killed animals. Definitions of terms used to describe color patterns are given in the methods section. Lateral line and orbitonasal canal characters were examined under 6x magnification. A tabular summary of characteristics is also helpful in tadpole identification (Table 5).

1. Body and tail covered with distinct, discrete, black dots less than 1 mm in diameter; body length greater than 34 mm at metamorphosis **R. catesbeiana**
 Body and tail often bearing blotches or mottling, but never tiny, distinct, evenly-spaced dots; body length less than 34 mm at metamorphosis **Leopard frogs. 2.**
2. Body and tail sparsely covered with distinct dark spots 1-2 mm in diameter that rarely fuse into larger spots; mouth wide, 22% or more of body length; marginal oral papillae pigmented; lateral line system distinct on head and body; third upper tooth row occasionally well developed; belly dark because of peritoneal melanin **R. yavapaiensis**
 Body and tail covered with various types of mottling and reticulation but not discrete spots; mouth narrow, less than 22% of body length; marginal oral papillae pigmented or not; lateral line system distinct or not; third upper tooth row present or not; belly dark, pale, or clear **3.**

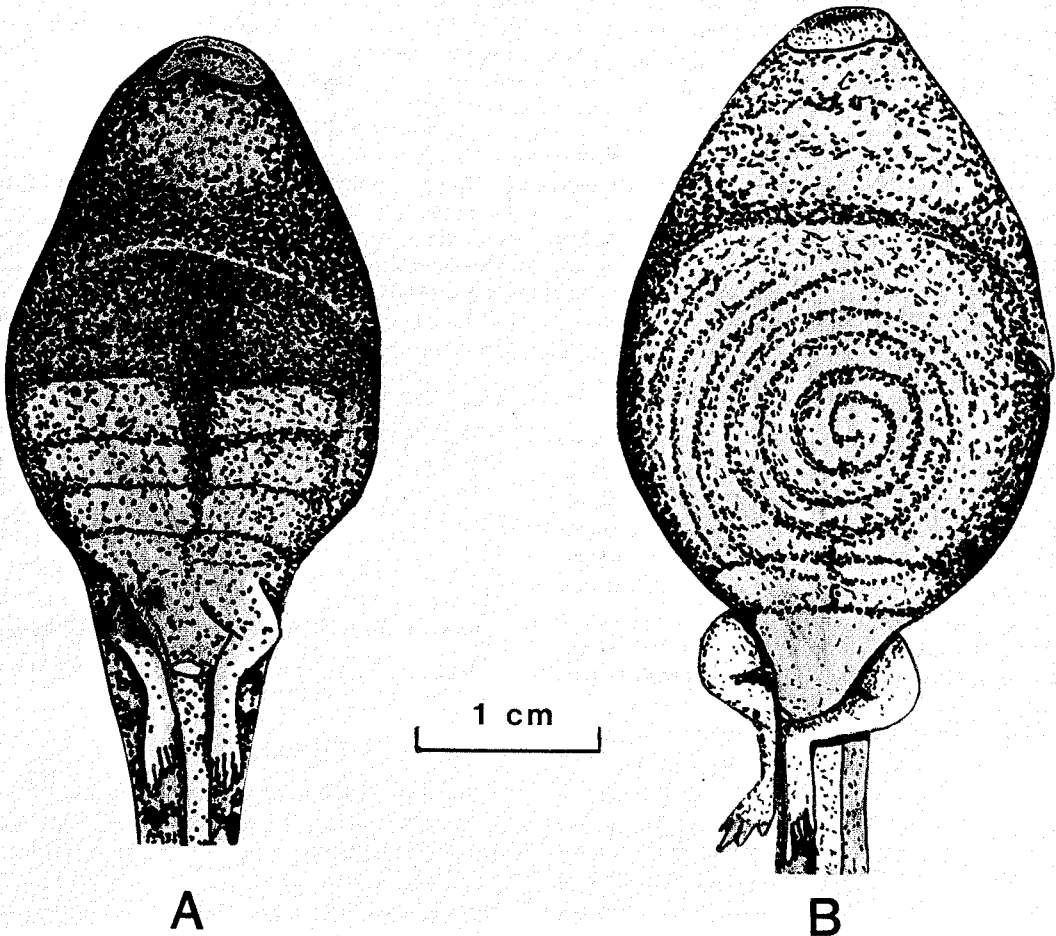


Figure 8. Camera lucida diagrams showing the relative opacity of the rectus abdominis muscle in *Rana chiricahuensis* (A) and *R. pipiens* (B) tadpoles. Localities as in Fig. 3.

- 3. Third upper tooth row never present, some individuals in a sample with only one upper tooth row; oral papillae pigmented or not; tail and body covered with large, dark blotches that tend to fuse into a mottled pattern which is especially striking on the sides of the body; lateral line system usually visible only on head; belly dark or clear; tail muscle exceptionally wide and deep; 3-4 myomeres of ventral muscle sheath opaque, obscuring intestine **R. chiricahuensis**
- At least a few labial teeth in the third upper tooth row present in some individuals in a sample of large tadpoles; large tadpoles with a single upper tooth row rare, usually found only in cases of extreme tooth wear; oral papillae not pigmented; color pattern varied; lateral line system more or less obvious; belly pale or clear; tail muscle wide or narrow, not exceptionally deep; ventral muscle sheath thin and translucent, not obscuring intestine 4.
- 4. Tail color pattern discrete dark and pale spots or a striking, sharply defined reticulation of dark figures enclosing pale blotches, especially on the muscle; distal half of tail not markedly darker approaching metamorphosis; a large number (often greater than 50%) of any sample with three well-developed upper tooth rows; lateral line system obscure, especially on the head **R. berlandieri**

- Tail color pattern obscure or mottled with indistinct blotches; distal half of tail in many individuals much darker approaching metamorphosis; much less than 50% of a sample with three well-developed upper tooth rows; lateral line system more or less obvious5.
5. Color pattern uniform or consisting of a fine mottle made up of fine, indistinct light and dark spots, body unspotted; many specimens with a few labial teeth in the third tooth row on the upper labium; lateral branch of lateral line system usually obvious and dorsal branch usually obscure; dorsal parietal peritoneum dark gray to black; iris in life without a cross-like pattern; tail exceptionally deep, tail muscle exceptionally wide **R. blairi**
- Color pattern variable, usually some with a coarse mottle made up of distinct dark spots, body usually spotted; usually lacking a third upper tooth row; lateral branch of lateral line system often obscure and dorsal branch obvious; dorsal parietal peritoneum pale gray; iris in life with a dark cross-like pattern; tail not exceptionally deep, tail muscle narrow**R. pipiens**

Breeding Seasons in New Mexico

In order to estimate the phenology of breeding seasons of New Mexican leopard frogs, the developmental classes represented in the MSB egg and tadpole collections were plotted by month (Table 6). There were no New Mexican collections for *R. yavapaiensis*. Although broad geographic areas and wide elevational differences are represented and the sampling was uneven through the year and inadequate for many periods, several trends can be discerned.

Rana berlandieri and *R. blairi* show similar patterns. The presence of small and medium-sized tadpoles in April probably indicates breeding as early as March, or perhaps February. There is no evidence that eggs are laid any later than August. There may be fewer egg clutches laid in May and June, especially by *Rana blairi*, but this may also be an artifact of our small number of samples. *Rana chiricahuensis* has a longer breeding season, at least February through September and perhaps year-round in some habitats. With this species there is also evidence of reduced oviposition in May and June. *Rana pipiens* apparently shows the clearest pattern of a strong spring (April-June) egg-laying period and a less important fall (September) period. Based on the presence of large tadpoles in the late winter and spring and evidence of late summer and fall breeding, all the New Mexican species studied, except possibly *R. pipiens*, sometimes overwinter as tadpoles.

Springs form an important segment of the breeding habitat of both *R. belandieri* and *R. chiricahuensis* in New Mexico. These habitats provide several advantages to the frogs, including a year-round flow of constant temperature water and a depauperate fish community. The relatively

warm winter water temperatures permit year-round adult activity and winter breeding, especially noticeable in *R. chiricahuensis*.

All the tadpoles examined at the MSB were probably taken from sites that harbored a single leopard frog species, and breeding season restrictions reported by Hillis (1981) and Frost and Platz (1983) for species found in sympatry were not observed. Greater differences in breeding seasons may be expected between species at sympatric localities in New Mexico.

Tadpole Habitats

In New Mexico, leopard frog tadpoles are found in a wide variety of waters; in fact, any fresh water that is relatively free of vertebrate predators (fish, salamander larvae) or has refuge areas for tadpoles (shallow water, flooded vegetation), and that persists for the 2-6 months necessary for the completion of egg and tadpole stages. However, each species seems to have different "preferences" for certain kinds of waters. In Nebraska, Lynch (1978) found that, in areas of sympatry, *R. blairi* was associated with turbid water and *R. pipiens* with clear water. Hillis (1981) stated that *R. berlandieri* in Texas was primarily a stream breeder whereas *R. sphenoccephala* and *R. blairi* most commonly bred in standing water. Comparing the last pair in Texas and Oklahoma, Hillis (1981) found that *R. blairi* was most often found in warm, turbid pools while *R. sphenoccephala* used clear, cool waters. Using the presence of transformed frogs to estimate differences in larval water requirements is risky, but the data on adult frogs collected by Frost and Bagnara (1977) are useful in the present discussion. They found that in an area of sympatry in Arizona, *R. blairi* was

Table 5. Characters useful in the identification of tadpoles of five species of leopard frogs (*Rana*) in New Mexico.

	<i>berlandieri</i>	<i>blairi</i>	<i>chiricahuensis</i>	<i>pipiens</i>	<i>yavapaiensis</i>
Tail	large dark and pale spots or a coarse dark reticulation enclosing large pale spots	fine indistinct mottling; palest species; distal half of tail tends to darken approaching metamorphosis	numerous dark blotches which may coalesce; darkest species	coarse indistinct mottling; distal half of tail tends to darken approaching metamorphosis	sparse discrete dark blotches
	depth medium, 65–80% of body length	deep, 70–90% of body length	depth medium, 60–80% of body length	depth medium, 65–80% of body length	shallow, 50–65% of body length
	muscle narrow, 26–31% of body length	muscle wide, 29–35% of body length	muscle wide, 29–36% of body length	muscle narrow, 22–32% of body length	muscle width medium, 31–33% of body length
	muscle depth medium, 28–35% of body length	muscle depth medium, 31–39% of body length	muscle deep, 34–42% of body length	muscle depth medium, 28–39% of body length	muscle depth medium, 34% of body length
Labial teeth	about half of all large tadpoles with three partial or complete rows	partial third row present in about half of all large specimens, but usually consisting of not more than one to three labial teeth on either or both sides	one or two rows on upper labium, never three	usually two rows on upper labium; rarely a partial third row	two or three rows on upper labium
Oral papillae	relatively long and moderately dense lateral to the beak; mostly unpigmented	relatively small and densely packed lateral to beak; mostly unpigmented	relatively small and sparse in area lateral to beak; mostly unpigmented	medium-sized and sparse lateral to beak; mostly unpigmented	small and very sparse lateral to beak; many with dark pigment on tips
Mouth shape	narrow, less than 22% of body length	narrow, less than 22% of body length	narrow, less than 22% of body length	narrow, less than 22% of body length	wide, greater than 21% of body length
Lateral line	most branches visible on face and on base of tail	dorsal branch usually visible	most obscure, often not visible	most branches usually visible	all branches obvious, including the angular
Iris	pale gold with dorsal, ventral, and lateral dark spots	medium-gold, lacking dorsal and ventral dark spots	dark with lateral, dorsal, and ventral dark spots	gold with dorsal, lateral, and ventral dark spots	dark with lateral, dorsal, and ventral dark spots
Peritoneum	black dorsally, white ventrally	black dorsally, white ventrally	black dorsally, gray ventrally	gray dorsally, white ventrally	black to gray dorsally, white ventrally
Ventral muscle sheath	two myomeres almost clear but visible	three myomeres translucent, visible	four myomeres opaque	ventral myomeres clear, almost invisible	two or three myomeres translucent, visible

Table 6. Phenology of tadpoles of leopard frogs in New Mexico. *Small* are hatched tadpoles less than 25 mm total length, *Medium* 25–50 mm, *Large* more than 50 mm, and *Transforming* Gosner stages 40–42. There are no records for December and January. Each “x” represents a separate collection of the developmental class. We have no *R. yavapaiensis* tadpoles from New Mexico.

Developmental Class	Months									
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
<i>Rana berlandieri</i>										
Eggs			x				x			
Small			xxxx		x		x			
Medium			xxx		x		xx		x	x
Large			xxxxxxx		x		xxx		x	xx
Transforming			x				xxx			
<i>Rana blairi</i>										
Eggs				x						
Small										
Medium			x	xx			xx			
Large			x	x	x		xxx	x		
Transforming				x	x		xx			
<i>Rana chiricahuensis</i>										
Eggs			x					x		
Small			xx				xxxx	xxxxxx		
Medium	x		x	xx	xx	x	xxxxx	xxxxxx		x
Large	x	xx	xx	xx	x	xx	xxxx	xxxx		
Transforming	x	xx	x	x	xxxx	xx	xxx	xx		
<i>Rana pipiens</i>										
Eggs			x	x				x		
Small			x	x	x	xx			x	
Medium				xx	xxxx	xxxx			x	
Large				xxxx	xxxxx	xxx	xxx			x
Transforming					x	x	xxxxx	x		

more common in temporary and semi-permanent tanks and sloughs, whereas *R. chiricahuensis* pre-dominated in permanent tanks and streams.

Rana berlandieri habitat in New Mexico receives little rainfall, but the limestone mountains give rise to numerous springs and spring-fed streams. The majority of our records came from the springs themselves; the others came from permanent spring-fed rivers and streams and a pool in a temporary streambed.

Rana blairi occurs in an area that is dotted with

playa lakes of variable duration. Man has increased this type of habitat by damming arroyos to catch runoff and form stock tanks. The *R. blairi* collection records are about evenly divided between rivers and ponds in temporary streambeds, either natural or man-made.

Rana chiricahuensis in the northern part of its New Mexican range (Socorro and Catron Counties) is associated with streams, rivers, and springs, (especially warm springs) and all of our collections have come from these habitats. However,

juvenile and adult *R. chiricahuensis* are often common in stock tanks in Grant and Hidalgo Counties where flowing water is probably not available for breeding, and they probably reproduce in these tanks as they do in Arizona (Frost and Bagnara 1977).

Rana pipiens tadpoles are found in a wide variety of habitats. Streams and rivers are most commonly used but lakes, marshes, and irrigation ditches also contain tadpoles. Much of the river valley habitat of these frogs has been modified by human activities, including draining of wetlands, channelization and damming of rivers, and the development of irrigation systems. On the other hand, the mountainous portion of this species' range has been disturbed only by grazing and logging, and the frog habitats there remain largely unchanged.

We have no *R. yavapaiensis* tadpoles from New Mexico. Locality records for transformed frogs of this species, our Arizona experience, and that of Frost and Platz (1983) indicate that the tadpoles are found in much the same habitats as those of *R. chiricahuensis*.

The ecological notes that accompany many specimens are often incomplete. For example, from a locality description of the "Pecos River," it cannot be determined whether a specimen was collected in still pools adjacent to the river or in areas with current. However, the following general statements can be made about leopard frog larval habitats in New Mexico. *Rana berlandieri* is most common in springs and streams, *R. blairi* is most common in muddy tanks and rivers, *R. chiricahuensis* and *R. yavapaiensis* are most often found in clear streams and rivers, and *R. pipiens* inhabits the clear waters of streams, lakes, and marshes. These observations are consistent with the meager data available from other studies.

Comparison with Previous Studies

Korky (1978) studied tadpoles of *R. blairi* and *R. pipiens* in Nebraska, and Hillis (1982) studied *R. berlandieri* and *R. sphenoccephala* in Texas. Because they used different sized tadpoles in their analyses, their measurements cannot be compared directly with our results, but certain ratios formed by dividing by body length can be compared.

Hillis' (1982) means for normalized tail length, tail depth, tail muscle depth, and tail muscle width

ratios fall within two standard deviations of our values and are probably not statistically distinct. However, Korky's (1978) ratios are considerably lower than ours in all comparable cases. He gave a normalized mean tail length ratio of 1.49 for *R. blairi* compared to our mean ratio of 2.01 ± 0.18 (two standard deviations) and a mean tail depth ratio of 0.57 versus 0.79 ± 0.10 . Likewise, for *R. pipiens*, Korky gave a normalized mean tail length ratio of 1.43 and a mean tail depth ratio of 0.56; our values are 2.01 ± 0.20 and 0.73 ± 0.08 , respectively. These differences either reflect allometry (as suggested by Hillis 1982), distinctly different tadpole shapes in Nebraska and Texas–New Mexico, or different ways of taking the measurements. Our preliminary data indicate that allometry does not seem to be sufficient to account for the discrepancies between Korky's (1978) ratios on one hand and our data and Hillis' (1982) on the other.

Hillis (1982) found that *R. berlandieri* had a larger tail muscle than *R. sphenoccephala* and he attributed this to habitat differences; *R. sphenoccephala* was most often found in ponds and *R. berlandieri* in rivers. In our analysis, *R. berlandieri* had a relatively small tail muscle compared to the other four species, some of which are most commonly found in ponds and others are most often found in rivers. The dichotomy of ponds and rivers may not be the most important distinction in describing leopard frog larval habitats, especially when looking for correlations with morphological variables. Probably all species of leopard frogs use both types of water under some conditions and the way they use a body of water is probably more important than whether or not it has a current. Clearly the study of habitats and their influence on tadpole morphology is a complex one that has just begun.

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SPECIMENS EXAMINED

Rana berlandieri

NEW MEXICO: *EDDY CO.*: Delaware Creek at US 285, 900 m (MSB 947-948); Blue Spring, 900 m (MSB 1924-1946, 1948-1949, 1951-2000, 2221-2234, 2237-2239, 2241-2243, 2581-2640, 16398, 24610, 41815-41816); Farrell (Geysers) Spring, 3 mi N, 12 mi W Carlsbad, 1,300 m (MSB 40592); Rocky Arroyo, T21S R25E sec. 19, 1,100 m (MSB 41814); McKittrick Spring, 28 km N, 1.6 km E Whites City, 1,000 m (MSB 38325, 38463-38464, 41723-41724); 0.5 mi E McKittrick Spring, 1,000 m (MSB 41726); Stream W McKittrick Spring, 1,000 m (MSB 36182, 36283).

Rana blairi

NEW MEXICO: *CHAVES CO.*: Salt Creek near Roswell, 1,000 m (MSB 41811); Rio Felix near source, T15S R17E sec. 13, 1,700 m (MSB 41809); *COLFAX CO.*: 2 mi S Carson-Maxwell Camp, Philmont Scout Ranch, 2,000 m (MSB 23861); Taylor Springs, 1,800 m (MSB 41810); *DE BACA CO.*: 400 yd S Alamogordo Lake Dam (= Sumner Lake Dam), 1,300 m (MSB 24616); *GUADALUPE CO.*: Pecos River between Santa Rosa and Puerto de Luna, 1,200 m (MSB 41812); *HARDING CO.*: Ute Creek, 3 mi N Gallegos, 1,300 m (MSB 2269-2272, 2274-2275); *LEA CO.*: \pm 6 mi W Crossroads, 1,300 m (MSB 41711); *OTERO CO.*: Bear Canyon Dam, 3 mi N, 3 mi W Weed, 2,200 m (MSB 41750); *SAN MIGUEL CO.*: 2.2 mi N Guadalupe County line on NM 129, 1,400 m (MSB 36211, 38397-38398, 38401).

Rana chiricahuensis

NEW MEXICO: *CATRON CO.*: Blue River at jct. of Campbell Blue and Dry Blue Forks, 2,000 m (MSB 1832-1843, 1846-1852, 1854, 1857-1868); Tularosa River above Aragon, T5S R16W sec. 3, 2,100 m (MSB 1872, 1876, 1878-1879, 1884, 1888, 1891-1923); Rio San Francisco, 10 mi below Luna, 2,100 m (MSB 974-976, 978-981); Middle Fork Gila

River, T11S R16W sec. 1, 2,400 m (MSB 983-984, 986-987); Dry Fork of Blue River, 1 mi above mouth, 2,000 m (MSB 2279-2285); NM 12, 1 mi E Aragon, 2,100 m (MSB 38982); Taylor Creek, T11S R12W sec. 8, 2,100 m (MSB 1795, 1797, 1799, 1801-1805, 41831), Patterson Spring and Lake, Plains of San Augustin, 2,100 m (MSB 1639-1642, 1644-1645, 1648-1688, 41830); West Fork Gila River, 2 mi above jct. with East Fork, 1,700 m (MSB 17585); Tularosa River above Apache Creek, 2,000 m (MSB 965, 968-969); Tularosa River, 2.2 mi NE Aragon, 2,100 m (MSB 11532, 41784); Tularosa River (MSB 41705); \pm 5 mi above Luna, T5S R21W sec. 31, 2,100 m (MSB 2472-2567); Gilita Creek at T10S R16W sec. 28, 2,200 m (MSB 2401-2470); Beaver Creek at T11S R12W sec. 6, 26 mi W, 2 mi N Chloride, 2,100 m (MSB 14130, 40547); Apache Springs (MSB 24434); Tularosa River, 5 mi above Reserve, 2,000 m (MSB 41828); *GRANT CO.*: Turkey Creek between Skeleton and Brush Canyons, 13.2 mi NE Gila, 1,800 m (MSB 41778, 41865); Duck Creek, 1.5 mi above Cliff, 1,500 m (MSB 41827); Mimbres River, 1 mi above Mimbres, 1,800 m (MSB 2245-2247, 2251-2267, 2276); Black Creek at T13S R12W sec. 12, 2,100 m (MSB 41829); Side channel Gila River, 8.5 mi NE Gila, 1,500 m (MSB 41779); Little Creek, 2 mi S Cliff Dwellings, 2,400 m (MSB 41585); *SIERRA CO.*: Hoyt Creek, T11S R11W sec. 7, 2,100 m (MSB 970-971, 973); *SOCORRO CO.*: Alamosa Warm Springs (= Fort Harmony Springs), 1,900 m (MSB 1701, 1704-1705, 1709-1794, 39518, 40579-40581); *ARIZONA: APACHE CO.*: Blue Lake, T8N R24E sec. 28, 2,300 m (MSB 17586); Bog Creek, T8N R25E sec. 26, 2,400 m (MSB 17587).

Rana pipiens

NEW MEXICO: *BERNALILLO CO.*: Riverside Drain, 1.5 mi N Alameda, 1,500 m (MSB 2249-2250); Rio Grande just N Valencia County line, 1,500 m (MSB 41821); *CIBOLA CO.*: Rio San Jose, \pm 11 mi E Grants (MSB 889); Acoma Reservation, 4 mi S Casa Blanca Post Office (MSB 1690-1694); *COLFAX CO.*: Merrick Lake, 7 mi WNW Vermejo Park Headquarters, 2,700 m (MSB 9282-9290); 25.5 mi N, 10 mi W Cimarron, near Castle Rock, 2,100 m (MSB 25711); *McKINLEY CO.*: Rio Pescado at Pescado Dam, 2,100 m (MSB 847); *MORA CO.*: Mora, 2,200 m (MSB 41813); *RIO ARRIBA CO.*: Jemez Mountains, top of San Pedro Peaks, 3,200 m (MSB 15595); *SANDOVAL CO.*: Riverside Drain, 3 mi N Alameda, 1,500 m (MSB 1695-1697, 1699); 3 mi N Bernalillo on old US 85, 1,600 m (MSB 41824); Jemez River, 3.5 mi above Jemez Springs, 1,900 m (MSB 41826); Jemez River, 3 mi above mouth of Guadalupe Creek, 1,800 m (MSB 41822); Rio San Antonio above Jemez Falls, 2,100 m (MSB 41825); Jemez River, 3 mi above Jemez Springs, 1,900 m (MSB 2201-2202, 2205-2206, 2208-2215, 2217-2218, 2220, 41320, 41820); Jemez River at San Ysidro, 1,700 m (MSB 41818); Rio San Antonio at La Cueva, 2,300 m (MSB 41817); East Fork Jemez River, 0.6 mi NE NM 4, 2,400 m (MSB 16400); 3.5 mi S Cuba, 2,100 m (MSB 41732); 2 mi N NM 44 on US 85, 1,600 m (MSB 24606-24608); 8 mi SSW Jemez Springs on Jemez River, 1,800 m (MSB 17216); NM 4, 1 mi E Del Norte Canyon turnoff, Jemez Mountains, 2,400 m (MSB 14644); Rio Grande \pm 1 mi below Cochiti Pueblo, 1,600 m (MSB 41823); Jemez River, 2 mi below Battleship Rock, 2,000 m (MSB 41819); Corrales, 1,500 m (MSB 17670); *ARIZONA: APACHE CO.*: Lake S of Trout Creek, 2,100 m

(MSB 13677); GREENLEE CO.: 1 mi N jct. of Oak Creek and Blue River, 1,500 m (MSB 22600); COLORADO: LA PLATA CO.: Allison (MSB 3338).

Rana yavapaiensis

ARIZONA: GREENLEE CO.: Turkey Creek, 5.5 mi W Juan Miller crossing of Blue River, 2,100 m (MSB 41800).

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