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A NEW *RANA* FROM SAN LUIS POTOSI, MEXICO

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During recent field work in San Luis Potosi state, Mexico, it was found that a considerable population of a pustulose *Rana tarahumarae*-like frog existed along the Arroyo Sacahuite, a small tributary of the Rio Moctezuma. The present paper is concerned with the taxonomy and general biology of this frog.

1. TAXONOMIC CONSIDERATIONS

STATISTICAL ANALYSIS

In order to make comparisons with Boulenger's types of *Rana tarahumarae*, the measurements chosen for comparison are those used by Boulenger (1920) and believed by the writer to be sufficiently reproducible that comparable measurements can be made on the present material. Table 5 gives measurements of four characters for *Rana tarahumarae*, *R. pustulosa*, *R. palmipes*, *R. boylii*, and Arroyo Sacahuite frogs. The following ratios were computed: body length/head length, body length/hind limb length, and head length/head width (tables 1, 2).

If a Critical Ratio (C.R.) of 2.5 be considered as significant, the Arroyo Sacahuite frogs differ significantly, with respect to body/head ratio, from *boylii* and *tarahumarae*, but not from *pustulosa* or *palmipes*. Body/hind limb ratio shows a significant difference between Arroyo Sacahuite frogs and *boylii*, *pustulosa*, *tarahumarae*, and *palmipes*. Head length/head width ratio, also, shows a significant difference between the Arroyo Sacahuite frogs and *boylii*, *pustulosa*, *tarahumarae*, and *palmipes*.

It is obvious from casual inspection of body size measurements that frogs of disproportionate size are being compared, and the apparent differences may be due to allometric growth. Body size of the five groups of frogs is as follows:

	N	m ± σm	Range
Arroyo Sacahuite	21	51.05 ± 1.58 mm.	38 – 62 mm.
R. pustulosa	20	67.70 ± 1.70	56.3– 88.0
R. boylii	6	44.25 ± 5.59	32.5– 75.5
R. palmipes	40	83.00 ± 1.92	66.1–109.0
R. tarahumarae	23	59.75 ± 3.11	42.0– 97.2

Two methods of comparing such samples are available: (1) compare like size groups, and (2) where like size groups are not available, determine the presence or absence of allometric growth, and, if allometric growth is involved, make the necessary correction.

If we take the five smallest *boylii* (m= 38.45 ± 2.00 mm.; range 32.5–52.7 mm.) and the six smallest Arroyo Sacahuite frogs (m= 42.33 ± 1.35 mm.; range 38–46 mm.) we have reasonably equivalent samples. Computed means for the ratios are as follows:

	Body Length/ Head Length m ± σm	Body Length/ Hind Limb Length m ± σm	Head length/ Head Width m ± σm
5 smallest *boylii*	2.94 ± 0.10	0.58 ± 0.02	0.87 ± 0.02
6 smallest Arroyo Sacahuite	2.60 ± 0.05	0.69 ± 0.01	1.04 ± 0.02

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Means differ significantly for the two samples for each of the three ratios (C.R.'s of 3.1, 5.3, and 5.5, respectively). This is the same result as that obtained with whole samples.

When the 10 smallest *pustulosa* (m = 61.95 ± 1.23 mm.; range 56.3–67.5 mm.) are taken for comparison with the 10 largest Arroyo Sacahuite frogs (m = 56.5 ± 1.17 mm.; range 52–62 mm.) the means for the three ratios under consideration are as follows:

	Body Length/ Head Length m ± σm	Body Length/ Hind Limb Length m ± σm	Head Length/ Head Width m ± σm
10 smallest *pustolosa*	2.60 ± 0.03	0.62 ± 0.00	0.94 ± 0.01
10 largest Arroyo Sacahuite	2.78 ± 0.05	0.66 ± 0.01	1.02 ± 0.02

Means differ significantly for the two samples for the ratios body/hind limb and head length/head width (C.R.'s of 3.7 and 3.8, respectively), which is the result found with whole samples. However, body/head length ratio, which did not show a significant difference between the two whole samples, now differs significantly (C.R. = 3.1). For a further check on this matter, the six smallest *pustulosa* (m = 59.25 ± 0.93 mm.; range 56.3–64.0 mm.) were compared with the six largest Arroyo Sacahuite frogs (m = 59.16 ± 0.96 mm.; range 56–62 mm.). Means for body/hind limb length ratio are as follows:

	m ± σm
6 smallest *pustulosa*	2.62 ± 0.04
6 largest Arroyo Sacahuite frogs	2.72 ± 0.04

This gives a C.R. of 1.6 for the two samples. Since the two samples are so nearly equal in body size, serious doubt is cast upon any difference in body/head length ratio between *pustulosa* and the Arroyo Sacahuite frogs.

Computation of means for the 16 smallest *tarahumarae* (body size: m = 51.75 ± 1.95 mm.; range 42.0–65.0 mm.) gives the following results:

	Body Length/ Head Length m ± σm	Body Length/ Hind Limb Length m ± σm	Head Length/ Head Width m ± σm
16 smallest *tarahumarae*	2.84 ± 0.04	0.63 ± 0.01	0.94 ± 0.01
All Arroyo Sacahuite frogs	2.69 ± 0.06	0.67 ± 0.01	1.03 ± 0.01

These animals are of comparable size to the Arroyo Sacahuite series. They differ from that series with respect to body/hind limb and head length/head width ratios (C.R.'s of 2.9 and 6.4, respectively), but do not differ with respect to body/head length ratio (C.R. = 2.1).

No direct comparison of Arroyo Sacahuite frogs and *palmipes* is possible, since the mean body size of the former is 51.05 ± 1.58 mm. (range 38–62 mm.), while that of the latter is 83.00 ± 1.92 mm. (range 66.1–109.0 mm.). If the *palmipes* are divided into two groups, those of 66.0–87.9 mm. body size (av. 75.75 ± 1.16 mm.) and those of 88.0–109.9 mm. body size (av. 98.00 ± 1.96 mm.), the following means for the ratios for the two groups are obtained:

	N	Body Length/ Head Length m ± σm	Body Length/ Hind Limb Length m ± σm	Head Length/ Head Width m ± σm
66.0– 87.9 mm. *palmipes*	27	2.64 ± 0.01	0.62 ± 0.01	0.99 ± 0.01
88.0–109.9 *palmipes*	13	2.70 ± 0.02	0.65 ± 0.01	0.96 ± 0.01

The 66.0–87.9 mm. *palmipes* differ significantly from 51–62 mm. Arroyo Sacahuite frogs with respect to body/head and body/hind limb ratios (C.R.'s of 2.6 and 3.5, respectively) but not with respect to head length/head width ratio (C.R. 1.7). For body/hind limb ratio this is the same result as that secured with whole samples;

for the other two ratios the result is not the same as that secured with whole samples. The 66.0–87.9 mm. *palmipes* and 88.0–109.9 mm. *palmipes* do not differ significantly (C.R. = 2.1) with respect to head length/head width ratio. Serious doubt is cast upon the validity of any difference between *palmipes* and Arroyo Sacahuite frogs. The differences between 66.0–87.9 mm. *palmipes* and 88.0–109.9 mm. *palmipes* with respect to body/head and body/hind limb ratios are, however, significant and merit further consideration. Let us divide the *palmipes* into four groups. Means are as follows:

	N	Body Length/Head Length m ± σm	Body Length/Hind Limb Length m ± σm
66.0– 76.9 mm. *palmipes*	15	2.63 ± 0.02	0.62 ± 0.01
77.0– 87.9 *palmipes*	12	2.65 ± 0.02	0.63 ± 0.01
88.0– 98.9 *palmipes*	6	2.70 ± 0.02	0.64 ± 0.01
99.0–109.9 *palmipes*	7	2.70 ± 0.03	0.66 ± 0.01

Comparison of 66.0–76.9 mm. *palmipes* to 56–64 mm. Arroyo Sacahuite frogs with respect to body/head and body/hind limb ratios shows no significant difference (C.R.'s of 1.9 and 2.1 for body/head and body/hind limb ratios, respectively). However, there are indications of allometric growth in *palmipes* with respect to both body/head and head/hind limb ratios, and animals of 61 mm. body size might be expected to have body/head and body/hind limb ratios of approximately 2.61 and 0.61, respectively. Assuming the standard deviations of this hypothetical sample to be about the same as those for the known *palmipes* groups, *palmipes* does not differ from Arroyo Sacahuite frogs with respect to body/head ratio (C.R. 2.3), but does differ with respect to body/hind limb ratio (C.R. 2.8).

In summary, then, Arroyo Sacahuite frogs differ in body/head length ratio from *boylii* only. In body/hind limb ratio Arroyo Sacahuite frogs differ from *boylii*, *pustulosa*, *tarahumarae*, and *palmipes*. In head length/head width ratio Arroyo Sacahuite frogs differ from *boylii*, *pustulosa*, and *tarahumarae*.[1]

[1] Some of these differences, it must be emphasized, are differences between local populations, and may or may not represent differences between species. The following example illustrates the fallacy of any premature conclusion as to species differences. A collection of American toads (*Bufo americanus*) was made at Tulsa, Oklahoma; these animals had a body/foot ratio of 1.69 ± 0.02. A collection of Fowler's toads from Lakeville, Massachusetts, showed a body/foot ratio of 1.53 ± 0.01. Since the difference is statistically significant (C.R. = 7.1) it is easy to conclude that Fowler's toad and the American toad differ as to body/foot ratio. However, another collection of Fowler's toads from Jena, Louisiana, showed a body/foot ratio of 1.70 ± 0.01, which does not differ significantly (C.R. = 0.4) from the ratio for the Tulsa collection of American toads. And a second collection of American toads, this time from Bloomington, Indiana, showed a body/foot ratio of 1.53 ± 0.01, which is identical with the ratio for Lakeville Fowler's toads.

Species Comparison

All but one of the Arroyo Sacahuite frogs exhibit a prominent white stripe extending from below the anterior edge of the eye posteriorly along the upper edge of the maxilla, under the tympanum, to the anterior edge of the insertion of the fore limbs. Some indication of such a stripe appears in some individuals of each of the four species: *R. tarahumarae*, *R. pustulosa*, *R. palmipes*, and *R. boylii*. Of the four species, it is best developed in *palmipes*, but even here it is variable, irregular, broken, and cream color.

The tympanum is small, one-half the diameter of the eye or less, in the Arroyo Sacahuite frogs. A similar condition is found in *pustulosa*, *boylii*, and *tarahumarae*. In *palmipes* the tympanum is from one-half to five-sixths the diameter of the eye.

The Arroyo Sacahuite frog and each of the four species mentioned above have a glandular fold running from the posterior edge of the eye above the tympanum to the shoulder. It is best developed in *tarahumarae*. In the Arroyo Sacahuite frogs and the other three species it is variable, ranging from absent to moderately well developed.

Prominent dorsolateral folds are present in *palmipes*. In *pustulosa* and *boylii* the situation is rather variable, with well-developed folds in some individuals and

indistinct folds in others. In *tarahumarae* and the Arroyo Sacahuite frogs there are no folds, although there is a slight indication of folds in some individuals.

The Arroyo Sacahuite frogs and the four species cited above agree in having a pustular dorsum. In size and number of pustules *tarahumarae* closely resembles the Arroyo Sacahuite frogs. The other three species are less pustular than the Arroyo Sacahuite frogs, although the pustules average somewhat larger in size.

The venter in the Arroyo Sacahuite frogs is white, with a light gray suffusion on the throat is some instances. In *tarahumarae* and *boylii* the venter is light. In *pustulosa* the venter frequently has a suffusion of gray, and in *palmipes* it usually is heavily marbled.

The Arroyo Sacahuite frogs have a single metatarsal tubercle, as do *pustulosa*, *palmipes*, and *tarahumarae; boylii* has two metatarsal tubercles.

The subarticular tubercles of the hind feet of the Arroyo Sacahuite frogs are elongated and knife-like. They are more oval and rounded in *pustulosa*, *palmipes*, *tarahumarae*, and *boylii*. Those of *pustulosa* show some resemblance to those of the Arroyo Sacahuite frogs.

In the Arroyo Sacahuite frogs the toe disks are large, rounded, flat, and free from the web. They are smaller, less rounded, less flat, and less free from the web in *pustulosa*, *palmipes*, and *tarahumarae*. In *boylii* they are small and not at all prominent; webbing is about the same as in the Arroyo Sacahuite frogs.

No *Rana sierramadrensis* are available for comparison. From the type description of this form (Taylor, 1938) it appears that the Arroyo Sacahuite frogs resemble it in having a light jaw stripe and differ from it, among other things, in lacking a dorsolateral fold.

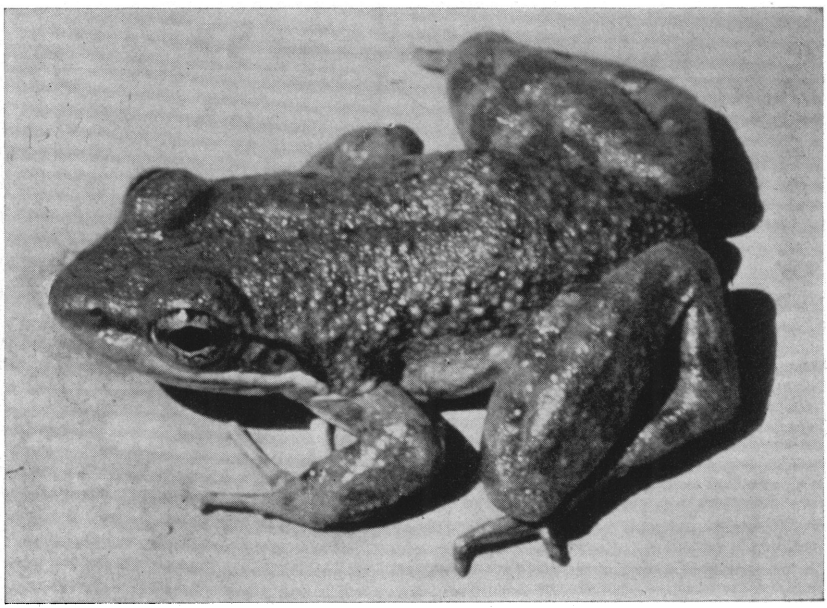

Fig. 1. *Rana moorei*, male, A.M.N.H. No. 52924, ×1.8.

Species Description

In view of the differences cited it seems necessary to describe the Arroyo Sacahuite frogs as a new species.

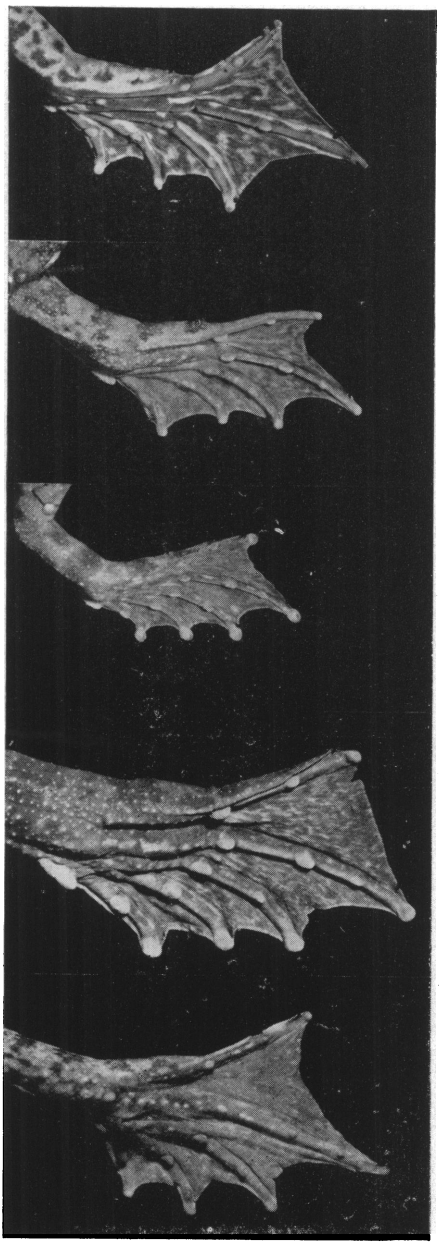

Fig. 2. Foot structure of *Rana moorei* and related species, ×1. From top to bottom: *Rana palmipes*, A.M.N.H. No. 44557; *Rana pustulosa*, A.M.N.H. unnumbered, Cuicatlan, Oaxaca, Mexico; *Rana moorei*, A.M.N.H. No. 52918; *Rana tarahumarae*, U.M.M.Z. No. 75743; *Rana boylii*, A.M.N.H. No. 52219.

Rana moorei,[1] new species

TYPE: A.M.N.H. No. 52908, collected on the Arroyo Sacahuite at Palictla, 6 miles (by highway) north of Tamazunchale, San Luis Potosi, Mexico, September 9, 1946. Collectors: A. P. Blair and J. A. Moore.

PARATYPES: A.M.N.H. Nos. 52903–52907, 52909–52923, collected at same locality September 9, 1946, same collectors, and A.M.N.H. No. 52924, collected at same locality September 2, 1946, by A. P. Blair and C. M. Bogert.

DIAGNOSIS: A medium-sized frog allied to *Rana tarahumarae* and *R. pustulosa*. Head usually longer than broad. A white stripe from below eye to insertion of arm. Toe disks very well developed, round, flat, free from web. Subarticular tubercles elongated, knife-like. No dorsolateral fold.

DESCRIPTION (FIGS. 1, 2): Color in life dark olive green above, very light or white below. Dorsal surface of hind legs with dark transverse bands. A white stripe from below eye to insertion of arm. Many small pustules on dorsal surface. Head depressed, as long as or longer than wide. Tympanum one-half diameter of eye or less. One metatarsal tubercle. Subarticular tubercles elongated, knife-like. Toe disks very well developed, round, flat, free from web. The type specimen is a male and shows an enlarged thumb. Snout-vent length 62 mm.; an 81-mm. male was observed during marking experiments.

RELATIONSHIP: Probably most closely related to *Rana tarahumarae* and *R. pustulosa*. Precise determination of relationship must await additional specimens from many localities, as well as a much better understanding of the Mexican species of *Rana*. *Rana moorei* may be restricted to rocky arroyos (fig. 3); intensive collecting along the Rio Axtla (fig. 4), 15 miles north of the Arroyo Sacahuite, yielded only *Rana pipiens*. No other *Rana* of the species complex to which *R. moorei* belongs has been taken in the immediate vicinity of the type locality (fig. 5).

[1] The studies of John A. Moore on temperature tolerance, rate of development, hybridization, and taxonomy of North American frogs of the genus *Rana* have done much to further understanding of this group. It is a pleasure to name the new species *Rana moorei*.

2. BIOLOGICAL CONSIDERATIONS

The Habitat

The elevation at Palictla is approximately 400 feet. The Arroyo Sacahuite is a small stream (figs. 3, 6) which arises in the mountains to the west of Palictla and flows generally southeast until it enters the Rio Moctezuma a few miles below Palictla. The water is clear. For the most part the stream bed is rocky, either massive limestone in place or coarse pebble and cobble gravel. In some of the quieter, deeper pools there is a thin layer of silt on the bottom. The general stream pattern is one of pools separated by shallow, rocky, swift riffles. The depth of the deepest pools (pools K and Q) is about 24 inches. On the last day of observations, September 9, the water level was approximately 2 inches lower than previously; this difference was most apparent in the riffles, in some of which the flow of water was now below the surface of the gravel. The greatest width of the stream is 25 feet. The banks of the stream are clear, with heavy undergrowth beginning 2 to 15 feet from the edge of the stream. No surface water plants are evident, but most pools contain beds of green algae. Algae are present in greatest mass in pools A, J, K, and M. Fish (several species, up to 6 inches in length), crayfish (probably three species), and snails constitute the most conspicuous aquatic forms other than Salientia.

The water of the stream is rather warm, as shown by the following temperature records made in the swift riffle between pools C and D:

	Time	Temperature
September 4	10:00 A.M.	25.4° C.
	11:00 A.M.	26.4°
	12:00 NOON	27.1°
	1:00 P.M.	29.0°
	2:00 P.M.	30.7°
	3:00 P.M.	31.6°
	4:00 P.M.	32.0°
	5:00 P.M.	30.0°
	6:00 P.M.	30.1°
	7:00 P.M.	29.3°
	11:00 P.M.	27.5°
September 5	8:30 A.M.	25.0°
	3:00 P.M.	30.6°
September 6	9:30 A.M.	24.9°

Fig. 3. Two views along the Arroyo Sacahuite. Left, pool D, looking downstream; right, pool K, looking downstream.

September 4 was a bright, sunshiny day with few clouds; the afternoon of September 5 the sun was obscured a considerable portion of the time. Isolated shaded pools without running water connection with the stream may remain considerably cooler. Two such pools showed temperatures of 25.4 and 26.6° C., respectively, at 3:00 P.M., September 6.

Marking Experiments

The degree to which an organism tends to be migratory or fixed in habit greatly affects the role of random gene fluctuation, selection, and hybridization in the production of genetically distinct local populations. Little is known of population size and migratory or sedentary tendencies in the North American frogs. The suggestive work of Breder, Breder, and Redmond (1927) on the green frog (*Rana clamitans*) and Raney (1940) on the green frog and bullfrog (*R. catesbeiana*) indicates that some individuals may be relatively sedentary over a period of several months while others wander freely.

A portion of the creek some 2000 feet in length was selected for investigation (figs. 3, 6). The procedure each night was to enter the creek at the lower end of pool G, where an Indian trail crosses the creek, proceed downstream to the lower end of pool S, then upstream to the riffle above pool A, and, finally, downstream to the point of entry at pool G. This procedure took some three to five hours. As frogs were encountered, they were caught by hand, measured with vernier calipers for body length, sex recorded if the thumb pads were unquestionably enlarged, individually marked by toe clipping, and released at the point of capture. On the final night, September 9, most of the animals collected were shot with .22 caliber shot shells.

Fig. 4. Rio Axtla.

Details of capture and recapture are given in table 3 and figures 7 and 8. Fourteen animals were marked the first night (September 2), six the second night (September 3), five the third night (September 4), and six the fourth night (September 5); nine unmarked animals were collected on the final night (September 9). On the

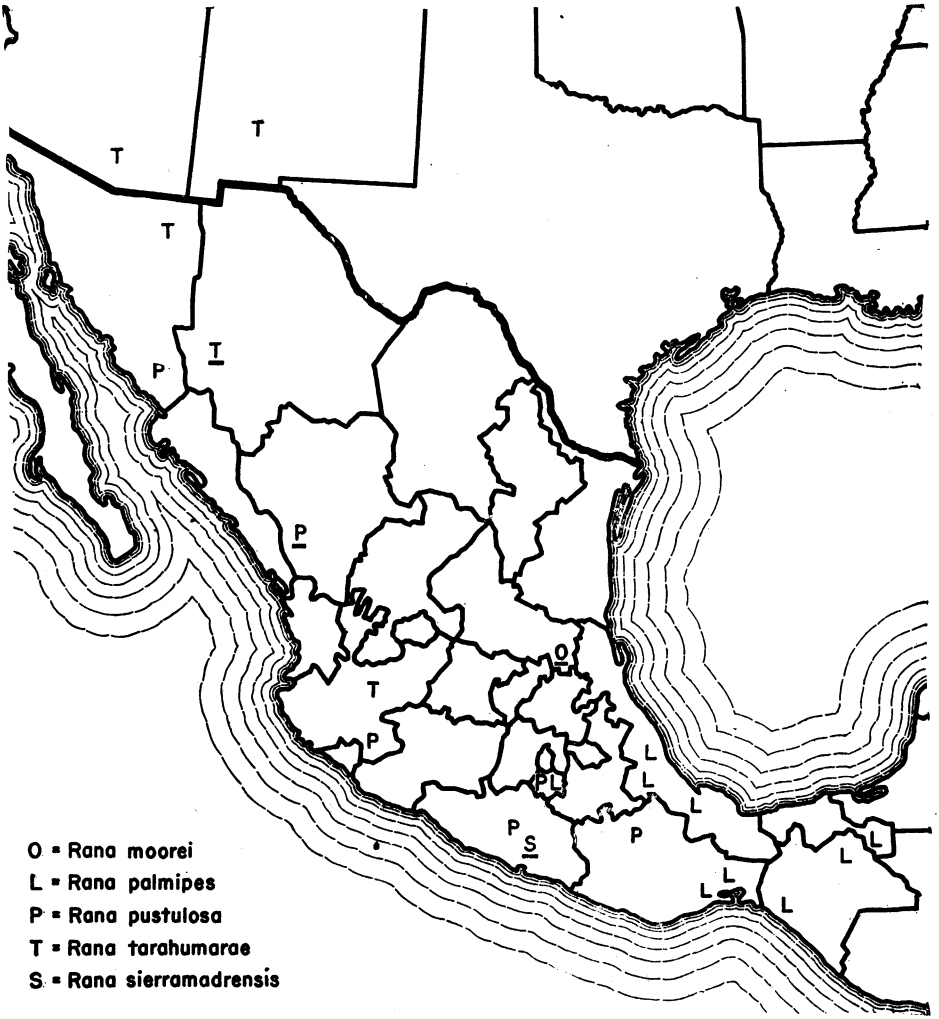

Fig. 5. Distribution of *Rana moorei* and related species; type localities underlined.

second night eight frogs marked the previous night were recovered; all were in the pools where marked and within 20 feet of the point where marked. The third night six frogs marked the first night and four the second night were recovered; all were in the pools where marked and within 20 feet of the point where marked. The fourth night three frogs marked the first night, two the second night, and three the third night were recovered. Five of the eight frogs were in the pools where marked and within 20 feet of the point where marked. No. 3 moved across a gravel bar and 35 feet upstream. No. 15 moved from pool J to pool K, a distance of only 10 feet. No. 24 moved from pool G upstream some 235 feet to pool D. On the last night six frogs marked the first night, four the second night, none the third night, and two the fourth night were recaptured. No. 3 was at the upper end of pool N, some 40 feet downstream from where marked in pool M. No. 10 was at the lower end of pool E, some 50 feet upstream from where marked in pool G. No. 17 was in the small brook

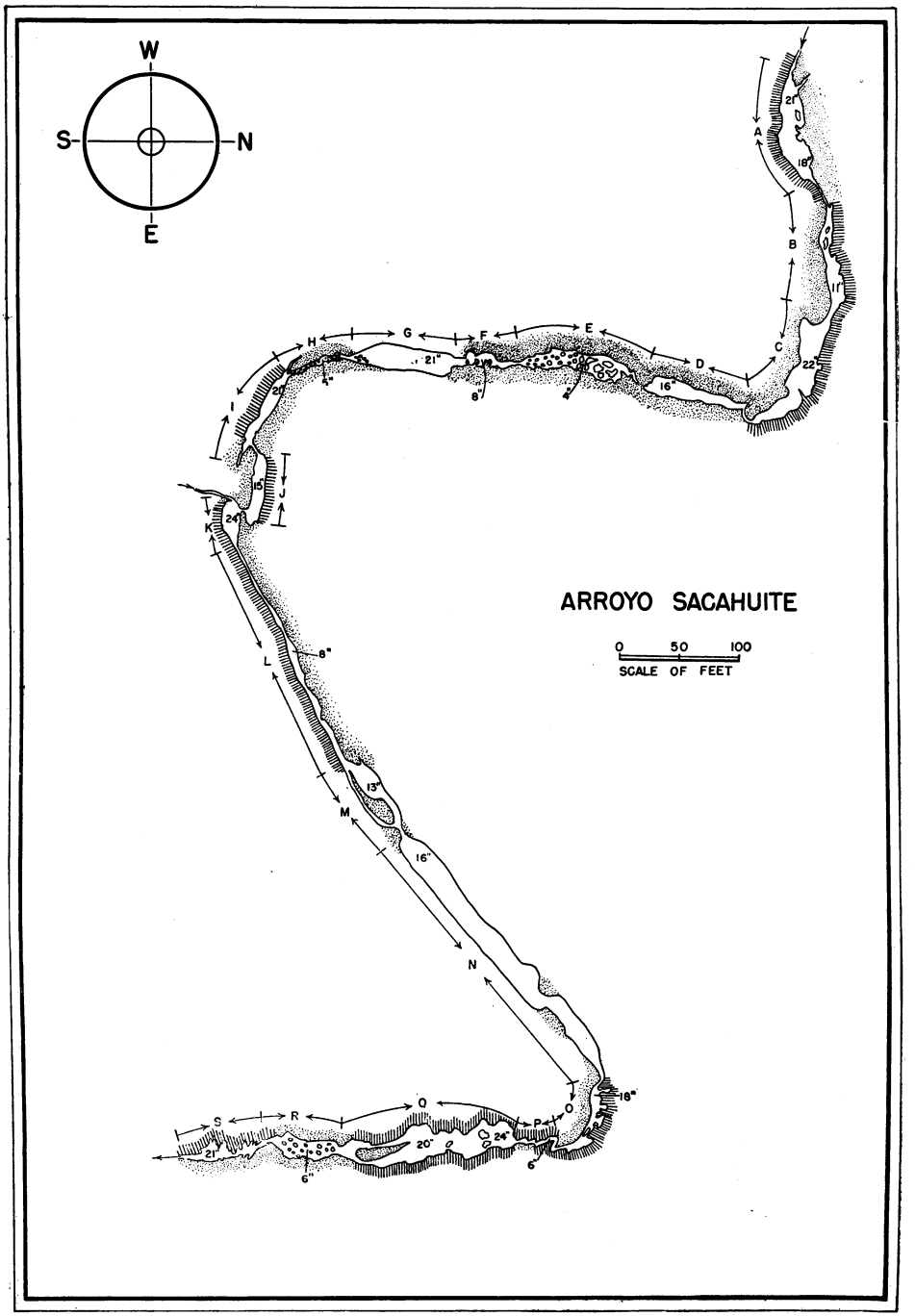

Fig. 6. The Arroyo Sacahuite: physical features. Stippled areas are gravel bars; parallel line marked areas are rock in place; numbers represent maximum depths of pools.

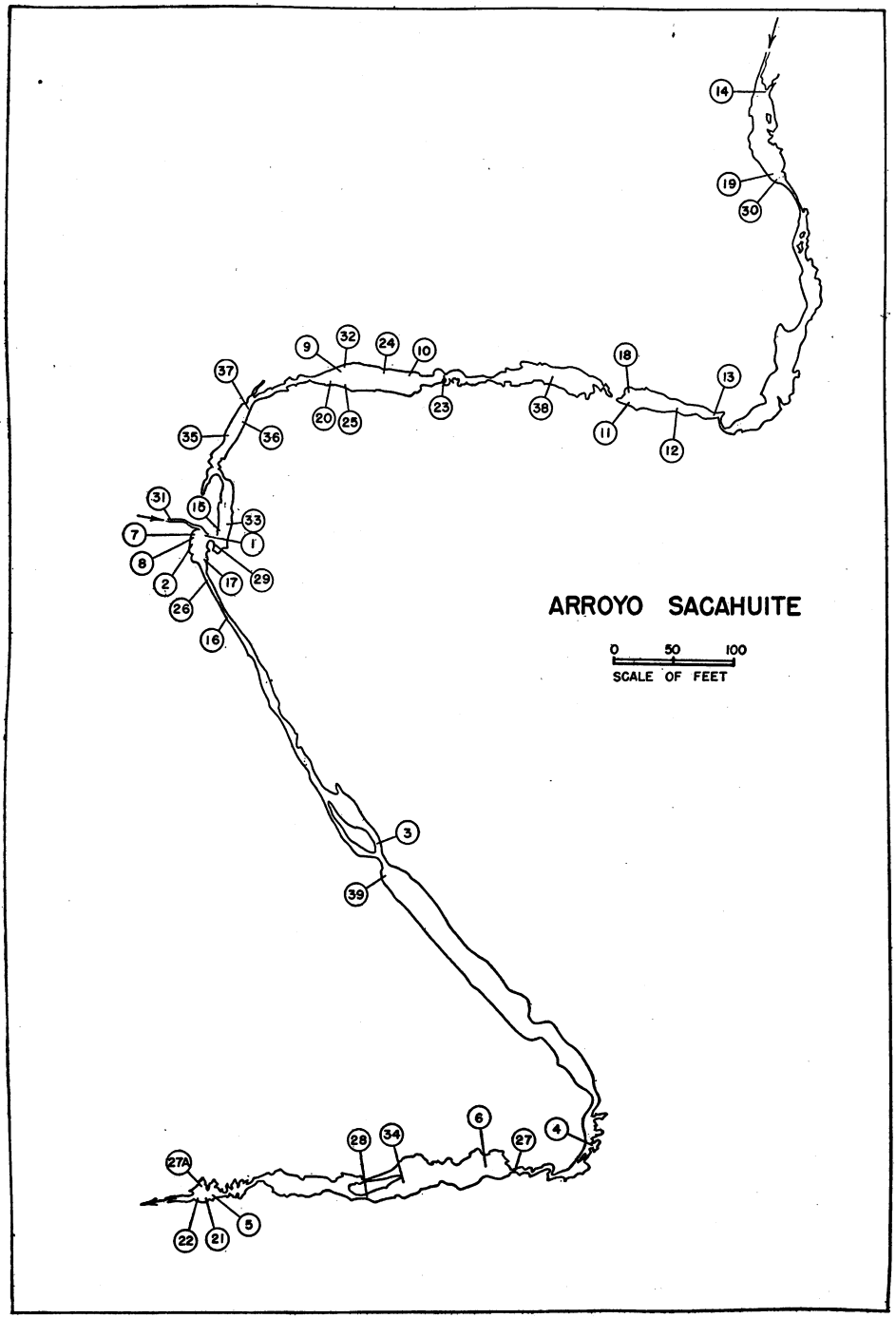

Fig. 7. The Arroyo Sacahuite: points at which frogs were collected; numbers correspond to field numbers of frogs.

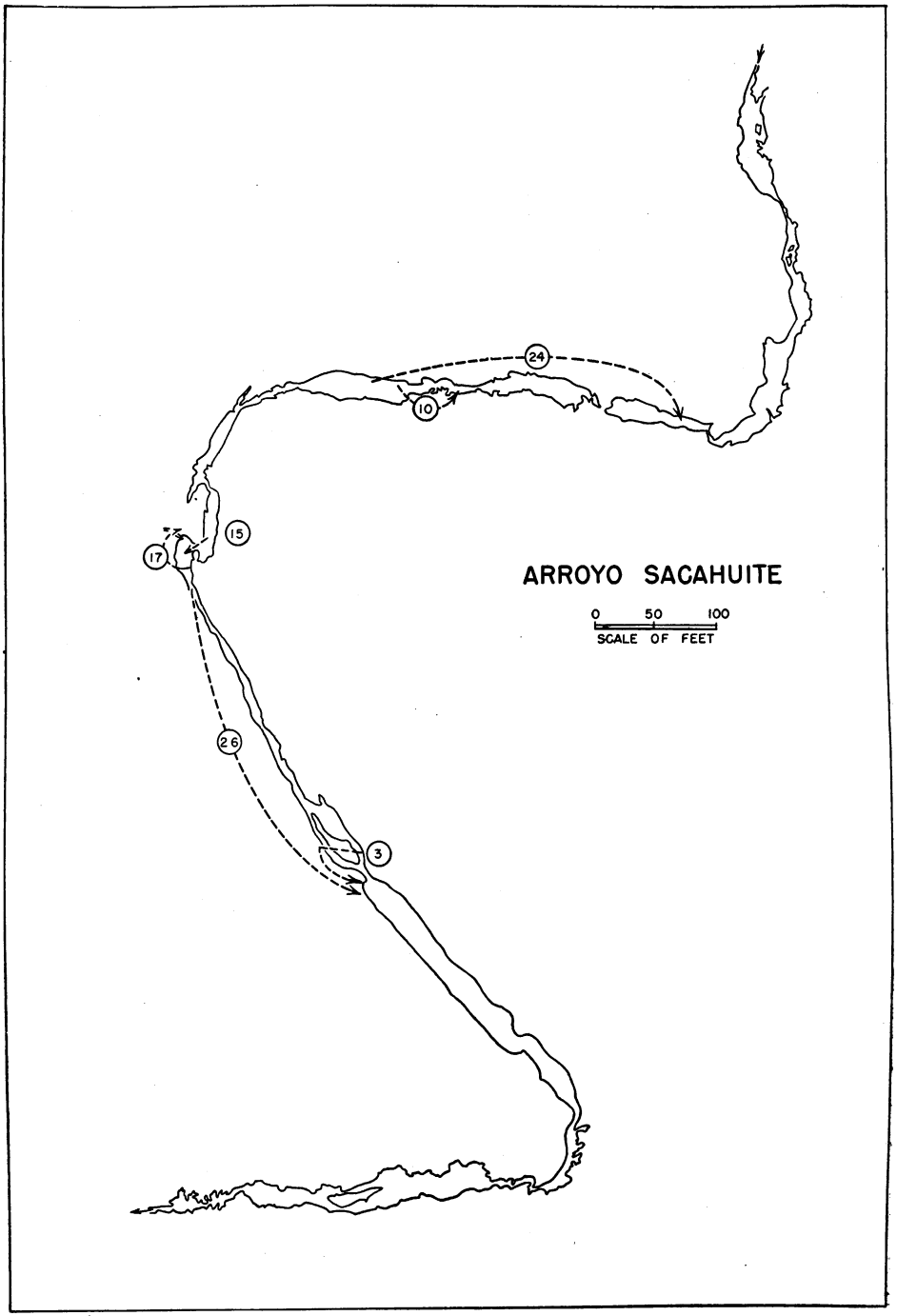

Fig. 8. The Arroyo Sacahuite: migrations of frogs; numbers correspond to field numbers of frogs.

which runs into the upper end of pool K. No. 26 was at the lower end of pool M, some 280 feet downstream from the point where marked at the upper end of pool L. The remaining eight were in the pools where marked and within 20 feet of the point where marked. Of the total of 30 animals marked previous to the last night, 23 were recovered at least once, nine two times each, and three three times each.

Whether the unmarked frogs captured subsequent to the first night represent animals which migrated in from outside the area of investigation, animals which were seen but not captured the first night, or animals not abroad the first night is not completely apparent. Examination of the area was sufficiently intensive that it is believed that few frogs which were abroad escaped detection. With a water temperature of 27° C. it hardly seems possible that animals might remain submerged for any considerable length of time. No animal was ever found more than a few inches from water, but it is not impossible that animals occasionally leave the stream and remain in the forest for days at a time. Animals were agile and sometimes eluded capture, but it is believed impossible that the number of frogs collected the last night can be explained on this basis. The remaining possibility is that animals were continually migrating into and out of the area of investigation. In view of findings this seems possible. Probably no valid inference as to population density, other than the number observed on a single night, can be drawn. For the last night of collecting the population density can be given as a minimum of 25 individuals (21 collected plus four which escaped) for the 2000-foot stretch of stream.

No strict correlation of concentration of frogs with type of pool was found. The greatest concentrations were in pool D (4 frogs), pool G (6 frogs), pool K (5 frogs), and pool S (4 frogs). Pool D is of moderate to shallow depth with stream bed of large cobbles (6–15 inches diameter). Pool G is deep with silt bottom and banks. Pool K, a deep gravel and rock-bottomed pool, has much algae. Pool S is much the same but with little algae. Some frogs were found in shallow, rocky riffles. The largest animal found (No. 22, 81 mm. body length) was in pool S. No frog was found in pool I for four successive nights. This pool has smooth bottom and banks affording little in the way of cover. On the final night, however, three frogs were in this pool.

Many of the animals observed were juveniles. All females captured the last night were small (38–49 mm.) and had immature ovaries. Two of the larger animals (62 and 81 mm.) were definitely determined as males in the field on the basis of enlarged thumb pads. Laboratory comparison of males and females (determination based on gonads) shows thumb enlargement in Nos. 5, 10, 17, 18, 19, 25, 33, and 34. Evidently, then, males begin showing secondary sex characters at a body length of 55–60 mm. when the testes are 5–8 mm. in length. The finding of 15 males to 7 females is well within sampling limits for a 1/1 sex ratio.

Food Habits

The contents of the digestive tracts of 22 animals were found to be as follows:

A.M.N.H. No.	
52903	Tipulid legs (Diptera), spider legs
52904	Two spiders
52905	Five roaches (Blattidae, Orthoptera), of two species
52906	One spider, one caddis fly (Trichoptera)
52907	One spider, caddis fly scales
52908	One bug (Pentatomidae, Hemiptera), one lepidopterous caterpillar
52909	One Trichoptera or Lepidoptera
52910	One spider
52911	One spider, one damsel fly (Zygoptera, Odonata), one lepidopterous caterpillar (?)
52912	One caddis fly (Trichoptera)
52913	One beetle (Gyrinidae, Coleoptera)
52914	One Hemiptera, one Trichoptera or Lepidoptera
52915	One Hemiptera (Neididae?), one Coleoptera), two spiders
52916	Spider legs, one ant (Formicidae, Hymenoptera), two Coleoptera
52917	One Lepidoptera
52918	One spider, one caterpillar (Lepidoptera), one beetle (*Gyrinus*, Gyrinidae, Coleoptera)
52919	One damsel fly (Zygoptera, Odonata), one beetle (Hydrophilidae, Coleoptera)
52920	One Lepidoptera

52921 One spider, one Hemiptera, one Orthoptera (Blattidae?)
52922 One water bug (Belostomatidae, Hemiptera), one crayfish (*Paracambarus*?)
52923 One ant (Formicidae, Hymenoptera)
52924 One damsel fly (Coenagrioidea, Zygoptera, Odonata)

The food consists of diurnal, nocturnal, and crepuscular forms. There was bright moonlight on the night of September 9, when all animals except No. 52924 were collected; No. 52924 was collected in daylight. While all food items found were Arthropoda, it is obvious that *Rana moorei* is not very selective in its diet. Food consists of aquatic forms, or forms which can be secured at the edge of the stream.

Predators

At night the frogs were found in shallow water near the edge of the creek, or on boulders projecting above the water in the creek. On several occasions they were seen swimming in the deeper pools. When disturbed they never jumped into the undergrowth along the stream, as the leopard frogs habitually did, but dove into the water and sought refuge under boulders, rock ledges, or beds of algae. They were exceedingly agile and elusive and slow moving predators would probably secure few. Of the 40 animals examined, only one (No. 27A) had a limb missing; this animal had lost the left rear foot.

It is probable that the very large leopard frogs, *Rana pipiens*, which are common along the stream, occasionally eat the smaller frogs. Kilby (1945) found leopard frogs, tree frogs, and cricket frogs in the stomachs of Florida leopard frogs. However, the most important predator is probably *Leptodeira maculata*, a rear-fanged snake known to feed on frogs. Four *L. maculata* were seen: one on the gravel bar at the edge of the water at pool L, one on the mud flat at the edge of the water at pool M, one swimming in the water at the upper end of pool Q, and one endeavoring to subdue a small leopard frog, which it had seized by one hind foot, on the rocky bank of pool R.

While the frogs were much more active at night, on four occasions single frogs were seen in the daytime. Several potential diurnal predators were observed. Egrets were common along the stream, and green and little blue herons were seen several times. There was a domestic pig wallow near the upper end of pool C, and it seems possible that pigs occasionally secure frogs. On one occasion Indians were seen turning over stones in the riffle at the head of pool O; while the food item sought was crayfish, it seems unlikely that frogs would be rejected.

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TABLE 1

MEANS FOR VARIOUS RATIOS

	N	Body Length/ Head Length m ± σm	Body Length/ Hind Limb Length m ± σm	Head Length/ Head Width m ± σm
Arroyo Sacahuite	21	2.69 ± 0.06	0.67 ± 0.01	1.03 ± 0.01
R. pustulosa	20	2.66 ± 0.03	0.63 ± 0.01	0.93 ± 0.01
R. boylii boylii	6	2.95 ± 0.08	0.58 ± 0.01	0.86 ± 0.02
R. palmipes	40	2.66 ± 0.01	0.63 ± 0.01	0.98 ± 0.01
R. tarahumarae	23	2.86 ± 0.03	0.63 ± 0.01	0.93 ± 0.01

TABLE 2

CRITICAL RATIOS

	Body Length/ Head Length	Body Length/ Hind Limb Length	Head Length/ Head Width
Arroyo Sacahuite: *R. pustulosa*	0.4	3.9	7.0
Arroyo Sacahuite: *R. b. boylii*	2.5	5.6	6.9
Arroyo Sacahuite: *R. palmipes*	0.4	3.9	4.0
Arroyo Sacahuite: *R. tarahumarae*	2.5	2.9	7.1

TABLE 3

RECOVERY OF MARKED *Rana moorei*, WITH SEX AND TESTIS SIZE FOR THOSE RECOVERED SEPTEMBER 9

	Field No. of Frog	Body Length (mm.)	Sex	Testis Length (mm.)	Dates Recovered Sept. 3	Sept. 4	Sept. 5	Sept. 9
Marked Sept. 2	1	54	♂	2.8	—	—	X	X
	2	55	—	—	X	X	X	—
	3	45	♀	—	—	—	X	X
	4	40	—	—	X	—	—	—
	5	62	♂	5.2	X	—	—	X
	6	50	—	—	X	X	—	—
	7	60	—	—	—	—	—	—
	8	48	♂	4.0	—	—	—	X
	9	45	♀	—	—	X	—	X
	10	62	♂[a]	6.7	X	X	—	X
	11	49	—	—	—	—	—	—
	12	47	—	—	X	—	—	—
	13	48	—	—	X	X	—	—
	14	44	—	—	X	X	—	—
Marked Sept. 3	15	42	♂	4.7	—	—	X	X
	16	53	—	—	—	X	—	—
	17	56	♂	6.4	—	X	X	X
	18	61	♂	6.4	—	X	—	X
	19	57	♂	5.3	—	—	—	X
	20	43	—	—	—	X	—	—

TABLE 3—*Continued*

	Field No. of Frog	Body Length (mm.)	Sex	Testis Length (mm.)	Dates Recovered Sept. 3	Sept. 4	Sept. 5	Sept. 9
Marked Sept. 4	21	52	—	—	—	—	—	—
	22	80	♂[a]	—	—	—	X	—
	23	63	—	—	—	—	—	—
	24	64	—	—	—	—	X	—
	25	65	—	—	—	—	X	—
Marked Sept. 5	26	54	♂	6.5	—	—	—	X
	27	61	—	—	—	—	—	—
	27a	61	—	—	—	—	—	—
	28	43	—	—	—	—	—	—
	29	38	♀	—	—	—	—	X
	30	46	—	—	—	—	—	—
Collected Sept. 9	31	38	♂	2.2	—	—	—	—
	32	55	♂	5.2	—	—	—	—
	33	60	♂	5.8	—	—	—	—
	34	57	♂	8.5	—	—	—	—
	35	49	♀	—	—	—	—	—
	36	52	♂	3.3	—	—	—	—
	37	49	♀	—	—	—	—	—
	38	46	♀	—	—	—	—	—
	39	49	♀	—	—	—	—	—

[a] Field determination based on thumb pads.

TABLE 4

MATERIAL EXAMINED

22	Arroyo Sacahuite frogs	A.M.N.H.[a]	Nos. 52903–24
20	*Rana tarahumarae*		
2	Oblatos, Jalisco, Mexico	A.M.N.H.	Nos. 12533–34[b]
1	Pilares 10 N., Sonora, Mexico	U.M.M.Z.	No. 78339
8	El Tigre Mts., Sonora, Mexico	U.M.M.Z.	Nos. 78340–1
9	Peña Blanca Spring, Santa Cruz Co., Ariz.	U.M.M.Z.	Nos. 75743-5
		C.U.	No. 3299
20	*Rana pustulosa*		
19	Cuicatlan, Oaxaca, Mexico	A.M.N.H.	Nos. 52040–4 14 unnumbered
1	Guirocoba, Sonora, Mexico	A.M.N.H.	No. 51224[b]
42	*Rana palmipes*		
40	British Guiana	A.M.N.H.	Nos. 44555–74
2	Santa Maria Chimalapa, Oaxaca, Mexico	A.M.N.H.	Nos. 51818–9
6	*Rana boylii boylii*		
1	Mill Valley, California	A.M.N.H.	No. 54
1	Marin Co., California	A.M.N.H.	No. 2770
3	Yosemite National Park, California	A.M.N.H.	Nos. 51683–5
1	Tuolomne Co., California	A.M.N.H.	No. 52219

[a] The following abbreviations are used: A.M.N.H., American Museum of Natural History; U.M.M.Z., University of Michigan Museum of Zoology; C.U., Cornell University.

[b] These allocations are tentative, and the specimens should be re-examined when larger and more extensive series are available.

TABLE 5

MEASUREMENTS (IN MILLIMETERS) AND RATIOS FOR *Rana moorei* AND RELATED SPECIES

	Body	Head Length	Head Width	Hind Limb	Body/ Head	Body/ Hind Limb	Head Length/ Head Width
Arroyo Sacahuite							
A.M.N.H. No. 52903	54	18.7	18.4	71.0	2.9	0.76	1.01
52904	45	17.5	17.0	67.5	2.6	0.67	1.03
52905	62	22.0	21.1	92.3	2.8	0.67	1.04
52906	48	18.2	17.7	69.2	2.6	0.69	1.03
52907	45	17.1	17.0	61.2	2.6	0.74	1.01
52908	62	24.7	22.2	95.1	2.5	0.65	1.11
52909	42	14.1	15.0	55.7	3.0	0.75	0.94
52910	56	19.7	19.8	89.5	2.8	0.63	0.99
52912	57	20.3	20.0	82.7	2.8	0.69	1.01
52913	54	18.0	19.3	84.4	3.0	0.64	0.93
52914	38	15.8	14.2	59.5	2.4	0.64	1.11
52915	38	15.0	13.7	56.1	2.5	0.68	1.09
52916	55	20.3	19.8	83.0	2.7	0.66	1.03
52917	60	22.3	21.3	93.8	2.7	0.64	1.05
52918	58	21.8	20.0	90.6	2.7	0.65	1.09
52919	49	18.0	17.4	67.4	2.7	0.73	1.03
52920	52	17.8	18.0	79.4	2.9	0.65	0.99
52921	49	17.2	16.8	71.3	2.8	0.69	1.02
52922	46	18.6	17.7	67.0	2.5	0.69	1.05
52923	49	20.5	18.4	77.5	2.4	0.63	1.11
52924	49	18.0	18.6	77.4	2.7	0.63	0.97
R. tarahumarae							
A.M.N.H. No. 12533	43.3	17.1	16.8	69.2	2.5	0.63	1.01
12534	47.6	18.6	18.8	78.5	2.6	0.61	0.99
U.M.M.Z. No. 75743	97.2	33.1	35.0	159.1	2.9	0.61	0.95
75743	57.0	21.3	22.2	95.0	2.7	0.60	0.96
75744	86.5	30.1	32.9	146.5	2.9	0.59	0.91
75745	42.0	15.8	16.0	62.0	2.7	0.68	0.99
75745	43.4	14.8	16.4	65.0	2.9	0.67	0.90
75745	45.5	16.7	17.0	72.8	2.7	0.62	0.98
78339	72.3	26.3	28.3	118.0	2.7	0.61	0.93
78340	70.5	24.1	26.5	113.6	2.9	0.62	0.91
78340	59.7	20.8	22.0	92.4	2.9	0.65	0.95
78340	48.5	15.8	18.5	78.1	3.1	0.62	0.85
78341	68.2	23.7	26.1	107.2	2.9	0.64	0.91
78341	64.1	22.1	23.0	95.0	2.9	0.67	0.96
78341	59.1	21.0	21.8	90.0	2.8	0.66	0.96
78341	47.8	16.7	17.2	70.7	2.9	0.68	0.97
78341	47.8	16.0	16.8	74.5	3.0	0.64	0.95
Boulenger's *R. tarahumarae*							
No. 1	73	25	30	125	2.9	0.58	0.83
2	77	25	29	122	3.1	0.62	0.86
3	65	21	24	104	3.1	0.62	0.87
4	58	20	23	98	2.9	0.59	0.87
5	61	21	23	103	2.9	0.59	0.91
6	45	16	17	74	2.8	0.61	0.94
R. b. boylii							
A.M.N.H. No. 54	38.7	14.5	16.1	74.0	2.7	0.52	0.90
2770	43.6	15.5	17.5	78.6	2.8	0.55	0.89
51683	41.6	15.0	16.0	71.8	2.8	0.58	0.94
51684	32.5	10.0	12.1	52.2	3.2	0.62	0.83
51685	32.5	10.0	12.4	52.5	3.2	0.62	0.81
52219	75.5	25.0	31.0	131.3	3.0	0.58	0.81
R. pustulosa							
A.M.N.H. No. 51224	74.8	25.5	27.3	121.3	2.9	0.62	0.93
52040	73.1	26.5	27.0	111.0	2.8	0.66	0.98
52041	73.8	25.8	27.9	115.0	2.8	0.64	0.92
52042	72.0	28.4	30.2	111.0	2.5	0.65	0.94
5204	77.5	29.0	31.0	122.0	2.7	0.64	0.94
5204	88.0	30.7	34.3	127.1	2.9	0.70	0.90
	70.5	27.2	29.1	113.6	2.6	0.62	0.93

TABLE 5—*Continued*

	Body	Head Length	Head Width	Hind Limb	Body/ Head	Body/ Hind Limb	Head Length/ Head Width
	66.0	24.8	28.5	105.8	2.6	0.62	0.87
	60.8	21.7	22.7	96.7	2.8	0.63	0.96
	68.3	25.6	28.9	111.1	2.7	0.61	0.89
	63.4	23.8	23.8	103.3	2.7	0.61	1.00
	58.2	22.8	23.7	94.3	2.5	0.62	0.96
	65.3	25.0	27.4	105.5	2.6	0.62	0.91
	69.1	26.8	28.2	115.6	2.6	0.60	0.95
	70.8	26.2	29.6	115.4	2.7	0.61	0.89
	57.6	22.7	23.5	92.8	2.5	0.62	0.97
	58.0	22.3	25.0	91.8	2.6	0.63	0.89
	56.3	21.6	22.3	91.5	2.6	0.61	0.97
	64.8	25.7	26.8	105.4	2.5	0.61	0.96
	67.5	25.5	29.0	110.5	2.6	0.61	0.88
R. palmipes							
A.M.N.H. No. 44555	105.0	40.3	41.1	154.8	2.6	0.68	0.98
44556	82.3	30.6	30.7	131.4	2.7	0.63	1.00
44557	84.1	32.0	31.3	137.0	2.6	0.61	1.02
44558	104.7	39.3	41.7	159.2	2.7	0.66	0.94
44559	89.4	33.3	34.1	139.1	2.7	0.64	0.98
44560	101.2	36.6	38.7	148.0	2.8	0.68	0.95
44561	76.0	29.2	28.6	118.4	2.6	0.64	1.02
44562	105.2	39.5	39.7	154.7	2.7	0.68	0.99
44563	85.8	30.1	31.7	130.7	2.8	0.66	0.95
44564	87.8	33.5	36.5	139.8	2.6	0.63	0.92
44565	82.6	31.7	32.8	136.1	2.6	0.61	0.97
44566	85.0	31.6	31.7	140.5	2.7	0.60	1.00
44567	109.0	38.1	41.0	157.8	2.6	0.69	0.93
44568	96.5	36.4	39.0	145.1	2.6	0.67	0.93
44569	106.0	38.6	41.8	166.4	2.7	0.64	0.92
44570	91.8	33.3	34.2	144.9	2.8	0.63	0.97
44571	100.0	35.7	37.0	158.3	2.8	0.63	0.97
44572	89.7	33.6	33.7	141.8	2.7	0.63	1.00
44573	88.2	32.2	35.0	144.8	2.7	0.61	0.92
44574	93.7	35.2	37.5	151.5	2.7	0.61	0.94
Unnumbered	74.1	28.2	29.2	120.7	2.6	0.61	0.97
	67.0	26.0	25.3	101.3	2.6	0.66	1.03
	75.3	28.5	29.2	113.7	2.6	0.66	0.98
	66.1	25.7	26.0	106.1	2.6	0.62	0.99
	77.0	28.7	30.0	121.0	2.7	0.64	0.96
	74.0	27.5	26.7	114.8	2.7	0.65	1.03
	73.1	26.5	25.0	115.5	2.8	0.63	1.06
	67.8	26.2	25.0	108.4	2.6	0.63	1.05
	77.2	29.3	30.7	124.7	2.6	0.62	0.95
	81.5	30.0	31.5	125.0	2.7	0.65	0.95
	74.9	28.0	29.6	131.0	2.7	0.57	0.95
	79.0	29.7	28.7	124.4	2.7	0.64	1.03
	72.4	28.1	28.7	120.5	2.6	0.60	0.98
	77.6	31.2	32.1	125.9	2.5	0.60	0.97
	75.0	29.0	31.0	124.4	2.6	0.60	0.94
	69.6	27.2	27.0	113.2	2.6	0.61	1.01
	70.8	26.3	25.5	107.5	2.7	0.66	1.03
	72.6	29.2	28.7	121.0	2.5	0.60	1.02
	76.1	28.3	29.0	121.2	2.7	0.63	0.98
	66.2	25.7	26.7	107.7	2.6	0.61	0.96