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## HERPETOLOGY OF THE ZUNI MOUNTAINS REGION, NORTHWESTERN NEW MEXICO<sup>1</sup>

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### Introduction

In decided contrast to the amount of herpetological information available for other southwestern states, relatively little is known about amphibians and reptiles in New Mexico. Several taxonomic papers have dealt with members of the state herpetofauna, but none have treated local distribution and differentiation in detail. It is the intent of this study, and of others in progress, to describe the amphibians and reptiles of New Mexico by natural regions, with the aim of understanding local variation in morphology, distribution, and life history.

Field observations and specimens obtained during portions of the summers of 1951, 1954, and 1955 constituted a preliminary survey of amphibian and reptilian species in northwestern New Mexico. Thereafter, emphasis was placed on the Zuni region as a biogeographic unit. Local studies of ecology and assumed gene flow were made

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intermittently during June–September in 1956 and 1957, and during June–August in 1958 and 1959. Additional data on vegetation were recorded in August 1960; a few herpetological specimens were added at this time and in July–August 1961. Altogether, 132 days and nights were spent in the field in the area covered by figure 1.

A long history of random herpetological collecting in the Zuni region has preceded these investigations. S. W. Woodhouse, a member of the 1851 Sitgreaves Expedition, first obtained representatives of the local herpetofauna. Two new species, *Tapaya ornatissima* (= *Phrynosoma douglassi hernandesi*) and *Pityophis affinis* (= *Pituophis melanoleucus affinis*) were described from among his specimens. Personnel associated with the United States Army at Fort Wingate, the U.S. Biological Survey, and various U.S. railway and army explorations west of the one-hundredth meridian, especially V. Bailey, E. A. Goldman, H. W. Henshaw, C. G. Newberry, and R. W. Shufeldt, contributed specimens prior to 1910. This historically important material is housed in the U.S. National Museum. E. T. Hooper and W. L. Chenoweth collected amphibians and reptiles in 1939 and 1949–1951 respectively; their specimens and my own have been deposited in the Museum of Zoology, University of Michigan, and the Cornell University herpetological collection.

Aspects of this study were discussed with several persons, especially Bruce B. Collette, Norman Hartweg, Charles F. Walker, and Thomas M. Uzzell, Jr. William J. Hamilton, Jr., at Cornell University and Norman Hartweg and Charles F. Walker at the University of Michigan greatly facilitated my research. William L. Chenoweth, Hillis L. Howie, and Rossiter D. Olmstead were contributors to success in the field. Edward C. Raney provided the opportunity for a trip to the U.S. National Museum, where Doris M. Cochran aided my quest for specimens and historical data. Stanwyn G. Shetler identified certain plants. My wife, Nancy Y. Gehlbach, helped with vegetational analyses and typed the manuscript. A Sigma Xi grant-in-aid for research made part of the 1958 field work possible.

The following loaned specimens or provided specific information about them: Curtis Allen, James D. Anderson, Ralph W. Axtell, W. Frank Blair, J. Roger Bider, Charles M. Bogert, James E. Böhlke, Bryce C. Brown, William G. Degenhardt, Floyd L. Downs, William E. Duellman, James S. Findley, Joe Gorman, Michael Hays, Arthur H. Harris, Norman Hartweg, Robert F. Inger, Clyde J. Jones, Laurence M. Klauber, John M. Legler, Paul Licht, Edmond V. Malnate, T. Paul Maslin, Samuel B. McDowell, Robert R. Miller, Jon A. Peterson, Paul W. Parmalee, Jay M. Sheppard, Hobart M. Smith, Wilmer W. Tanner, Robert W. Risebrough, Robert C. Stebbins, David A. West, Ernest E. Williams, Kenneth L. Williams, and Richard G. Zweifel.



I am very grateful to each of the above persons and institutions. I am equally indebted to the Prairie Trekers, whose efforts in my behalf produced many specimens and much inspiration; I dedicate this paper to them.

### Physical and Climatic Environments

The study area, referred to as the Zuni region or Zunis, includes most of McKinley and Valencia Counties, New Mexico (fig. 1). It is situated in portions of both Datil and Navajo Sections of the Colorado Plateau at the southeastern extremity of this physiographic province (Hunt, 1956, fig. 1). Elevations range from 5794 to 11,389 feet. The diverse topography and semiarid climate, with their attendant effects on vegetation, greatly influence herpetofaunal distribution.

#### Topography

Most spacious of the various topographical features are the Zuni Mountains, a domal uplift approximately 25 miles wide and 70 miles long, lying northwest by southeast near the southeastern edge of the Colorado Plateau. Strata surrounding the dome are gently sloping Pennsylvanian through Cretaceous formations, mostly sandstones (Fenneman, 1931, pp. 217-319). Rock outcrops are exposed in canyons, mesas, and the great retreating cliffs characteristic of Colorado Plateau topography. These major erosional features probably were formed no earlier than the Miocene and, along with the entire Plateau, have been uplifted in Pliocene and Pleistocene times (Hunt, 1956). The summit of Mount Sedgwick at 9156 feet is the highest point above the basal plain, which averages 7000 feet.

Running along Oso Ridge, the Continental Divide separates the Zuni Mountains almost equally into eastern and western watersheds. The former is partly drained by Azul and Bluewater Creeks, which flow into the Rio San Jose and ultimately into the Rio Grande. The latter is drained by the Rio Puerco (this name is also given to a stream of the Rio Grande basin), Rio Nutria, and Zuni River, which empty into the Little Colorado River. All streams, except the headwaters of the Zuni, are intermittent, and steady flow occurs only during the summer period of heaviest precipitation. Bluewater Lake and Ramah Reservoir are relatively permanent man-made features.

Between the Zuni Mountains and other structural upwarps are broad, open valleys such as the Gallup-Zuni Basin. The strata of this basin slope gently westward from the Zuni Mountains, decreasing from 8000 feet to 6500 feet toward the mouth of the Zuni River. Such features give the region its continuous yet vertically diverse aspect. To the north, gently undulating topography of the Navajo



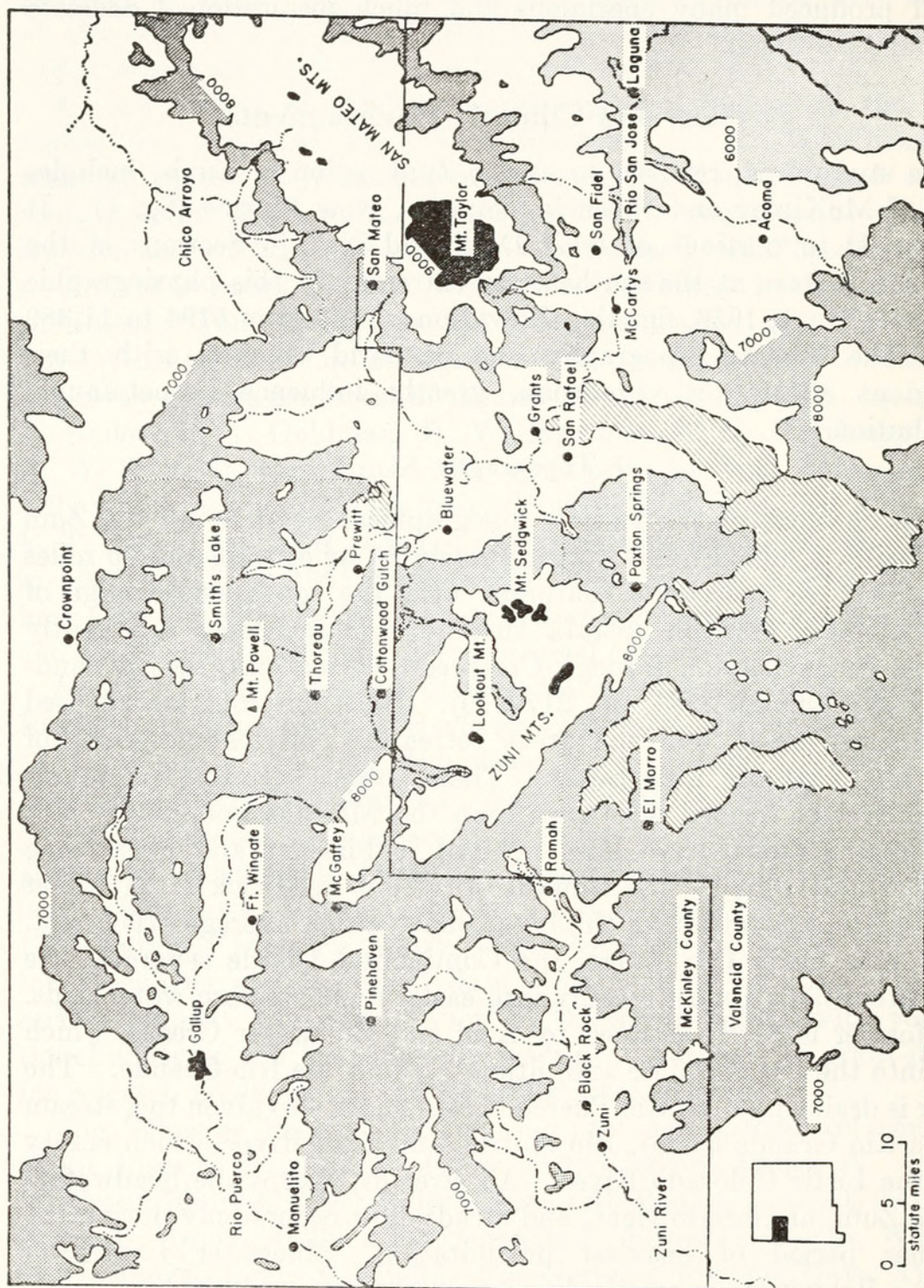


FIGURE 1.—Zuni Mountains region, adapted from the U.S. Coast and Geodetic Survey, Albuquerque and Douglas Aeronautical Charts, 1957. (Major lava beds are indicated by diagonal lines; other topographic features are stippled. Position of the region within New Mexico is shown by the inset map.)



Section continues into the San Juan Basin. On the south the Zunis and North Plains of the Datil Section are replaced by the San Augustine Plains and rugged montane highlands associated with the Basin and Range physiographic province.

East of the Zuni Mountains, Mount Taylor, an 11,389 foot Miocene volcano, dominates the area of eroded, basalt-capped mesas known collectively as the San Mateo Mountains (not to be confused with an uplift of the same name in Socorro County). Mesa Chivato is the northeastern extension of this highland mass, which is approximately 15 by 35 miles in extent. Its slopes are drained by the Rio San Jose and Chico Arroyo and drop to 5794 feet at Laguna on the eastern end of the study area. This is about the southeastern boundary of the Colorado Plateau as marked by the westernmost faults of the Rio Grande (Hunt, 1956, p. 6).

Extensive lava beds or malpais, derived in part from Mount Taylor, are most conspicuous south of Grants. They stretch 30 miles on a southwesterly-northeasterly axis and are surrounded by a relatively flat plain several feet lower than the overrun lava. Cinder cones border the main malpais, which ranges from 8308 feet at the top of Flagpole Crater to 6200 feet near McCarteys. Much soil has accumulated where the lava is relatively smooth, as in the vicinity of El Morro National Monument and Cebolleta Mesa. This basalt is probably of late Miocene origin, whereas rough, broken malpais along the Rio San Jose near Grants is of Pleistocene derivation (Hunt, 1956, pp. 46, 53). The McCarteys lava may be less than 1200 years old (Nichols, 1946, p. 1049). North of Bluewater another small malpais lies isolated on the Cretaceous plain and, near it, numerous volcanic necks stud the landscape.

### Climate

The Zunis are characterized by a semiarid-mesothermal climatic regime with a P-E Index of 16-32 (Thornthwaite, 1931). It may be seen that local moisture conditions are allied closely with elevation and exposure (fig. 2). Prevailing air currents are southwesterly. Below 8000 feet average annual precipitation values are 13 inches on the southwest and 10 on the northeast; above 8000 feet, 20 inches is the average annual value (U.S. Dept. Comm., 1945-1957). The period of greatest rainfall occurs from July through September. Short, heavy thundershowers are then common and often result in flash floods. Heavy winter snows usually are limited to the elevations above 8000 feet.

Pearson (1931, table 14) has assembled annual mean precipitation data for various plant zones in Arizona and New Mexico. They range from 11 inches in the grasslands and 16 in pinyon-juniper



woodlands to 21 in ponderosa pine and 22 in Douglas fir zones. The evaporative effect of winds, however, limits mesophytic vegetation on exposed slopes so that correlations between precipitation and elevation are often spurious for indexing vegetational distribution.

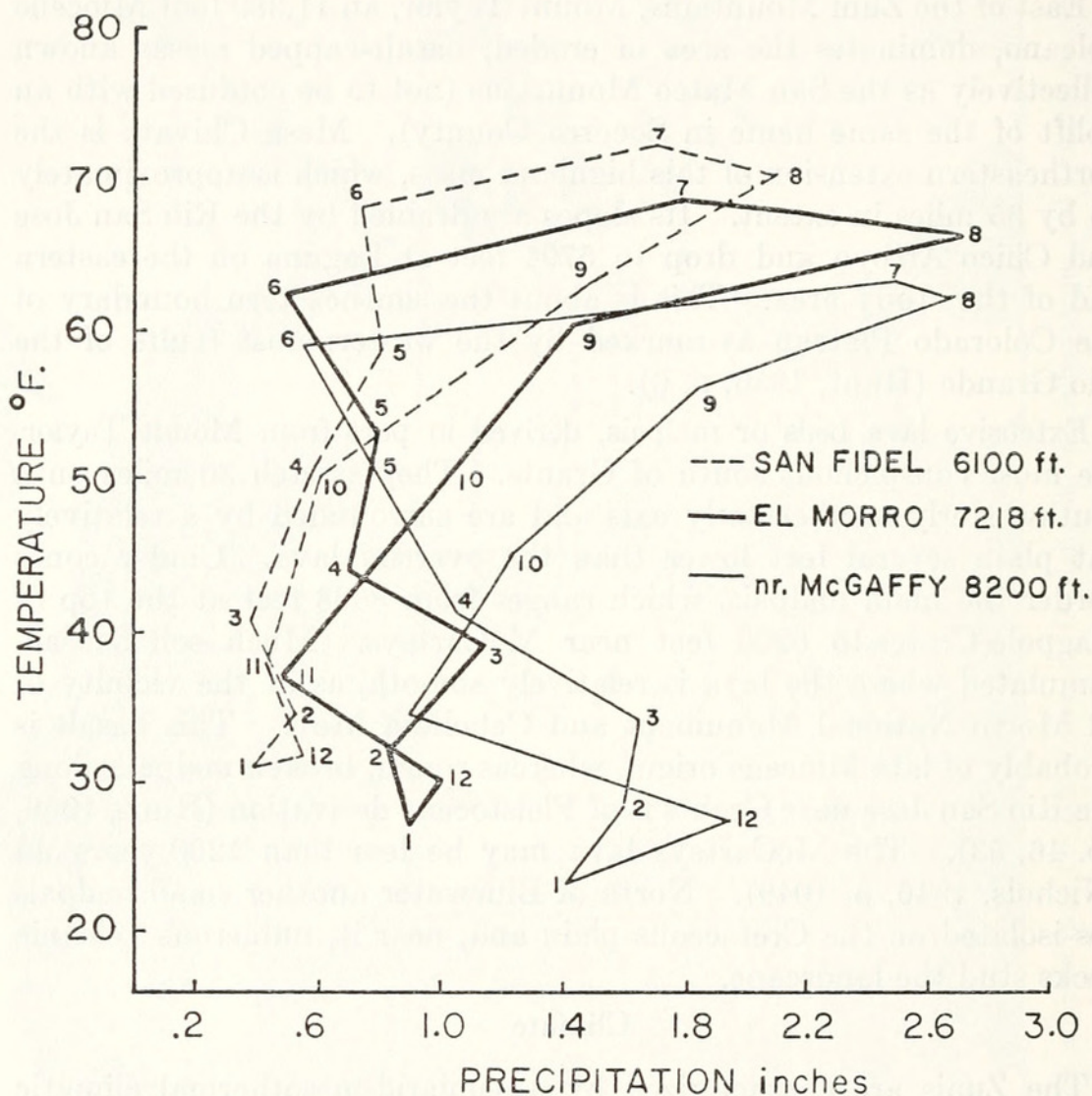


FIGURE 2.—Climatograph of three weather stations in the Zuni region. (Plotted points are mean monthly temperatures and precipitation; months are indicated by numbers. Data compiled from U.S. Department of Commerce climatological summaries for New Mexico, 1945-1957.)

Air temperatures generally fall with increasing elevation, the annual fluctuation being equally great at all stations (fig. 2). The number of days between 32° F. extremes is 123-194 ( $\bar{x}$  162) below 7000 feet, 72-148 (120) above 7000 feet (U.S. Dept. Comm., 1945-1957). Daily temperature variation is also considerable (table 1). Pearson (1931, tables 3, 4) calculated June-September maximum and minimum temperatures in New Mexico and Arizona as follows: 90, 55 (°F) in the grassland zone; 83, 52, pinyon-juniper woodland; 79, 46, ponderosa pine zone; and 74, 40, in the Douglas fir zone. Hooper



(1941, table 1) and Lindsey (1951, table 1) have presented other temperature data for the Zuni region.

TABLE 1.—*Temperature and humidity in the pinyon-juniper-ponderosa pine ecotone, 7200 feet, Cottonwood Gulch, McKinley County, New Mexico*

Measurement	1959	Value
Avg. max. temp.	July 1-31	93° F.
	August 1-20	87
Avg. min. temp.	July 1-31	51
	August 1-20	47
Max. temp.	July 3	98
Min. temp.	July 3	38
Avg. rel. humidity		
7:00 A.M.	July 1-August 10	56%
1:00 P.M.	July 1-August 10	29%

### Ecological Distribution

Included in the Navahonian biotic province of Dice (1943), the Zuni region contains Plains, Roughlands, and Montane Life Belts. While these biogeographic units vary with ecologic succession and exposure, they may be employed to describe elevational distribution of amphibians and reptiles. Within each life belt, the characterization of vegetational associations and substrate conditions will further delimit herpetofaunal range. No attempt at complete vegetational analysis is made here; only the relative positions of certain aspect dominants, important in providing cover, are described. The life belts and associations are both vertically and horizontally discontinuous, becoming increasingly mesophytic with ascending elevation.

#### Plains Life Belt

This lowermost unit extends in patchwork fashion from 5794 feet at the eastern end of the study area to approximately 7200 feet on the lava beds near El Morro. Shrub cover is relatively sparse except in the vicinity of arroyos and around rock outcrops and mesas. The soil may consist of loose sand or clay with little rock or restricted areas of gravel and rubble. At the edges of the Zuni and San Mateo Mountains this life belt is broken by mesas included in the Roughlands Life Belt and by malpais. Part of Bailey's (1913, pp. 25-41) Upper Sonoran Zone, the mixed grasslands of Castetter (1956), the basin sagebrush and short-grass plains of Clements (1920, pp. 139-144, 156, 160); and Pearson's (1931) grassland zone are included in the Plains Life Belt.



Eight (27 percent) of the 30 species of amphibians and reptiles recorded from the Zuni region are, so far as known, restricted to this belt. They are *Scaphiopus intermontanus*, *Scaphiopus bombifrons*, *Bufo punctatus*, *Uta stansburiana*, *Holbrookia maculata*, *Thamnophis dorsalis*, *Masticophis flagellum*, and *Crotalus atrox*. Certain other species, especially *Sceloporus graciosus*, *Eumeces obsoletus*, *Pituophis melanoleucus*, and *Crotalus viridis*, appear to reach their maximum abundance here.

For the most part, the Plains Life Belt is characterized by the short-grass or mixed-grass association in which blue grama (*Bouteloua gracilis*) is dominant or codominant with such other grasses as hairy grama (*B. hirsuta*) and galleta (*Hilaria jamesi*) (pl. 1A). *Holbrookia maculata* usually is found where shrub cover is sparse and composed of rabbitbush (*Chrysothamnus nauseosus*), snakeweed (*Gutierrezia sarothrae*), or narrow-leaved yucca (*Yucca glauca*). Reptile life is more varied in somewhat heavier cover, as in the saltbush-sage association dominated by shadscale saltbush (*Atriplex canescens*), spiny saltbush (*A. confertifolia*), or big sagebrush (*Artemisia tridentata*). *Sceloporus graciosus* is limited primarily to this vegetational type. *Crotalus atrox* seems similarly limited to the cholla-juniper association dominated by cholla cactus (*Opuntia imbricata*) and one-seed juniper (*Juniperus monosperma*).

Between elevations of 6500 and 7200 feet there may be an ecotone or a broad continuum between Plains and Roughlands Life Belts marked by an increased number of one-seed junipers and various taller shrubs such as mountain mahogany (*Cercocarpus montanus*). Pinyons (*Pinus edulis*) may be present. The widespread continuum could, in part, be caused by excessive grazing (Castetter, 1956, p. 272). *Eumeces obsoletus* occurs here as do most other Plains species that range into the Roughlands. Rock-strewn arroyos also permit species like *Crotaphytus collaris* and *Masticophis taeniatus* to bridge the ecological gap between the two life belts.

### Roughlands Life Belt

The Roughlands Life Belt comprises rocky uplands from around 6800 feet to at least 8000 feet. Its outside elevational limits are influenced by the presence of rocky soil combined with the effects of less moisture at lower elevations and lower temperatures in Montane environments (see Castetter, 1956, p. 271). Vegetative cover is much thicker than on the plains, and outcropping sedimentary strata produce boulder piles and talus slopes, thus providing additional retreats for secretive species. This life belt includes the upper part of Bailey's (1913, pp. 25-46) Upper Sonoran Zone and lower limits of his Tran-



sition Zone in addition to the woodland biome of Castetter (1956), pinyon-cedar woodland and petran chaparral of Clements (1920, pp. 183-187, 197-199), and pinyon-juniper and lower ponderosa pine zones of Pearson (1931).

Two species, *Diadophis punctatus* and *Salvadora grahamiae*, presently are known only from this life belt but probably are more widely distributed. *Ambystoma tigrinum*, *Scaphiopus hammondi*, *Bufo woodhousei*, *Rana pipiens*, *Hyla arenicolor*, *Phrynosoma douglassi*, *Sceloporus undulatus*, *Urosaurus ornatus*, *Eumeces multivirgatus*, *Cnemidophorus velox*, and *Thamnophis elegans* reach their greatest abundance here. Other, rarer species, such as *Hypsiglena torquata* and *Crotalus molossus*, may be centered in the Roughlands Life Belt.

Dominated by pinyons, one-seed junipers, alligator junipers (*Juniperus deppeana*), and Rocky Mountains junipers (*J. scopulorum*), the pinyon-juniper association is the most widespread vegetational type (pl. 1B). Shrub cover is relatively sparse but consists of aspect dominants similar to those of the oak-mahogany association described below. Amphibians and reptiles such as *Scaphiopus hammondi*, *Phrynosoma douglassi*, and *Cnemidophorus velox* are more abundant where the pinyon-juniper resembles a rocky savanna. Openings in the savanna often are occupied by saltbush and occasionally extensive stands of big sagebrush. If large boulders are present, as on hillsides and mesa edges, *Crotaphytus collaris* and *Urosaurus ornatus* are typically present.

The oak-mahogany association is composed largely of Gambel oak (*Quercus gambeli*) and mountain mahogany. Below approximately 7000 feet, wavyleaf oak (*Q. undulata*) may replace Gambel oak. Shrubs like gooseberry (*Ribes* sp.), skunkbush (*Rhus trilobata*), and datil (*Yucca baccata*) are present in varying numbers. This association occupies canyon sides and may replace the pinyon-juniper or ponderosa pine where timber is cut. Marked by heavier, more mesic cover, it shelters *Bufo woodhousei*, *Eumeces multivirgatus*, and some adults of *Ambystoma tigrinum*. It is distinct from the riparian association of canyon bottoms that is dominated by the narrowleaf cottonwood (*Populus angustifolia*) and various willows (*Salix* spp.) (pl. 1B). *Hyla arenicolor*, *Rana pipiens*, and *Thamnophis elegans* are more or less limited to the vicinity of streams and ephemeral ponds resulting from stream subsidence in the riparian association.

Transition from pinyon-juniper woodland into the Montane Life Belt often is gradual, especially on the north side of the Zuni Mountains and on Mount Taylor. Ponderosa pine (*Pinus ponderosa*) occurs in a few, relatively pure stands as low as 7200 feet. In the ponderosa pine association, mountain muhly (*Muhlenbergia montana*) may be the predominant ground cover. *Pituophis melanoleucus* and



*Crotalus viridis* were collected here as were representatives of all species found to be more abundant in pinyon-juniper, oak-mohogany, and riparian associations.

### Montane Life Belt

The heavy cover characteristic of this uppermost life belt prevails above approximately 7800 feet; lower limits may be found in sheltered canyons and on north-facing slopes, where exposure is a restricting factor. The ponderosa pine association marks the lower boundary and may include Douglas fir (*Pseudotsuga menziesi*) in cooler situations. Upper limits are best developed on the higher peaks, where the spruce-fir association includes Engelmann spruce (*Picea engelmanni*) and Douglas fir along with alpine fir (*Abies lasiocarpa*) and other conifers (pl. 1C). With the exception of parks and the limited alpine tundra association on Mount Taylor, vegetation is usually too thick to permit much heating of the substrate. The soil is composed of humus covered by conifer needles. Bailey's (1913, pp. 41-51) Transition, Canadian, and Hudsonian Life Zones are included in this belt as are the coniferous forest and petran alpine biomes of Castetter (1956), petran montane and subalpine forests of Clements (1920, pp. 207-210, 224-226), and Pearson's (1931) ponderosa pine, Douglas fir, and Englemann spruce zones.

No reptiles or amphibians are restricted to this belt and none appear to reach their maximum abundance here. While 14 species were collected in montane associations, all of the reptiles except *Thamnophis elegans* came from logged-off areas or rocky openings in ponderosa pine and spruce-fir associations. *Rana pipiens*, *Bufo woodhousei*, and *Hyla arenicolor*, among others, follow the riparian association that also penetrates the Montane Life Belt. *Ambystoma tigrinum*, *Pseudacris triseriata*, *Eumeces multivirgatus*, *Phrynosoma douglassi*, and *T. elegans* were found in parks or stands of quaking aspen (*Populus tremuloides*) (pl. 1C). Only *P. douglassi* was taken in the alpine tundra association, which has no arboreal vegetation.

### Recent Environmental Changes

There is little doubt that the Zuni region has suffered considerable modification within the past hundred years. The impact of man is superimposed on a record of continuous climatic change. Drought reduced the water supply and, coupled with grazing pressure, has eliminated much of the original grassland (Castetter, 1956, pp. 269, 272). Statements on the former abundance of grass were made by Bigelow (1856, p. 6), Whipple (1856, p. 62), and many others. Rothrock (1875, p. 120) described open parklike stands of ponderosa pine



with good forage at about 8000 feet near Ft. Wingate and noted that fir covered surrounding hillsides. Woodlands are now much thicker in some places and thinner or nonexistent in others because of grazing and logging, respectively (Castetter, 1956, pp. 272, 277). Correlated changes in herpetofaunal distribution may be surmized.

Surface water was more abundant prior to the twentieth century. Whipple (1856, pp. 14, 63) noted that the Zuni Indians cultivated without irrigation and described Agua Fria as a permanent spring. Kennerly (1856, pp. 9-10) observed the Zuni River as a small, clear stream in which fishes were secured at several localities. He also noted many frogs along the Rio Pescado in November. Coues (1875, pp. 614-615) found *Thamnophis elegans* in the Zuni River, "wherever this stream spread into sluggish lagoons." While seasonal changes influenced differences of opinion as to the abundance of water (e.g., in September, Sitgreaves, 1854, p. 5, described the Zuni River as a mere rivulet), it is noteworthy that Agua Fria and the lower Rio Pescado and Zuni are presently intermittent. Zuni Indians now irrigate; streams in the vicinity of their pueblo are extensively controlled.

As suggested by extensive arroyo cutting, which began in the late 1880's (Bryan, 1925, 1928), drought may account for the disappearance of surface water not purposely diverted by man. When this study was initiated, the Zuni region, indeed the entire Southwest, was in the midst of severe drought. Breeding amphibians were not collected until July 1954 and remained uncommon until 1957. *Diadophis punctatus* was not discovered at a previously worked locality (Cottonwood Gulch) until August 1959. The drought ended locally in 1957 when the Colorado Plateau Section of New Mexico received 146 percent of average annual moisture (U.S. Dept. Comm., 1945-1957). Profound changes in the neighboring Texas herpetofauna were linked to this drought (Blair, 1957; Milstead, 1960).

In 1960 the Bureau of Sport Fisheries exterminated all native aquatic organisms in the upper Zuni River (R. R. Miller, in litt.). Not a single aquatic animal depending on dissolved oxygen was left; an apparently undescribed fish, genus *Pantosteus*, was among the forms eliminated. Such wanton destruction probably will continue as the human population continues to increase. Grants experienced a 354 percent rise in population between 1950 and 1960 (Grants Chamber of Commerce, in litt.). Fortunately, however, small portions of Zuni grassland and pinyon-juniper association are preserved in El Morro National Monument and hopefully will be preserved in the proposed Manuelito National Monument.



### Lava

In contrast to numerous investigations of coloration in lavicolous mammals, relatively few workers have shown similar interest in lava-dwelling amphibians and reptiles. Lewis (1949; 1951), Norris (1958, p. 270), and Lawrence and Wilhoft (1958) have demonstrated, however, the presence of abnormally dark reptiles on southwestern lava flows. Apparently selection favoring procrypsis is operating in these environments. Tertiary lava beds in the Zuni region were described adequately by Hooper (1941) and Lindsey (1951). Hooper found that mammals restricted to the malpais had not developed dark races there.

With the exception of *Uta stansburiana*, *Sceloporus graciosus*, *Masticophis flagellum*, and *Crotalus atrox*, the species characteristic of the Plains Life Belt occasionally were taken on soil-covered lava. This substrate, widespread near El Morro and Cebolleta Mesa, presents an appearance similar to the short-grass association except that it is generally higher in elevation (see Lindsey, 1951, figs. 10, 11). The Grants lava flow, on the other hand, is rough and relatively unweathered, with less soil accumulation (see Hooper, 1941, pl. 2). *Crotaphytus collaris*, *Sceloporus undulatus*, *Urosaurus ornatus*, *Eumeces obsoletus*, *Thamnophis elegans*, *Pituophis melanoleucus*, and *Crotalus viridis* were collected or observed on the rougher malpais.

Only *C. collaris*, *U. ornatus*, and *Scaphiopus hammondi* show evidence of unusually dark coloration. The latter two species are predominantly dark gray with little trace of the usual patterned dorsum. Because local populations of these species tend to resemble substrate color to a remarkable extent, it appears unlikely that the dark, lavicolous individuals represent unique variation. Lewis (1951) found dark *U. ornatus* in southern New Mexico. Three adults of *C. collaris* are patterned but are quite dark in general coloration. This is the usual situation on New Mexico lava flows (Fitch, 1956a, p. 223).

Numbers of lavicolous reptiles and amphibians were not large. While the rubble of broken lava offers uncountable hiding places, the presence of ponderosa pine and Douglas fir, postclimax to adjacent nonlava vegetation (Lindsey, 1951, p. 220), may limit the ranges of Plains species on such a substrate. Sections of sparsely vegetated malpais dominated by apache plume (*Fallugia paradoxa*) held the most reptiles, but there appeared to be easy access to and from the lava margins, with the possibility of strong immigration pressure from contiguous grassland supporting larger populations of several species. Gene flow may thus reduce the effectiveness of local selective pressures. Marginal habitats, relative accessibility, and geologic recency of the Grants malpais undoubtedly account for the fact that no indigenous dark races have developed there.



### Vertical Distribution

In comparison with the Guadalupe Mountains, a region of about equal size and vertical range in southeastern New Mexico, it is evident that Zuni environmental diversity exceeds the diversity of the Zuni herpetofauna. Only 7 (33 percent) of 21 Zuni genera contain more than one species whereas 17 (41 percent) of 42 genera in the Guadalupe have two or more species (Gehlbach, in ms.). Sixty-five amphibians and reptiles currently are recorded in the Guadalupe region; only 30 definitely are known in the Zunis. This relative paucity may be influenced directly by the high elevations and climatic extremes. With increasing elevation there is a decline in the number of species (fig. 3). Such forms as *Scaphiopus bombifrons*, *Eumeces obsoletus*, and *Crotalus molossus*, near the boundary of their range in the Zunis, are restricted locally in contrast to their greater vertical distributions elsewhere.

Vertical transects from Thoreau, McKinley County, south to Cottonwood Gulch, thence to Lookout Mountain and El Morro, Valencia County (7000–9100 feet), and from Grants to Mount Taylor, Valencia County (6400–11,389 feet), were repeated in several summers (fig. 1). These, the locality records, and miscellaneous observations demonstrate that no two morphologically related species have precisely the same vertical range or relative abundance (fig. 3). This displacement pattern is especially apparent within genera but also occurs between genera if species possess similar habits (e.g., between *Holbrookia maculata* and *Phrynosoma douglassi*, or between *Masticophis taeniatus* and *Pituophis melanoleucus*). Axtell (1959, table 1) and Lowe and Zweifel (1952, fig. 4) have diagramed similar patterns in west Texas and central New Mexico respectively. The probability that two species will not be equally efficient in the same environment has been discussed by many biologists (e.g., Lack, 1949; Hutchinson, 1957).

Ecological differences were observed most readily among the Zuni lizards (table 2). Since similar differences have been correlated with morphological variation (Collette, 1961; Lundelius, 1957) and thermoregulation (Bogert, 1949; Fitch, 1956b), the presence or absence of such correlations may help to elucidate local ecological segregation. *Sceloporus undulatus*, *S. graciosus*, *Urosaurus ornatus*, *Phrynosoma douglassi*, *Eumeces multivirgatus*, and *Cnemidophorus velox* are of similar size; hence, presumably they are able to capture similar-sized prey. Attention is focused on these species with particular reference to the number of lamellae as an index to climbing ability (Collette, 1961).

Of the iguanids, *U. ornatus* shows the greatest climbing propensities and has the most lamellae in proportion to size (cf. table 2; fig. 4).



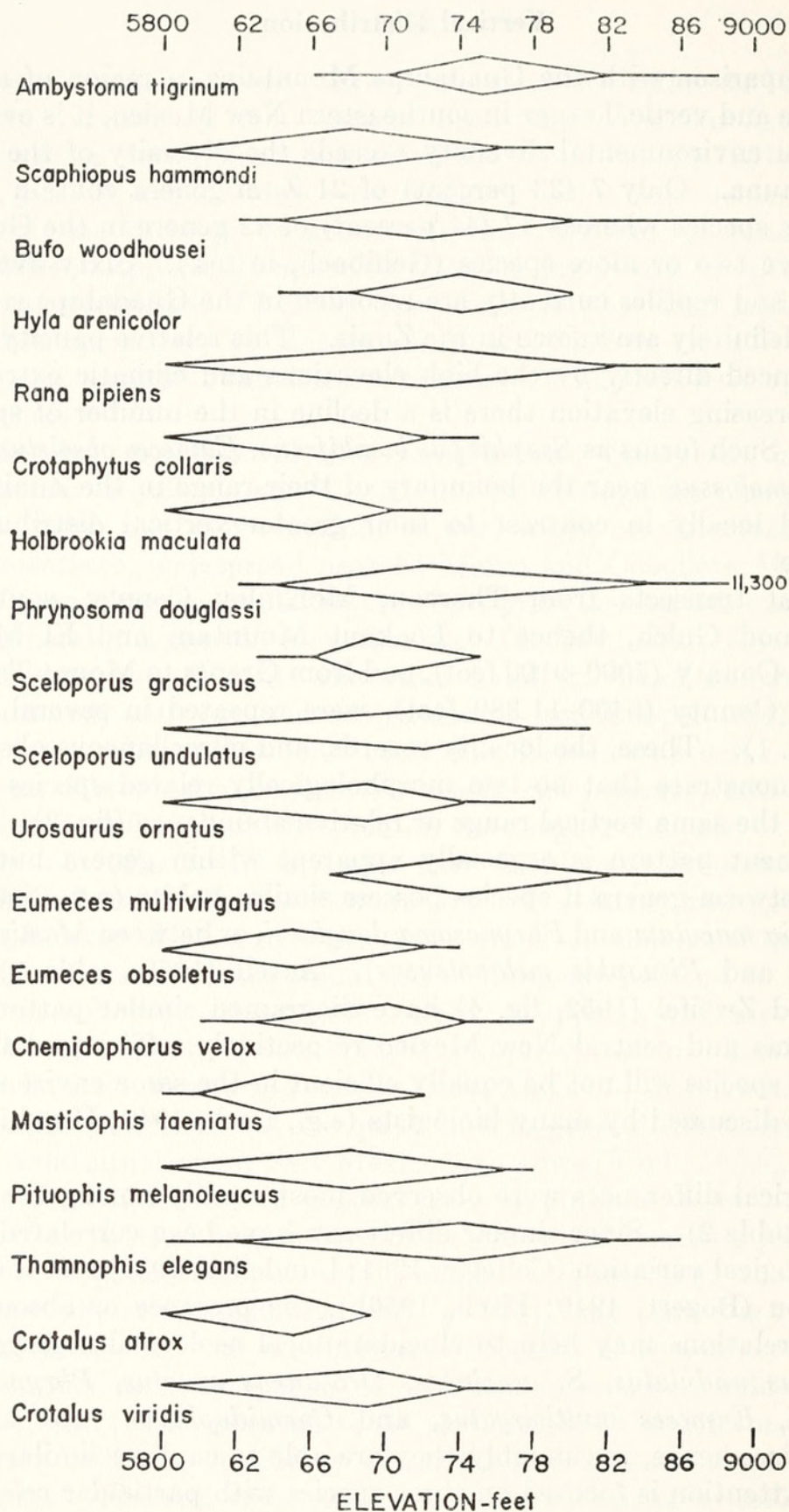


FIGURE 3.—Schematic vertical distribution and relative abundance of some amphibians and reptiles in the Zuni region. (The horizontal line indicates marginal occurrence; the widest part of each polygon is the approximate elevation of greatest abundance irrespective of habitat considerations noted in the text.)



Its elevational range is about equal to that of *S. undulatus*, but the two species are separated ecologically in all life belts. As suggested by its fewer lamellae, *S. undulatus* is primarily terrestrial, while *U. ornatus* is distinctly scansorial and saxicolous. At the same locality *S. undulatus* is found on the ground or on fallen or leaning tree trunks (rarely on vertical trunks), and *U. ornatus* inhabits rock outcrops, boulder piles, and cliffs. *U. ornatus* maintains body temperatures that are two to three degrees higher than *S. undulatus* or *S. graciosus* (P. Licht, in litt.). It frequents situations with greater exposure (table 2).

TABLE 2.—Niche relationships of adult lizards in the Zuni region (species are arranged from most scansorial to most terrestrial, top to bottom of table)

Shade	Partial shade	Sun
<i>Eumeces multivirgatus</i>	<i>Sceloporus undulatus</i> <i>Sceloporus graciosus</i> <i>Eumeces obsoletus</i> <i>Phrynosoma douglassi</i>	<i>Urosaurus ornatus</i> <i>Crotaphytus collaris</i> <i>Cnemidophorus velox</i> <i>Holbrookia maculata</i>

*S. graciosus* also is predominantly terrestrial and does not occur in ecological sympatry with *U. ornatus*. It has more lamellae than *S. undulatus* and fewer than *U. ornatus*; its vertical range and center of abundance are quite different (fig. 3). *S. graciosus* was found only in the vicinity of big sagebrush or saltbush on loose soil. In contrast, *S. undulatus* rarely was seen on such a substrate and was taken commonly on hard-packed clay or broken sandstone in the pinyon-juniper savanna. While these edaphic factors may separate partially the two species of *Sceloporus*, marked terrestriality in *S. graciosus* belies the obvious adaptive significance of having more lamellae. This character actually may have little to do with local ecological segregation, or it could permit more effective locomotion on loose soils.

*P. douglassi* has the lowest lamellae count among the iguanids considered here and is characteristically the most terrestrial (table 2; fig. 4). Although the two species of *Sceloporus* sometimes climb in rock-piles, bushes, and trees, *P. douglassi* was never observed off the ground. It has the greatest elevational range of any species in the Zunis and is more sedentary in habit and more abundant above 7200 feet (fig. 3). The vertical distribution and lamellae count of *E. multivirgatus* are most like those of *P. douglassi*; however, this skink typically inhabits dense vegetative cover (table 2). Bogert (1949) and Fitch (1956b) have shown that low body temperatures are more typical of *Eumeces* than either *Sceloporus* or *Cnemidophorus*.



The very high lamellae count of *C. velox* apparently is unrelated to scansorial ability, for this teiid rarely climbs. Instead, might the lamellae count be correlated with a longer toe, as Hecht (1952, p. 116) has suggested in other lizards? The number of lamellae cannot be used as an index of relative climbing ability here; its inapplicability

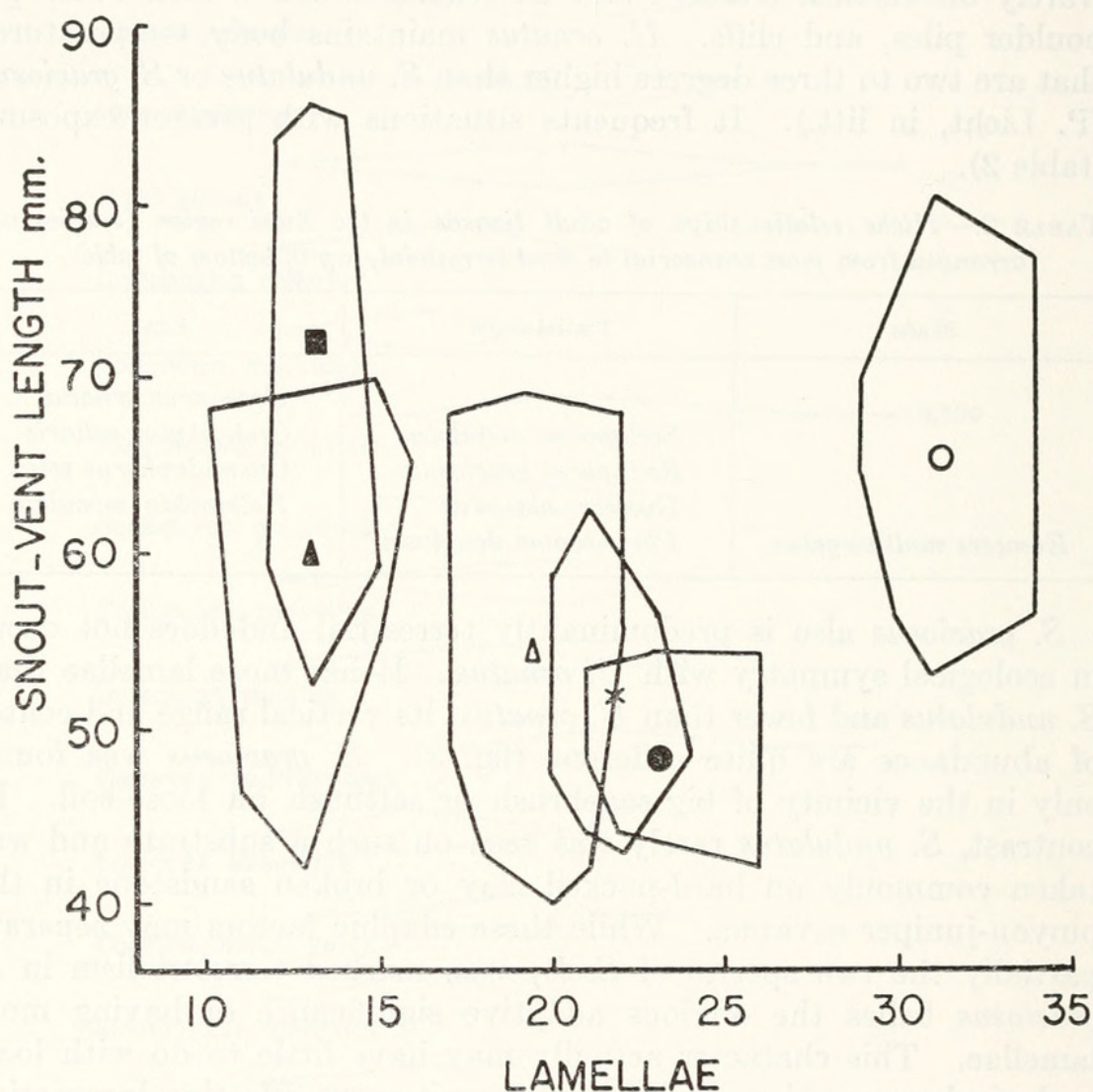


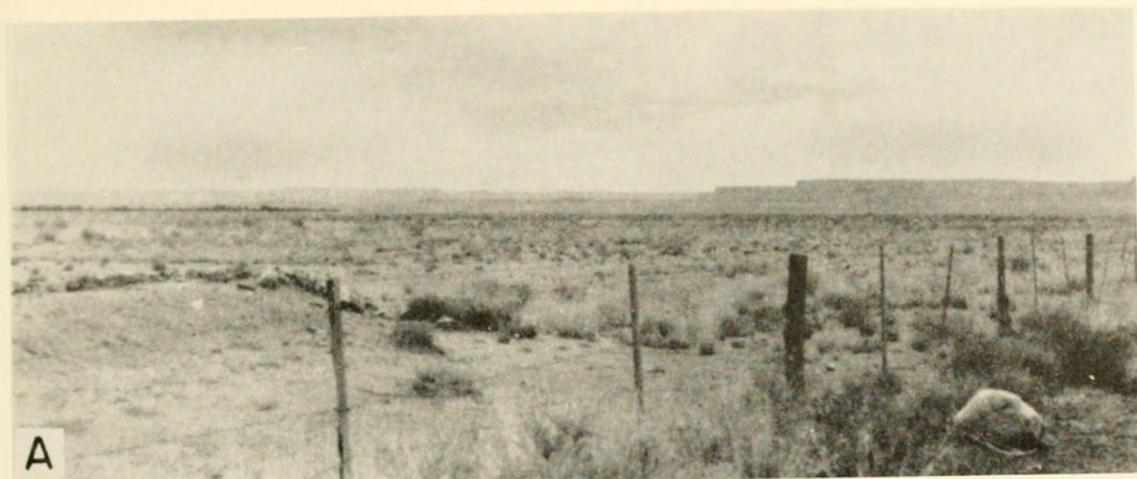
FIGURE 4.—Relationship of the number of fourth-toe lamellae to snout-vent length in adults of some Zuni lizards. (Outside limits of the plotted points are joined to form polygons representing each species. Means are indicated by position of the symbols.)

■ *Phrynosoma douglassi*  
 ▲ *Eumeces multivirgatus*  
 △ *Sceloporus undulatus*

× *Sceloporus graciosus*  
 ● *Urosaurus ornatus*  
 ○ *Cnemidophorus velox*

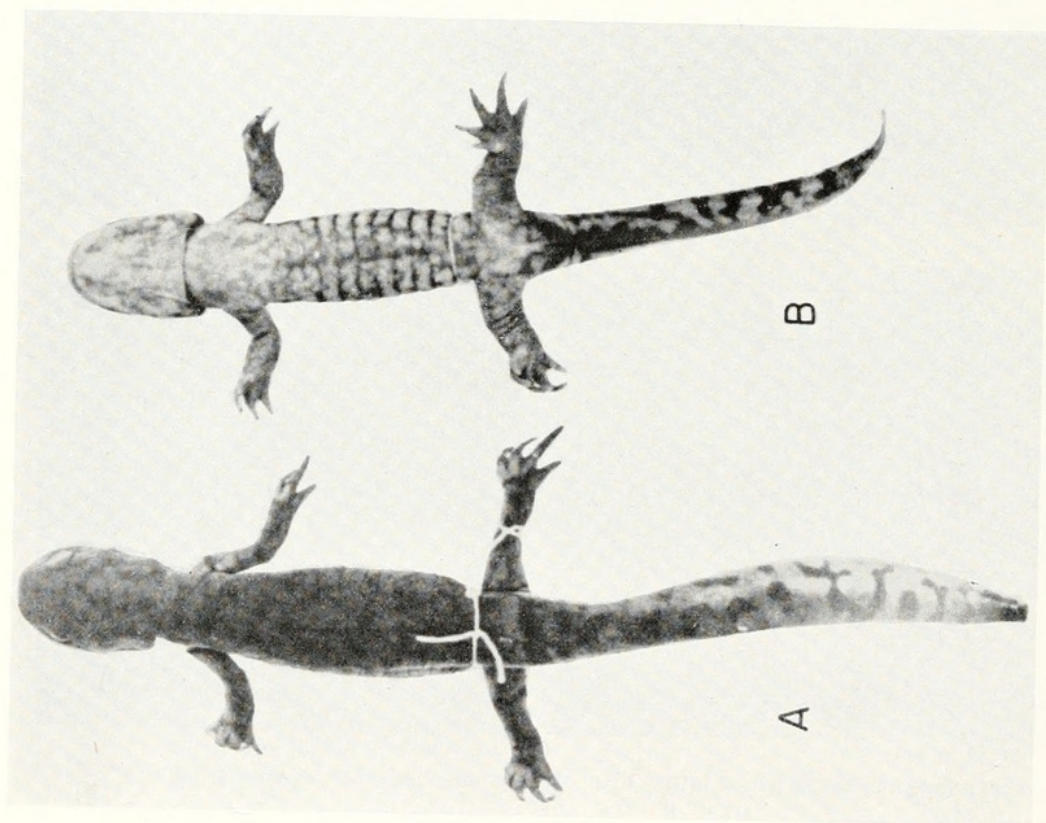
with respect to the observed intergeneric differences is apparent (fig. 4). Ecological separation is indicated, however; *C. velox* inhabits areas of greater insolation than the other nonclimbing species (table 2). Its congeners maintain much higher body temperatures than the other genera studied (Bogert, 1949; Fitch, 1956b).



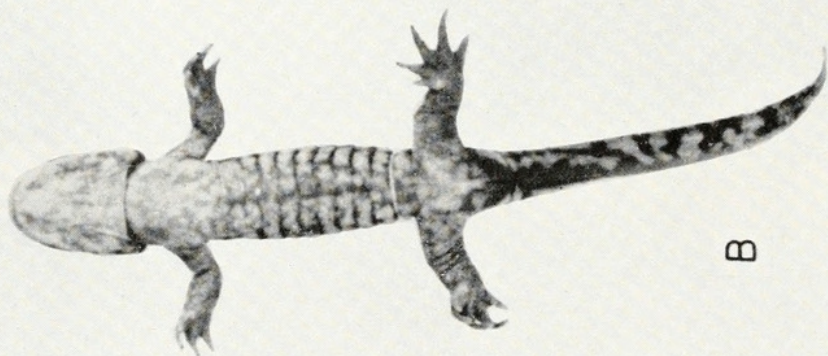


A, Short-grass association of the Plains Life Belt near Laguna, Valencia County, New Mexico, ca. 5700 feet, June 1957; B, Roughlands Life Belt at Cottonwood Gulch, McKinley County, New Mexico, ca. 7200 feet, June 1957 (the hillside supports pinyon-juniper association with riparian association on the right); C, Montane Life Belt at Ojo Redondo, Valencia County, New Mexico, ca. 8600 feet, July 1954 (a natural park in the foreground is surrounded by spruce-fir association perforated by aspen stands).

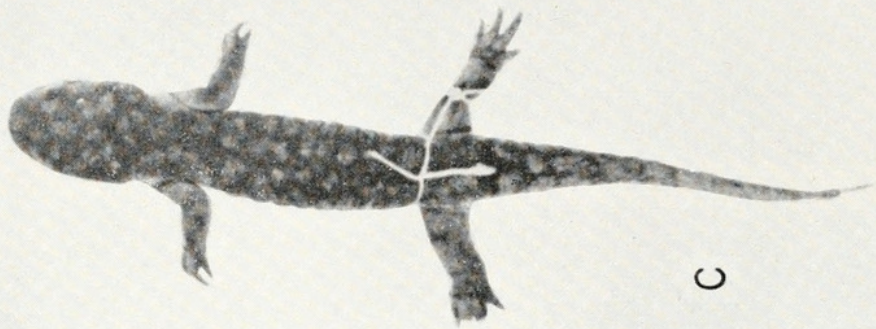




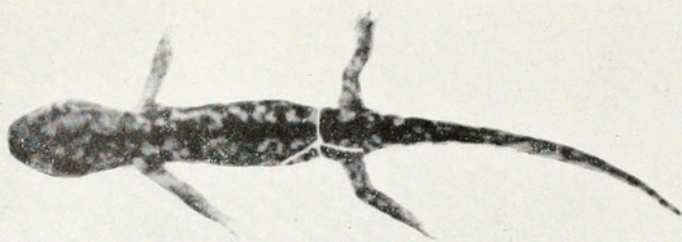
A



B



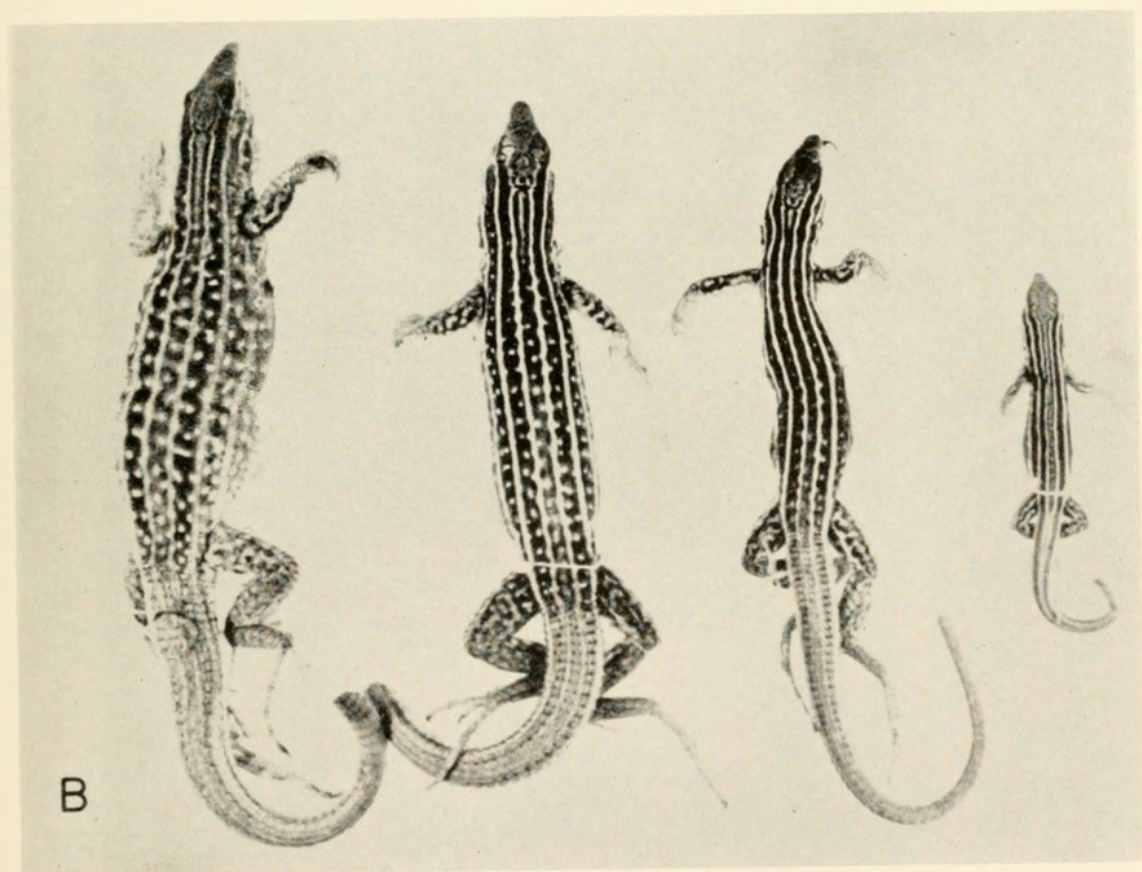
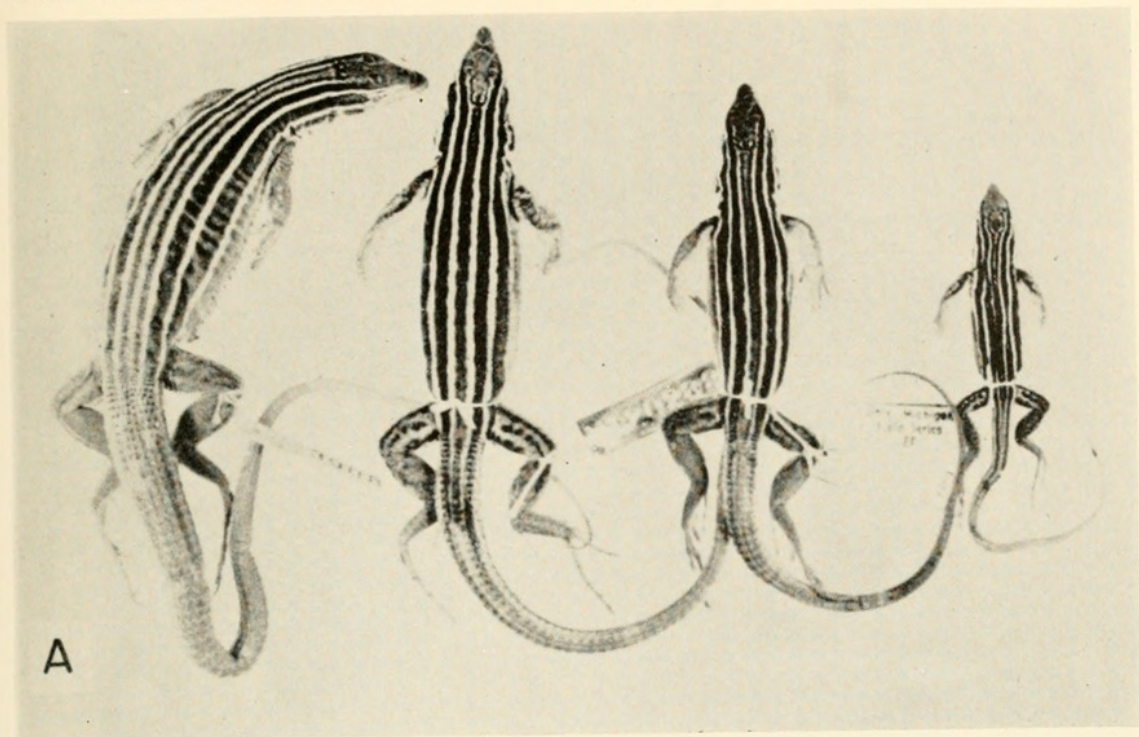
C



D

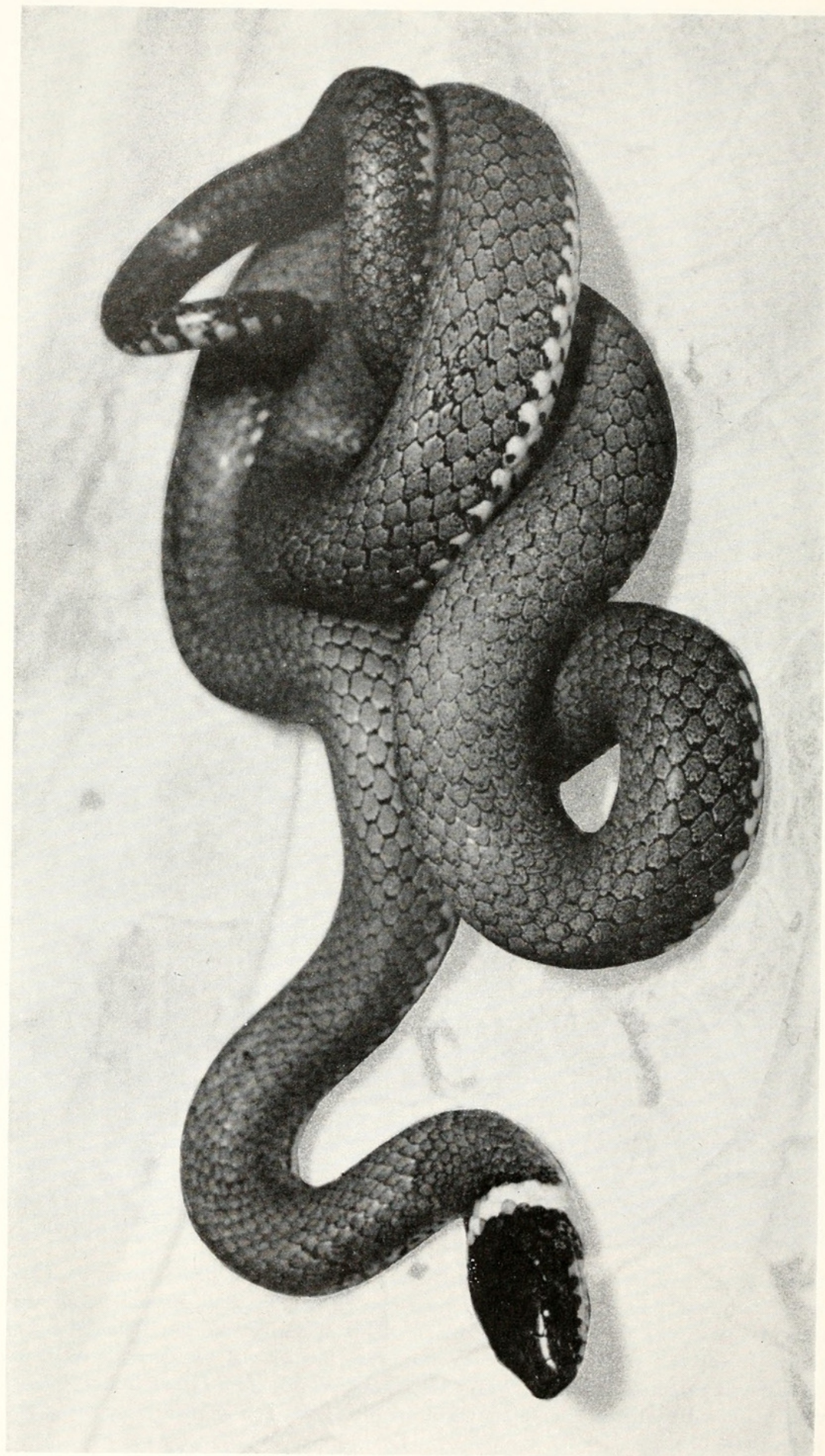
*Ambystoma tigrinum nebulosum* from the Zuni region: A, dorsum of UMMZ 120301, adult male, 102 mm. snout-vent, without yellow spots; B, venter of UMMZ 120305, adult female, 87 mm. snout-vent; C, dorsum of UMMZ 120305, adult female, 81 mm. snout-vent, with yellow spots; D, dorsum of UMMZ 120305, subadult, 60 mm. snout-vent, with yellow reticulated pattern.





A, Ontogenetic series of *Cnemidophorus velox* (UMMZ 120288-89, 120309) from the Zuni region: snout-vent lengths from left to right are 80, 70, 61, and 36 mm.; note the absence of spots, also the complete middorsal light stripe on the left followed by a specimen lacking this stripe and two with incomplete stripes. B, Ontogenetic series of *Cnemidophorus exsanguis* (UMMZ 79212, 15052, 102729-30) from Grant County, New Mexico: snout-vent lengths from left to right are 87, 81, 65, and 39 mm.; note the gradual appearance of spots.





*Diadophis punctatus regalis* from six miles south of Thoreau, McKinley County, New Mexico. The specimen (UMMZ 122947) is an adult male, 478 mm. in total length.



### Accounts of Species

Adult specimens of Zuni amphibians and reptiles that have been critically examined number about 700. Many more larval amphibians and collections from outside areas also have been studied. Meristic, morphometric, and color-pattern variations are analyzed according to taxonomic criteria set forth by the latest revisers. These criteria are recognizably different, depending on the student of the group (Pimentel, 1958). Their value, in certain cases, may be challenged. In addition, novel characters are described and evaluated with particular regard for environmental and ontogenetic variation.

For most species, a brief, locally pertinent, nomenclatorial history is followed by taxonomic analysis, data on life history, and a summary of ecological distribution. A more penetrating taxonomic account is included for *Ambystoma tigrinum*, *Cnemidophorus velox*, and *Diadophis punctatus* in view of certain problems that exist. Less space is devoted to some species because other workers are utilizing Zuni material or because few specimens or observations actually are available.

Locality records refer to the Zuni herpetofauna exclusively. Most of these records are based on specimens examined, but a few, indicated by asterisks, represent museum data supplied by colleagues. Comparative material examined includes only those extralimital specimens used in figures and tables or specifically referred to in the separate accounts and not given full provenance data in these discussions. In some cases newer maps permit more accurate mileages and elevations than previously published by Chenoweth (1950), Gehlbach (1956), and Hooper (1941); however, the Zuni region remains to be thoroughly surveyed.

Museum specimens are denoted by the following abbreviations:

AMNH	American Museum of Natural History, New York, N.Y.
ANSP	Academy of Natural Sciences, Philadelphia, Pa.
BCB	Bryce C. Brown (private collection), Waco, Tex.
BYU	Brigham Young University, Provo, Utah
CCNP	Carlsbad Caverns National Park, Carlsbad, N.M.
CNHM	Chicago Natural History Museum, Chicago, Ill.
CU	Cornell University, Ithaca, N.Y.
CWGF	Cottonwood Gulch Foundation, Thoreau, N.M.
ISM	Illinois State Museum, Springfield, Ill.
KUMNH	Kansas University, Museum of Natural History, Lawrence, Kans.
LMK	Laurence M. Klauber (private collection), San Diego, Calif.
MCZ	Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass.
MVZ	Museum of Vertebrate Zoology, Univ. of California, Berkeley, Calif.
TNHC	University of Texas Natural History Collection, Austin, Tex.
UCM	University of Colorado Museum, Boulder, Colo.



UIMNH	University of Illinois, Museum of Natural History, Urbana, Ill.
UMMZ	University of Michigan, Museum of Zoology, Ann Arbor, Mich.
UNMCV	University of New Mexico, Collection of Vertebrates, Albuquerque, N.M.
USNM	United States National Museum, Washington, D.C.

## Class Amphibia: Order Caudata

### *Ambystoma tigrinum nebulosum* Hallowell

The subspecific status of tiger salamanders on the Colorado Plateau and in adjacent areas has been interpreted variously. Allocation of Zuni specimens was left in doubt by Dunn (1940, p. 162). Bishop (1943) and Stebbins (1951; 1954) included the Zunis within the range of *A. t. nebulosum*, possibly because some of Dunn's specimens resembled material from Utah and Colorado then known as *A. t. nebulosum* through confusion of type locality. Lowe (1955d, p. 244) correctly reassigned the name *nebulosum* to *A. tigrinum* of the Mogollon Plateau and vicinity. But as evidence now indicates, Lowe (1955d, p. 247) inadvertently confused the status of Colorado Plateau populations by describing *A. t. utahense* from this region.

Adult specimens, above 80 mm. snout-vent length, of *A. tigrinum* from the Zunis have relatively longer tails in larger individuals, especially the males (fig. 5). With two exceptions, their color pattern consists of yellow spots or reticulations on a brownish to black ground (pl. 2C). Five adults have reticulate patterns and five subadults, 60–73 mm. snout-vent, resemble them (pl. 2D). In 15 other adults the number of dorsal spots between extremes of limb insertions ranges from 11 to 50 ( $\bar{x}$   $30.8 \pm 2.8$ ); tail spots number 8 to 37 ( $13.0 \pm 2.9$ ). These resemble *A. t. stebbinsi* on the basis of dorsal spots but are closer to *A. t. nebulosum* as regards tail spots (cf. Lowe, 1955d). When compared to the topotypic *A. t. nebulosum* described by Lowe (1955d, table 1), the Zuni salamanders average more dorsal body spots and fewer tail blotches. Their venters are mottled as in *A. t. nebulosum* or variously suffused with dark pigment as in *A. t. stebbinsi* or *A. t. utahense* (pl. 2B; cf. Lowe, 1955d, figs. 4A, C, 5A). They are as distinct from topotypic *A. t. nebulosum* as *A. t. stebbinsi* is and combine the diagnostic features of both races. I suggest that *A. t. stebbinsi* belongs in the synonymy of *A. t. nebulosum*.

In contrast to the specimens described above, one adult male (KUMNH 45762, 95 mm. snout-vent) is much darker in general aspect, with dorsal spots reduced to minute points of dull yellow, although the tail spots are plainly indicated. Another large, dark male is olive brown with irregular black body markings and light-olive tail spots (pl. 2A). These specimens resemble *A. t. utahense* or *A. t. utahense* x *nebulosum*, as does a similar specimen from San



Francisco Mountain, Coconino County, Arizona, the type locality of *A. t. nebulosum* (see Hallowell, 1854, p. 144).

Evidence from other Colorado Plateau localities coupled with the Zuni data suggests that *A. t. utahense* is an ontogenetic variant of *A. t. nebulosum*. Lowe's statement (1955d, p. 238) that adult color

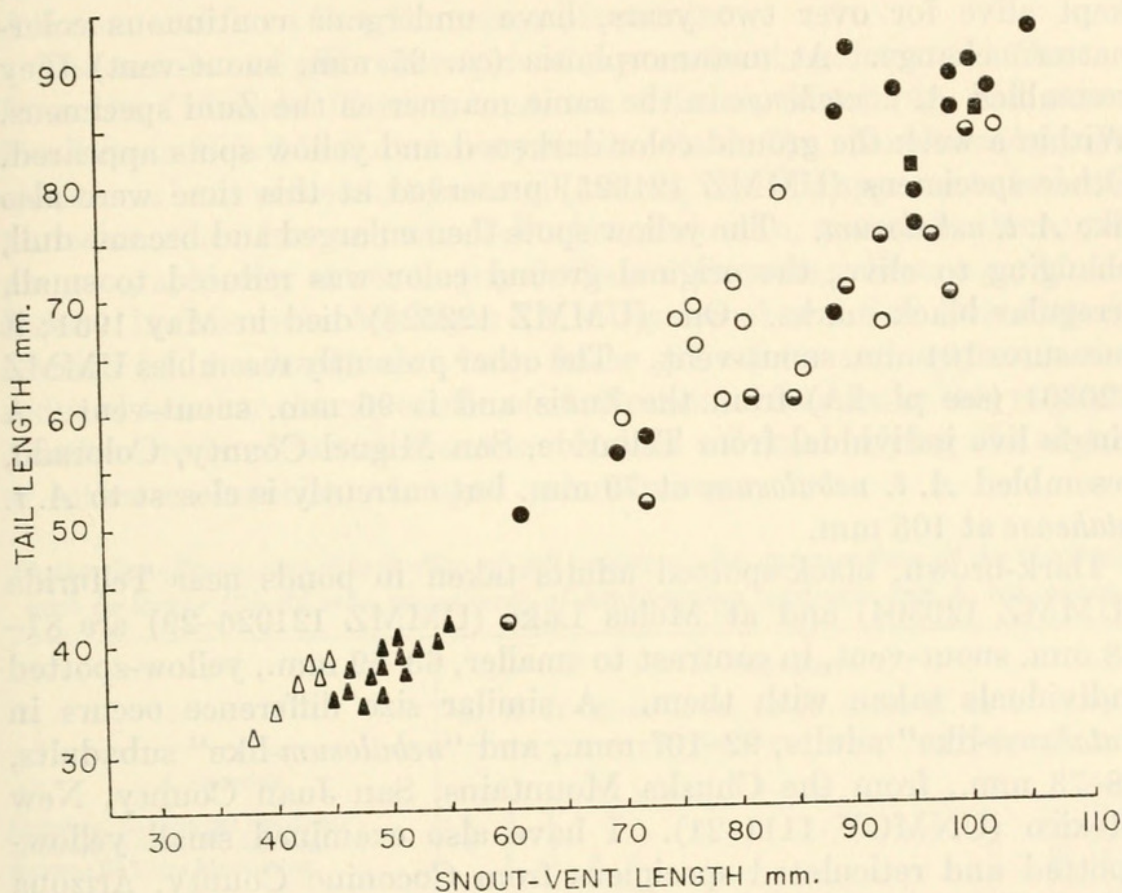


FIGURE 5.—Relationship of tail length to snout-vent length in *Ambystoma tigrinum nebulosum* from the Zuni region.

- Males, metamorphosed
  - ◐ Females, metamorphosed
  - Larvae
  - Males, metamorphosed
  - ▲ Metamorphosed
  - △ Larvae
- } Yellow-spotted
- } Non-yellow-spotted
- } Experimentally maintained (collected July 16, 1957, 7800 feet)

pattern is established upon transformation, unfortunately, is misleading. Dunn (1940, p. 154) and Bishop (1941, p. 163) have summarized ontogenetic changes in color pattern with which I concur. In fact, Dunn (1940, p. 158) diagnosed *A. t. nebulosum* (= *A. t. utahense*, Lowe, 1955d) as containing yellow-spotted young and



non-yellow-spotted adults. It is significant that recently transformed Zuni specimens, like certain larvae, are olive brown above with small scattered dark spots and some lemon-yellow mottling on the tail, thus approximating *A. t. nebulosum* figured by Bishop (1943, fig. 45: 1, 2). Only later do they develop the yellow spotting characteristic of subadults.

Two individuals from Molas Lake, San Juan County, Colorado, kept alive for over two years, have undergone continuous color-pattern change. At metamorphosis (ca. 65 mm. snout-vent) they resembled *A. t. utahense* in the same manner as the Zuni specimens. Within a week the ground color darkened and yellow spots appeared. Other specimens (UMMZ 121925) preserved at this time were also like *A. t. nebulosum*. The yellow spots then enlarged and became dull, changing to olive; the original ground color was reduced to small, irregular black marks. One (UMMZ 122526) died in May 1961; it measures 101 mm. snout-vent. The other presently resembles UMMZ 120301 (see pl. 2A) from the Zunis and is 96 mm. snout-vent. A single live individual from Telluride, San Miguel County, Colorado, resembled *A. t. nebulosum* at 70 mm. but currently is closest to *A. t. utahense* at 105 mm.

Dark-brown, black-spotted adults taken in ponds near Telluride (UMMZ 120304) and at Molas Lake (UMMZ 121926-29) are 81-98 mm. snout-vent, in contrast to smaller, 63-69 mm., yellow-spotted individuals taken with them. A similar size difference occurs in "utahense-like" adults, 92-107 mm., and "nebulosum-like" subadults, 68-73 mm., from the Chuska Mountains, San Juan County, New Mexico (UNMCV 1111-21). I have also examined small yellow-spotted and reticulated specimens from Coconino County, Arizona (UMMZ 120302), and San Juan County, Utah (UMMZ 121931). This rough correlation of size and coloration favors the hypothesis of ontogenetic change. Sexual pattern dimorphism is absent; however, relative size at metamorphosis may influence color pattern (see below). Since *A. t. utahense* as defined by Lowe (1955d, pp. 246-247) is based apparently on ontogenetic variation in *A. t. nebulosum*, it is suggested that this name also be placed in the synonymy of *A. t. nebulosum*.

Color-pattern comparisons of larvae, 35-65 mm. snout-vent, from the Colorado Plateau and adjacent areas reveal no basic geographic differences. The coloration described by Stebbins (1951, p. 46), however, may vary locally as regards density of spotting and shade of ground color; for example, the specimens from Catron County, New Mexico (UNMCV 1163-68), are heavily spotted or mottled with brown and black. The tail fin has black edges, and the lateral light line or row of light spots is nearly indistinct. In contrast, specimens from



Bernalillo County (UNMCV 1138-61) are very light with little hint of spotting. It is apparent that larvae from shallow, well-illuminated pools are lighter in color than those from deeper, darker environments. Very large larvae are usually greenish, olive, or brown, with widely spaced black spots. They often lack light and dark mottling and a lateral light line. Coues (1875, p. 633) described this "*Siredon*" or axolotl coloration in specimens from Jacob's Well, Apache County, Arizona, and from San Francisco Mountain.

The number of gill rakers provides structural evidence that larvae from the Colorado Plateau, southern Arizona, Wyoming, and other localities in New Mexico are very similar (table 3). Northern Arizona specimens have somewhat fewer gill rakers, but this appears to be local variation since larvae from Telluride, Colorado, resemble them yet are geographically closer to populations with more rakers, e.g., Molas Lake. Larvae from Michigan (*A. t. tigrinum*) and San Luis Potosi, Mexico (*A. t. velasci*), also have fewer gill rakers and approach the reduced number characteristic of *Ambystoma rosaceum* in this respect. Further study of larval characters should aid in clarifying the status of other subspecies of tiger salamanders.

TABLE 3.—Frequency distribution of gill rakers on the anterior face of the third gill arch in larvae (35-65 mm. snout-vent) of *Ambystoma tigrinum* and *A. rosaceum*

	Gill rakers																
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	N	$\bar{x}$	
<i>A. rosaceum</i>																	
Durango, Laguna del Progreso	3	5	1												9	10.8	
Durango, 2.5 mi. W. San Luis	2	5	2												9	11.0	
Sonora, El Tigre Mountains		2	5	2	1										10	12.2	
<i>A. tigrinum</i>																	
San Luis Potosi, San Diego							1	6	2	1					10	17.3	
Michigan, Ann Arbor							2	6	2	1					10	18.3	
Arizona, Hauchuca Mountains									2	2	4	2			10	20.6	
New Mexico, 9 mi. E. Mogollon									1	2	2	1	1	7	20.9		
New Mexico, Zuni region									4	7	2	2	1	16	20.3		
New Mexico, 10 mi. S. Albuquerque										3	4	2	1	10	21.1		
New Mexico, Sandia Park									2	3	2	1	1	9	20.5		
New Mexico, Pecos								1	3	1	4		1	10	20.2		
Arizona, Wheatfield Creek								1	3	1	2			7	19.6		
Arizona, Grand Canyon							1	2	3	3	1			10	19.1		
Colorado, 9 mi. SW. Telluride							2	2	5	1				10	19.5		
Colorado, Molas Lake									2	1	6	1		10	20.6		
Wyoming, Hoback Basin									2	2	2	4		10	20.8		

In the Zunis, larvae and adults of *A. t. nebulosum* usually were found in temporary potholes and canyon-bottom pools. Larvae were collected in cattle tanks on Mount Taylor in 1959, and S. W. Woodhouse (1854, p. 35) reported *Siredon lichenoides* (=large larvae of *A. tigrinum*) in a spring near the Zuni Pueblo. Although suitable habitats were investigated repeatedly throughout the present study, larvae were not discovered until July 1957, when the unusually heavy rainfall produced



great amounts of surface water. Prior to that time, one active adult was dug from moist ground in the riparian association at a depth of six feet during excavations for a swimming pool.

One hundred and fifty-three larvae, similar in coloration to that described by Stebbins (1951, p. 46) from near Flagstaff, Arizona, were seined from a pothole approximately 10 feet in diameter on July 16, 1957, at 7800 feet. Of these, 36 measured 35–45 ( $\bar{x}$  42.2) mm. snout-vent, 32–39 (35.8) mm. tail length. In the laboratory, 25 were kept for 28 days, 5 to a gallon jar. At the end of this period, 5 specimens had died, 14 had fully transformed, and 6 still possessed well-developed gills and larval body form. Body proportions of these specimens reveal greater size in the recently metamorphosed individuals (fig. 5). During captivity the larvae continuously gulped air at the water surface, something they had not been doing when collected.

On July 27, 1957, larvae equal in size to those previously captured at 7800 feet were taken from an arroyo 500 feet lower at the mouth of the same canyon and nearly one mile distant. A week of heavy rain that flooded the first locality filled the previously dry arroyo and presumably carried larvae to the new locality.

Five large larvae and one adult were collected in the pothole at 7800 feet, July 3, 1958, prior to the onset of heavy summer rainfall. The pond was 15 feet wider at this time than previously. About 20 other *A. tigrinum* of similar size could be seen surfacing and gulping air. The majority of these had normal larval gills and body form, but several had reduced gills. No other adults were observed although several were taken in ponds later in the summer. The collected larvae were light olive green dorsally with scattered dark spots. Two transforming specimens had light lateral reticulations on the tail; their venters were unmarked. These five larvae and six others from a pool at 7000 feet are of similar coloration and proportions. They have relatively longer tails than transformed specimens of similar body size (fig. 5).

The above data suggest that larval development requires at least two years in some populations of *A. t. nebulosum* in the Zuni. First proposed by Burger (1950b), this life history pattern does not apply necessarily to all Zuni larvae, for shallow pools at 7300 feet examined July 3, 1958, contained small larvae similar in size to the first-year individuals taken in 1957. Spatial isolation of larval size groups is not surprising when one considers the predacious nature of these salamanders. The tadpoles of *Hyla arenicolor* and *Bufo woodhousei*, although abundant in the area, rarely were found in the same pools with *A. tigrinum*. Food habits of tiger salamander larvae during the anuran breeding season demonstrate why this is so (fig. 6).



That paedogenesis occurs in larger Zuni larvae is evidenced by the fact that at least one specimen (USNM 8240, 103 mm. snout-vent) contains many large yolked eggs. Environmental factors believed to cause neoteny in *A. tigrinum* have been widely reviewed. In the present study, transformation, both natural and experimentally tested, seemed to be initiated by shrinkage of the pond environment associated with increased temperatures and decreased oxygen supply.

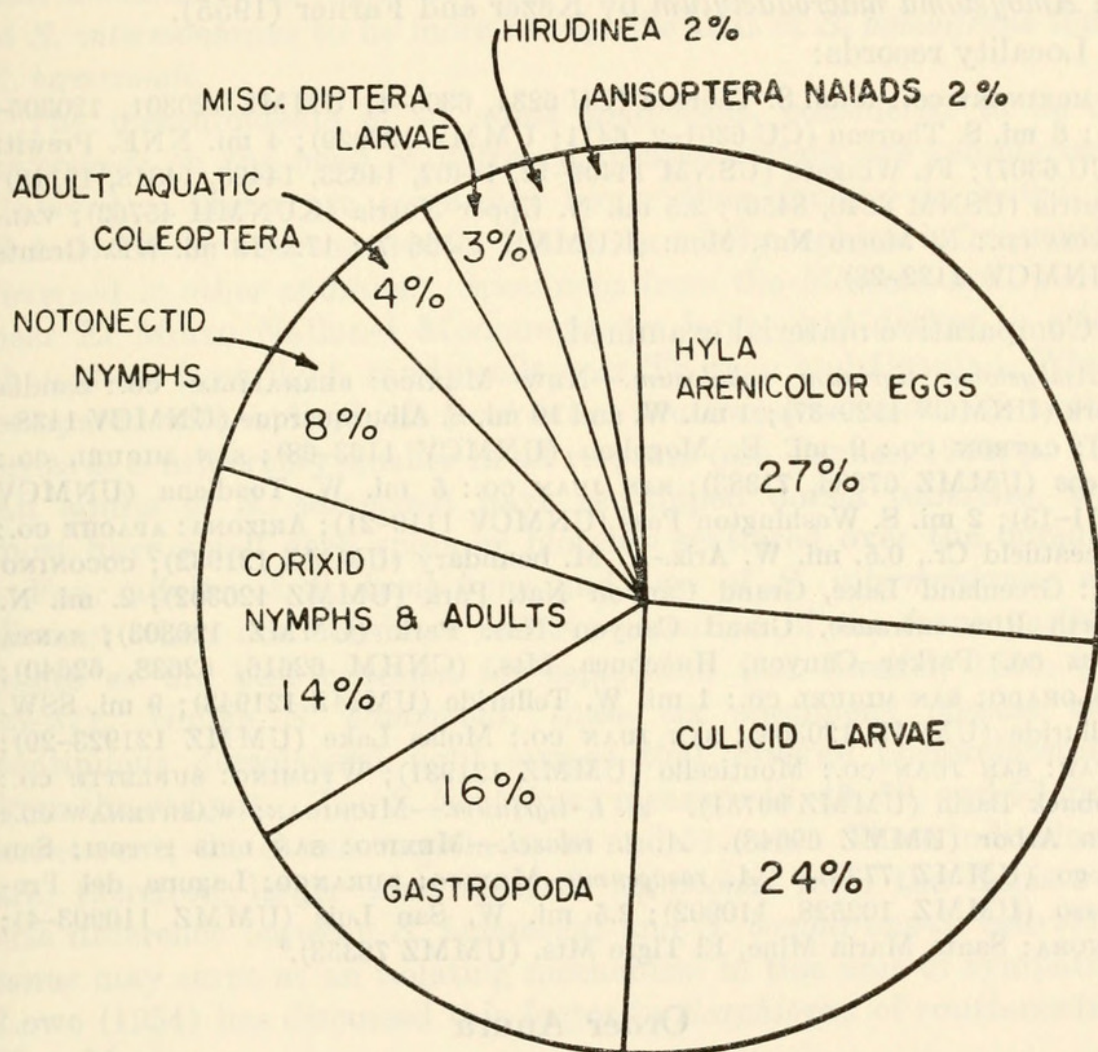


FIGURE 6.—Food (in percent of volume) of 36 larvae of *Ambystoma tigrinum nebulosum*, 35–45 mm. in snout-vent length, collected July 16, 1957, at 7800 feet.

Shufeldt (1885) cited similar evidence for metamorphosis in Zuni larvae as did Durham (1956, p. 220) for *A. tigrinum* from northern Arizona. Schuierer (1958) said that, among other things, a well oxygenated, constant water supply was implicated in maintaining neoteny.

Most Zuni larvae forced to gulp air at the surface in laboratory jars metamorphosed within four weeks of capture regardless of size. Specimens under similar conditions remained larval in form when provided with an artificial oxygen supply. Some larvae, approxi-



mately 50 mm. snout-vent, in an exposed, rapidly evaporating pool, transformed during a 59-day observation period in 1959. Another group of similar size located under a ledge in a nearby pool showed little reduction of larval features during this time. Thus, *A. tigrinum* in the Zunis may remain larval and become paedogenic if provided with a relatively permanent aquatic environment but can transform under arid conditions. Such ecotypic plasticity also has been noted in *Ambystoma macrodactylum* by Kezer and Farner (1955).

#### Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (CU 6234, 6303-4; UMMZ 120301, 120305-6); 8 mi. S. Thoreau (CU 6301-2, 6411; UMMZ 122929); 4 mi. NNE. Prewitt (CU 6307); Ft. Wingate (USNM 14409-12, 14402, 14633, 14490, 14818, 19118); Nutria (USNM 8240, 8456); 2.5 mi. N. Upper Nutria (KUNMH 45762); VAL-  
ENCIA CO.: El Morro Nat. Mon. (KUMNH 15556-7); 17.5-18 mi. NE. Grants (UNMCV 1122-28).

#### Comparative material examined:

*Ambystoma tigrinum nebulosum*.—NEW MEXICO: BERNALILLO CO.: Sandia Park (UNMCV 1129-37); 1 mi. W. and 10 mi. S. Albuquerque (UNMCV 1138-61); CATRON CO.: 9 mi. E. Mogollon (UNMCV 1163-68); SAN MIGUEL CO.: Pecos (UMMZ 67886, 71383); SAN JUAN CO.: 5 mi. W. Toadlena (UNMCV 1111-13); 2 mi. S. Washington Pass (UNMCV 1119-21); ARIZONA: APACHE CO.: Wheatfield Cr., 0.5 mi. W. Ariz.-N. M. boundary (UMMZ 121932); COCONINO CO.: Greenland Lake, Grand Canyon Nat. Park (UMMZ 120302); 2 mi. N. North Rim entrance, Grand Canyon Nat. Park (UMMZ 120303); SANTA CRUZ CO.: Parker Canyon, Huachuca Mts. (CNHM 62616, 62638, 62640); COLORADO: SAN MIGUEL CO.: 1 mi. W. Telluride (UMMZ 121943); 9 mi. SSW. Telluride (UMMZ 120304); SAN JUAN CO.: Molas Lake (UMMZ 121923-29); UTAH: SAN JUAN CO.: Monticello (UMMZ 121931); WYOMING: SUBLETTE CO.: Hoback Basin (UMMZ 99751). *A. t. tigrinum*.—MICHIGAN: WASHTENAW CO.: Ann Arbor (UMMZ 69648). *A. t. velasci*.—MEXICO: SAN LUIS POTOSI: San Diego (UMMZ 77331). *A. rosaceum*.—MEXICO: DURANGO: Laguna del Progreso (UMMZ 102528, 110902); 2.5 mi. W. San Luis (UMMZ 110903-4); SONORA: Santa Maria Mine, El Tigre Mts. (UMMZ 78353).<sup>3</sup>

### Order Anura

#### *Scaphiopus hammondi* Baird, *S. intermontanus* Cope, and *S. bombifrons* Cope

Members of the subgenus *Spea* of *Scaphiopus* have been treated differently with respect to specific status. Linsdale (1940, p. 200), VanDenburgh (1924, p. 194), and Wright and Wright (1949, pp. 112-120) considered *S. intermontanus* and *S. bombifrons* to be races of *S. hammondi*, an arrangement first proposed by Cope (1889). *S. intermontanus* was placed as the northern subspecies of *S. hammondi*,

<sup>3</sup> These larvae were reported as *A. tigrinum* by Stebbins (1951, p. 40, pl. 52) but apparently they are *A. rosaceum* because of their striking light- and dark-reticulated pattern (unlike any *tigrinum* known to me) and because of their fewer gill rakers (table 3).



and *S. bombifrons* was considered a distinct species by Schmidt (1953, p. 59) and Stebbins (1951, pp. 202–218; 1954, pp. 92–94). Stejneger and Barbour (1943, pp. 37–39), Tanner (1939), and Zweifel (1956) separated the three forms as species, an arrangement which I favor on the basis of available Zuni material. I further concur with Zweifel (1956, p. 37) in suggesting that *S. bombifrons* and *S. intermontanus* may be conspecific. Blair (1956) thought the call of *S. intermontanus* to be more nearly like that of *S. bombifrons* than *S. hammondi*.

The measurements of 41 adult spadefoots, considered to be *S. hammondi* on the basis of flattened frontoparietals, are summarized (table 4). Males are somewhat larger than females as noted in *S. holbrooki* by Pearson (1955). Such sexual dimorphism is frequently reversed in other anurans. Specimens from the Miocene lava plains near El Morro National Monument are larger and darker in color than those from light, sandy soils near Thoreau and Grants. When compared with individuals from other southwestern states, the total series is considerably smaller in all respects (see Tanner, 1939, p. 17). All adults of *S. hammondi* have red-tipped dorsal tubercles, and most have small dark spots or blotches scattered over the dorsum.

Four adults of *S. bombifrons* and two of *S. intermontanus* are distinct when one considers relative elevation of the frontoparietal bones as the best criterion for separation (see Zweifel, 1956, pp. 35–37). Unlike *S. hammondi*, these six specimens possess two continuous dorsolateral light stripes that diverge posterolaterally from the occiput. The *S. bombifrons* measure 48, 49, 50, and 52 mm. snout-vent; the *S. intermontanus*, 46 and 51 mm. These individuals are, therefore, larger than most *S. hammondi* from the Zunis. A size difference between *S. hammondi* and *S. bombifrons*-*S. intermontanus* may serve as an isolating mechanism in this area of sympatry. Lowe (1954) has discussed this factor in *Scaphiopus* of south-central New Mexico.

*S. intermontanus* is recorded here from New Mexico for the first time. The specimens were taken at 7200 feet in an area of mixed grass and one-seed junipers. The present localities for *S. bombifrons*, at 6400 to 7200 feet in the Plains Life Belt, are near the extreme northern limit of its range in New Mexico; hence, an ideal situation for studying the relationships of *S. bombifrons* and *S. intermontanus* exists in the Zunis. Conclusive evidence that these two species are isolated reproductively rests with the collection of additional material in this critical area.

The spawning of *S. hammondi* in rainpools, cattle tanks, roadside ditches, and canyon-bottom potholes was observed during periods of heavy rainfall in July and August. Breeding sites were located in



TABLE 4.—Measurements in mm. (range and mean) of some Zuni anurans

Species	N	Snout-vent length	Head length	Femur length	Tibia length	Hindfoot length
<i>Scaphiopus hammondi</i> <sup>1</sup> (♂)	16	38-47 (42.2)	13-15 (13.7)	17-21 (18.5)	13-16 (14.6)	15-18 (16.7)
" (♀)	8	40-45 (41.9)	13-15 (13.6)	18-20 (18.6)	13-15 (14.4)	14-16 (15.3)
<i>Scaphiopus hammondi</i> <sup>2</sup> (♂)	11	44-53 (47.2)	14-15 (14.7)	20-23 (20.9)	15-18 (16.1)	17-19 (17.9)
" (♀)	6	36-46 (42.0)	13-15 (13.8)	16-21 (19.3)	13-16 (14.8)	13-17 (15.4)
<i>Bufo woodhousei</i> (♂)	14	80-96 (86.9)	18-20 (18.8)	29-45 (36.4)	30-38 (34.2)	32-43 (39.5)
" (♀)	8	65-101 (80.9)	13-22 (17.7)	30-45 (35.1)	26-41 (31.6)	27-45 (34.8)
<i>Hyla arenicolor</i> (♂)	9	40-49 (43.8)	12-15 (13.0)	19-24 (21.5)	19-23 (20.5)	17-21 (18.2)
<i>Rana pipiens</i> (♂)	9	38-52 (46.1)	14-19 (16.4)	19-25 (21.5)	20-31 (25.4)	21-38 (26.6)

<sup>1</sup> From 15 mi. E. Grants, Valencia County, New Mexico.<sup>2</sup> From El Morro National Monument, Valencia County, New Mexico.



all major vegetational associations below the spruce-fir, but western spadefoots were most abundant in the pinyon-juniper savanna and Plains-Roughlands continuum. The earliest observed egg-laying occurred July 4, 1954, at 6400 feet in a small tank on the eastern soil-covered edge of the Grants malpais; the air temperature was 48° F., water 53° F., at 9:30 p.m.

In the choruses of *S. hammondi*, most vocal males swam or floated in the middle of the pond, but several called from shallow water or shore. *S. bombifrons* and *S. intermontanus* were not taken in breeding aggregations. They may breed earlier in the season here as *S. intermontanus* does in Utah (Blair, 1956). This could explain the shore-calling station of *S. hammondi* in view of its apparent preference for a swimming-floating position when in reproductive sympatry with other spadefoots (Gehlbach, 1956, p. 365; McAlister, 1959).

The larvae of *S. hammondi* commonly occurred with tadpoles of *Hyla arenicolor* and *Bufo woodhousei* in the riparian association of the Roughlands Life Belt. They were found only with *Bufo punctatus* in cholla-juniper grassland and without anuran associates in the short-grass association. On July 3, 1959, cannibalistic larvae of *S. hammondi* with hypertrophied jaw muscles and beaked upper mandibles were collected at 7700 feet in pinyon-juniper-ponderosa ecotone. They were located with typical larvae in a rainpool four inches deep and two by six feet in outside dimensions. The water temperature was 75° F., air 83° F., at 11:20 a.m. A single dip net sample held 15 cannibalistic (6–13,  $\bar{x}$  10.9 mm. body length) and 6 typical (16–18,  $\bar{x}$  17.4 mm.) specimens, the former with hindlimb buds, the latter with larger hindlimbs and toes. Seven recently transformed *Scaphiopus* species, taken at 6900 feet, September 1925, by Neil M. Judd, measure 16–22 ( $\bar{x}$  18.6) mm. snout-vent.

#### Locality records:

*S. hammondi*.—MCKINLEY CO.: 6 mi. S. Thoreau (CU 6309; UMMZ 120300); 8 mi. S. Thoreau (CU 6476; UMMZ 120308); Thoreau (USNM 70412–21); 16 mi. S. Gallup (CU 6231); VALENCIA CO.: 15 mi. E. Grants (KUMNH 14547–66, 14569–72); 11.5 mi. SSE. Grants (CU 5775); El Morro Nat. Mon. (KUMNH 14538–46, 17271–8). *S. bombifrons*.—MCKINLEY CO.: 16 mi. S. Gallup (CU 6310); VALENCIA CO.: Grants (KUMNH 14568); El Morro Nat. Mon. (KUMNH 17222–3). *S. intermontanus*.—VALENCIA CO.: 2 mi. W. El Morro Nat. Mon. (CU 6308).

#### *Bufo punctatus* Baird

This red-spotted toad is known from only two localities in the Zuni region. It apparently does not breed above 6800 feet, for intensive search has not revealed its presence in numerous anuran choruses in or above the pinyon-juniper association. Thus, it is somewhat ecologically separated from *Bufo woodhousei*, which is most abundant above 7000 feet (fig. 3). *B. punctatus* may be common in the cholla-



juniper grassland and Plains-Roughlands continuum around Grants. A single chorus observed at 6400 feet, July 4, 1954, after a heavy rain, consisted of more than 100 calling males in a small cattle tank on soil-covered lava adjacent to the rough Grants malpais (Gehlbach, 1956, p. 365). *Scaphiopus hammondi* was present in about equal numbers in the breeding aggregation.

Locality records:

VALENCIA CO.: 11.5 mi. SSE. Grants (CU 5766); Grants (Smith, 1950, fig. 45).

*Bufo woodhousei woodhousei* Girard x *B. w. australis* Shannon  
and Lowe

Rocky Mountains toads in Arizona recently have been split into two races (Shannon and Lowe, 1955). The nominate, northern subspecies is now considered to occupy the Colorado Plateau in that state; it is separated presumably from a new southern, lowland form, *B. w. australis*, by the Mogollon Plateau. Shannon and Lowe (1955, pp. 188, 190) included New Mexico within the range of *B. w. australis* but did not state specific localities. *B. woodhousei* from the Zuni region does not conform readily to either subspecies. Geographically these toads might be expected to resemble typical *B. woodhousei*, but structurally they combine some characters of *B. w. australis* with *B. w. woodhousei* and are considered intergrades.

With regard to diagnostic features, 22 adult specimens have: (1) frontal area of cranium elevated in 91 percent; (2) snout-vent length/parotoid gland width 10.6–13.9 ( $\bar{x}$  11.9 $\pm$ 0.19); (3) snout-vent length/parotoid gland length 4.4–5.6 (5.1 $\pm$ 0.74); (4) skin of upper surfaces smooth; (5) median white line on snout present in 82 percent; (6) black pectoral semicircles not strongly developed; (7) dorsal color brown with 68 percent having large warts set in black. Characters 1, 2, 4, 5, and 6 favor allocation with *B. w. woodhousei*, while 3 and 7 are closer to *B. w. australis*.

Colorado Plateau populations of *B. woodhousei* should be more or less uniform in the Zunis and adjacent Arizona since no important barriers to east-west dispersal exist. Such continuity is shown, for the characters of *B. w. woodhousei* predominate in the specimens at hand. The features of *B. w. australis*, however, indicate that gene flow from the south occurs if, in fact, these features are sufficient to distinguish *B. w. australis* from the nominate form in New Mexico. Irrespective of the validity of the taxonomic characters involved, the Rio Grande valley and associated lowlands provide a suitable pathway for north-south gene flow in central New Mexico (see discussion under "Zoogeography," p. 315).

Although Shannon and Lowe (1955) furnish ratios of parotoid gland size to body length, they do not limit these criteria to any certain age



group or sex. The validity of such ratios in terms of isometric growth of the parotoid gland and sexual dimorphism can be tested (fig. 7). It may be seen that juvenile specimens have a relatively larger gland and that gland width is more variable than length. No sexual dimorphism is apparent, but females are too few to demonstrate this adequately. In juveniles of less than approximately 30 mm. snout-vent, the cranial crests often are barely discernible, and the frontal area of the cranium undeveloped. These features and the parotoid gland, therefore, should be utilized to separate larger specimens only, preferably sexually mature adults (table 4).

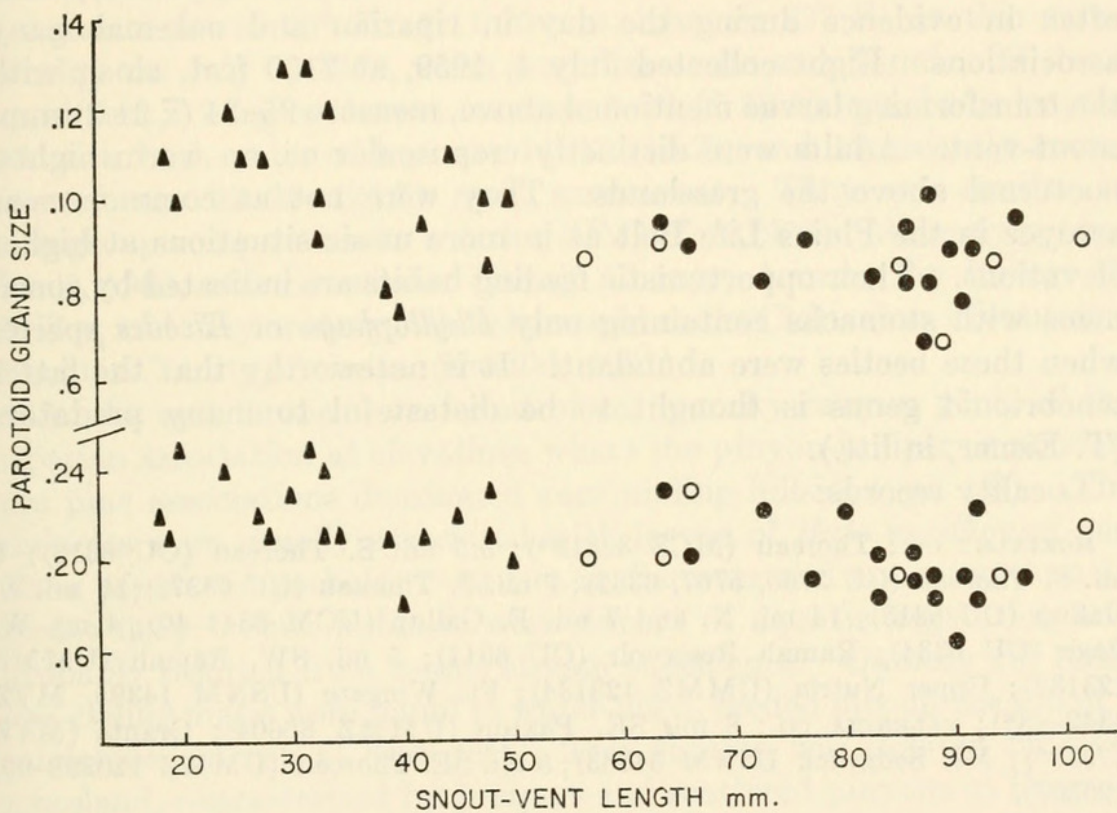


FIGURE 7.—Relationship of parotoid gland length/snout-vent length (lower symbols) and parotoid gland width/snout-vent length (upper symbols) to body size in *Bufo woodhousei* from the Zuni region.

● Sexually mature males      ○ Sexually mature females      ▲ Juveniles

The larvae of *B. woodhousei* have been collected throughout the summer months in slowly running streams, potholes, and cattle tanks. A sample of 12 taken at 7800 feet, July 3, 1959, are 7–12 ( $\bar{x}$  9.4) mm. body length; they have hindlimb buds. One day later, at 7100 feet, 12 larvae with well-developed legs and complete tails were collected; they measure 15–17 (15.7) mm. and approximate the size of transforming *B. woodhousei* from northern Arizona (Wright and Wright, 1949, p. 209). Six recently metamorphosed individuals, 13–19 ( $\bar{x}$  16.9) mm. snout-vent, were found on August 8, 1957, at 7000 feet.



That the Zuni toads have a biannual breeding regime is indicated by the formation of a chorus July 29, 1957, in a pond where large larvae were already present. Choruses often were heard after the initial summer rains, suggesting that perhaps summer and spring peaks of precipitation initiate breeding. Gravid females were found at two such choruses, but amplexed pairs were not seen. Thornton (1960, p. 181) found previously marked females of *B. woodhousei* in amplexus twice in the same breeding season at Austin, Texas. Bragg (1941, p. 112) stated that *B. woodhousei* breeds more or less independently of rain at Las Vegas, New Mexico.

Juveniles, previously characterized (Gehlbach, 1956, p. 365), were often in evidence during the day in riparian and oak-mahogany associations. Eight collected July 4, 1959, at 7100 feet, along with the transforming larvae mentioned above, measure 25–34 ( $\bar{x}$  31.2) mm. snout-vent. Adults were distinctly crepuscular or, on warm nights, nocturnal above the grasslands. They were not as common near arroyos in the Plains Life Belt as in more mesic situations at higher elevations. Their opportunistic feeding habits are indicated by specimens with stomachs containing only *Phyllophaga* or *Eleodes* species when these beetles were abundant. It is noteworthy that the latter tenebrionid genus is thought to be distasteful to many predators (T. Eisner, in litt.).

#### Locality records:

MCKINLEY CO.: Thoreau (MCZ 32813\*); 5.5 mi. S. Thoreau (CU 6312); 6 mi. S. Thoreau (CU 5765, 5767, 6332); 7 mi. S. Thoreau (CU 6337); 16 mi. S. Gallup (CU 6313); 14 mi. N. and 7 mi. E. Gallup (UCM 6544–49); 4 mi. W. Page (CU 6334); Ramah Reservoir (CU 6311); 5 mi. SW. Ramah (UMMZ 123133); Upper Nutria (UMMZ 123134); Ft. Wingate (USNM 14395, MVZ 9342–48\*); VALENCIA CO.: 8 mi. SE. Paxton (UMMZ 86604); Grants (MVZ 57640\*); Mt. Sedgwick USNM 54363); 8 mi. SE. Thoreau (UMMZ 120298–99, 120307).

#### *Hyla arenicolor* Cope

The taxonomic status of canyon tree frogs from the Zunis is being studied elsewhere; certain observations on adult size and metachrosis, nevertheless, seem worthy of record here. Canyon tree frogs exhibit considerable color-pattern variation (Stebbins, 1951, p. 315). Zuni specimens were spotted usually with greenish or dusky, lichen-like markings, but when exposed to sunlight, they often became a uniform dirty cream or grayish white. The skin of such exposed individuals was noticeably more pustulose than in recently captured specimens found in dark crevices or cracks between rocks. The ground color of most *H. arenicolor* was yellow cream, tan, or light reddish brown, closely approximating the sandstone substrate on which they were resting.



Like *Bufo woodhousei*, this hylid may have two or more breeding seasons coinciding with separate peaks of precipitation. Heavy July rains initiated calling in pools where adult *H. arenicolor* had not been in evidence previously. Two adult females with large yolked eggs (ca. 1.6 mm. diameter) were collected July 6 and August 27, 1956; they measure 45 and 50 mm. snout-vent and are larger than most males taken with them (table 4).

Four transforming larvae, 17 to 20 mm. body length, were found July 2-6, 1956, at 7800 feet; eggs were laid July 16, 1956, in the same pond. On the latter date, in 1957, larvae in all stages including some with external gills were collected at 7800 feet. The water temperature was 75° F. at 11:20 a.m., the air 83° F., at this same locality on July 3, 1959, when a similar series was found. Of these specimens, 12 legless larvae measure 9-13 ( $\bar{x}$  10.9) mm. body length; 12 with both pairs of legs are 14-17 (15.7); and 12 recently transformed are 22-28 (24.7) mm. snout-vent. They are similar in size-group composition to a series (UMMZ 121950) obtained September 4, 1960, near Snowflake, Navajo County, Arizona, by Robert R. Miller, and they are larger than larvae from the Chiricahua Mountains, Cochise County, Arizona (Zweifel, 1961).

Adults and larvae were found often in rocky canyon pools of the riparian association at elevations where the pinyon-juniper or ponderosa pine associations dominated surrounding hillsides (pl. 1B). The tadpoles were usually associated with larvae of *Bufo woodhousei* and *Rana pipiens* in potholes 1-10 feet in diameter and not more than 10 inches deep. Such habitats were devoid of aquatic vegetation and probably resulted from recent stream subsidence. On July 18, 1956, five calling males were found in water-filled, eroded pits on the top of a sandstone outcrop at 6400 feet. This outcrop was isolated by level grassland, characterized by junipers and scattered pinyons at the east edge of the Grants malpais.

#### Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (UMMZ 120297); 7 mi. S. Thoreau (CU 6333); 8 mi. S. Thoreau (CU 6232, 6412); Ft. Wingate (USNM 14404, 53587); VALENCIA CO.: 1 mi. N. Cebolleta (UMMZ 86605); 4 mi. WSW. Cebolleta (UMMZ 86606); Ranger Station, Lobo Canyon, Mt. Taylor (UMMZ 86607); 11.5 mi. SSE. Grants (CU 6233); Grants (CU 5371, 5373, 5381, 5393, 5402; KUMNH 19360-7\*).

#### *Pseudacris triseriata triseriata* Wied x *P. t. maculata* Agassiz

Known from only seven published localities, the western chorus frog has been studied very little in New Mexico. Smith (1956) reassigned the subspecific name *maculata* to *P. nigrita* (= *P. triseriata*, Schwartz, 1957, p. 11) from Colorado, Utah, and northward. With the exception of a single specimen of *P. t. triseriata* x *P. t. maculata* from Colfax



County, New Mexico, he left the Arizona-New Mexico population as *P. t. triseriata*. His criterion was the greater tibia length/body length ratio in frogs from the latter states. Five specimens from the Zunis have ratios of 38.8–43.5 ( $\bar{x}$  40.9  $\pm$  0.4), thus placing them as *P. t. triseriata* x *P. t. maculata* intergrades (cf. Smith, 1956, table 2).

Recently transformed specimens, 13 and 14 mm. snout-vent, were collected July 13, 1949, in a meadow of the spruce-fir association at about 9200 feet. They were thought to be singing at the time of capture (Chenoweth, 1950, p. 532), but this seems improbable in view of their immaturity. Three males, also judged to be singing, were collected May 21, 1924, by Charles L. Camp at 7000 feet; they measure 29, 30, and 31 mm. snout-vent and are reproductively mature. All Zuni specimens have three distinct dorsal stripes that are broken posteriorly in the three adults.

Locality records:

MCKINLEY CO.: Ft. Wingate (MVZ 9339–41); VALENCIA CO.: Mark Elkin's Ranch, Mt. Taylor (CU 6338).

*Rana pipiens* Schreber

I have not attempted to assign Zuni leopard frogs to any particular geographic race in view of the notorious variability and inadequate definition of the various proposed subspecies (e.g., see Moore, 1944). In the study area these frogs may be many shades of green, brown, or gray; but they usually have 5–12 ( $\bar{x}$  9.1) large, regularly arranged dorsal spots and smooth skin. With respect to the latter feature, they are quite different from the highly pustulose leopard frogs occurring near Snowflake, Navajo County (UMMZ 121949), and 13 miles west of Chevalon, Coconino County (UMMZ 121951), Arizona, although from the same drainage system (Colorado River). The preserved specimens are small and may not represent the typical adult size range (table 4). A single female is 55 mm. snout-vent.

Lack of a large series and the few locality records reflect only the amount of attention directed toward collecting this species. My field notes indicate that *R. pipiens* is one of the most abundant anurans in the Zunis; it was seen commonly around isolated pools and streams in the riparian association of Roughlands and Montane Life Belts. Coues (1875, p. 631) found it to be similarly abundant along the Zuni River and Rio Gallo near Ft. Wingate. I did not see *R. pipiens* in cattle tanks or roadside ditches, nor did I note any breeding activity; however, larvae of all sizes were found throughout the summer months, and a great concentration of recently transformed individuals, 9–25 ( $\bar{x}$  21.6) mm. snout-vent ( $N=5$ ), was noted August 21–23, 1959, at 7200 feet.



Like *Bufo woodhousei*, leopard frogs also feed upon the tenebrionid beetle, *Eleodes*.

Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (CU 5773, 6306, 6340; CWGF); Thoreau (MCZ 32820-47,\* 33300-05\*); Ft. Wingate (USNM 16760); VALENCIA CO.: Grants (CU 5371-3).

Class Reptilia: Suborder Sauria

*Crotaphytus collaris collaris* Say x *C. c. baileyi* Stejneger

The western collared lizard, originally described as *C. baileyi* by Stejneger (1890, p. 103) from the Painted Desert, Little Colorado River, Arizona, can be characterized by its two discrete interorbital scale rows, a tan or brown head with darkly spotted green to blue throat (in males), and a sharply contrasting, spotted body pattern (Fitch and Tanner, 1951, pp. 549-550). Burt (1928) synonymized *baileyi* with nominate *C. collaris* and listed (Burt, 1933, p. 229) two localities in the Zuni region. Presently relegated to subspecific status, *C. c. baileyi* is the form usually found in the Zunis. This occurrence is not surprising because suitable habitats are more or less continuous between the type locality and the study area.

According to Fitch and Tanner (1951, p. 549) and Stebbins (1954, p. 310), a broad zone of intergradation exists between *C. c. collaris* and *C. c. baileyi*. This is evident in the Zunis, for 3 of 18 specimens have one scale common to both interorbital rows. On the basis of this criterion and the fact that certain Arizona specimens show a similar condition (Burt, 1928, p. 11), the three Zuni individuals may be labeled *C. c. collaris* x *C. c. baileyi*. It seems likely that a relatively smooth, east-west cline of variation is present in southwestern collared lizards (see discussion under "Zoogeography," p. 315).

Reasons for retaining subspecies in *C. collaris* and the description of a new intermontane Utah-Colorado race, *C. c. auriceps*, were given by Fitch and Tanner (1951). Although *C. c. auriceps* occurs in Montezuma County, Colorado (Maslin, 1959, p. 26), and logically in San Juan County, New Mexico, its characters could not be discerned in the Zuni sample or in specimens from Chaco Canyon National Monument, San Juan County (UMMZ 122892). This is somewhat puzzling when one considers that other reptiles with similar distributions are present in both areas, e.g., *Sceloporus undulatus elongatus*.

Fitch and Tanner (1951, fig. 1) show modal numbers of 14 for both supra- and infralabials of *C. c. baileyi*, 13 and 12 for these respective counts in *C. c. auriceps*. They apparently plotted labials on both left and right sides of the head in the same histogram. The figure is labeled "Numbers of Specimens" but does not agree with the number



of specimens examined (cf. Fitch and Tanner, 1951, p. 556); thus, the relatively small difference in labial number appears twice as strongly emphasized. Actually, such a distinguishing feature easily could be missed in possible intergrades.

Neither sexual dimorphism nor bilateral imbalance of labial scales was alluded to by the authors of *C. c. auriceps*. Etheridge (1960, p. 114) noted that males of *C. c. collaris* have larger heads and more robust lower jaws than females. In the Zunis, adult females are proportionately smaller than males (table 5) and possess fewer infralabials; seven have 11-14 ( $\bar{x}$  12.6), 12-16 (13.6) left and right infralabials respectively, and have 13-15 (14.0), 12-16 (14.3) left and right supralabials respectively. Eight males have 12-14 (13.1), 13-15 (13.8), 14-16 (14.5), and 13-16 (15.0) left and right infra- and supra-labials. The bilateral imbalance is interesting in that the right side of the head seems to be favored, although this may not be meaningful in light of the sample size.

Collared lizards are a typical reptile of boulder-strewn hillsides where vegetation is sparse. Such situations usually are found on the lower slopes of mesas and canyons and at the malpais edge in the Zunis. On several occasions, foraging individuals encountered on the tops of mesas seemed to be attracted by large numbers of grasshoppers feeding on the thicker vegetation. These lizards are not restricted to the Roughlands Life Belt, but on the plains they are confined to the vicinity of rocky arroyos. *Sceloporus undulatus*, *Eumeces obsoletus*, *Masticophis taeniatus*, *Salvadora grahamiae*, and *C. collaris* were collected in and around an arroyo at 6400 feet in a cholla-juniper dominated section of the Plains-Roughlands continuum.

Females of *C. collaris* with the typical red breeding coloration were observed as late as August 11, 1959, but none collected in July or August held large eggs. Specimens taken by Emmet T. Hooper, May 7-9, 22, 1939, have only small ova. Two cross-banded hatchlings, 40 and 41 mm. snout-vent, with evident yolk-sac scars, were found August 25, 1951, at 6500 feet; thus, if about 51-74 days of incubation are needed (Fitch, 1956a, p. 234), egg-laying may occur in June or early July, ahead of the summer rains.

#### Locality records:

MCKINLEY CO.: Thoreau (MCZ 62420\*); 5.5 mi. SE. Thoreau (CU 5748); 6 mi. S. Thoreau (CWGF); Ft. Wingate (USNM 16761); Gallup (USNM 27738); 14 mi. N. Gallup (UCM 6583-84); VALENCIA CO.: 1.5 mi. S. Grants (UMMZ 86616); 8 mi. SE. Grants (UMMZ 86615); 5 mi. E. Grants (CU 3051, 3376); 10.4 mi. S. Grants (CU 5747); 11.5 mi. SSE. Grants (UMMZ 122621-22); 7 mi. SE. Laguna (UMMZ 72649); 5 mi. NW. Rio Puerco (USNM 86937).



TABLE 5.—Measurements in mm. and scale counts (range, mean, standard error) of some Zuni lizards<sup>1</sup>

Species	N	Snout-vent length	Dorsal scales	Scales around midbody	Lamellae on right fourth toe
<i>Crotaphytus collaris</i> (♂)	8	90-105(97.9)	—	—	31-37(33.7 ± 0.57)
“ (♀)	7	87-101(93.7)	—	—	
<i>Sceloporus undulatus</i> (♂)	25	40-63(51.8)	39-48(43.8 ± 0.28)	42-50(46.1 ± 0.25)	17-22(19.6 ± 0.18)
“ (♀)	25	43-70(59.1)			
<i>Sceloporus graciosus</i> (♂)	6	47-55(50.5)	52-60(55.3 ± 0.40)	50-59(53.9 ± 0.52)	20-24(21.8 ± 0.17)
“ (♀)	10	45-61(52.7)			
<i>Urosaurus ornatus</i> (♂)	16	39-52(48.3)	35-53(43.3 ± 0.45)	—	21-26(23.3 ± 0.26)
“ (♀)	13	42-53(47.5)			
<i>Phrynosoma douglassi</i> (♂)	10	56-83(69.9)	—	—	12-15(13.4 ± 0.18)
“ (♀)	19	54-98(75.0)			
<i>Eumeces multivirgatus</i> (♂)	12	42-68(55.6)	57-61(59.4 ± 0.23)	23-26(24.8 ± 0.18)	10-16(12.8 ± 0.35)
“ (♀)	11	49-70(65.5)			
<i>Cnemidophorus velox</i> (♀)	20	53-80(65.0)	168-190(177.2 ± 1.4)	68-76(71.7 ± 0.85)	29-34(31.1 ± 0.48)

<sup>1</sup> Scale counts of both sexes are combined for each species.



*Holbrookia maculata campi* Schmidt

Subspecific assignment of *H. maculata* in the Zuni region is based on specimens examined by Ralph W. Axtell (in litt.), who has revived the name *campi* and restricted it to Colorado Plateau populations (Axtell, 1958).

The lesser earless lizards that I collected are brown, red-brown, or gray dorsally, with 10–17 darker blotches or interconnected spots between extremes of limb insertions. They come from localities with soils of similar coloration. *H. m. campi* also approximates substrate color near Springerville, Apache County, Arizona, where specimens taken on soil-covered lava are dark brown or gray in general aspect. By contrast, an individual from the white sand along Choukai Wash, San Juan County, New Mexico (UMMZ 120277), is white to light gray, with darker gray dorsal spots (observations during three months in captivity). It is identical with *H. m. ruthveni*, the pallid "subspecies" of the White Sands, Otero County, New Mexico (see Smith, 1943b; 1946, pl. 20A). Other pallid specimens of *H. maculata* come from the vicinities of Montoya (Quay County), Pedernal (Torrance County), and Carrizozo (Lincoln County), New Mexico. I suggest that *H. m. ruthveni* be relegated to the synonymy of *H. m. approximans*, the form inhabiting lowlands south of the Colorado Plateau, since this white sand population is not geographically unique in its only distinguishing character, coloration.

In the Zunis, lesser earless lizards are inhabitants of the Plains Life Belt only. Four specimens come from the short-grass association in which snakeweed and rabbitbush is locally abundant. Another is from soil-covered malpais dominated by scattered junipers and apache plume. A third was in open grassland near a thicket of shadscale saltbush. Northeast of Prewitt where *H. m. campi* is associated marginally with *Cnemidophorus velox* and *Sceloporus graciosus*, a pursued earless lizard took refuge in the burrow of *Dipodomys ordi*. *C. velox* and *S. graciosus* frequent heavier cover such as saltbush or sage at this locality.

Gravid females with the following snout-vent length, date of collection, and egg number and size provide an estimate of local reproductive capacity in *H. m. campi*: 54 mm., May 12, 1939, 6 avg. 9.8 x 5.2 mm.; 57 mm., July 16, 1957, 3 avg. 13.4 x 7.4 mm.; 48 mm., July 16, 1957, 3 avg. 12.8 x 7.5 mm.; 48 mm., July 16, 1957, 2 avg. 13.8 x 7.6 mm.; 41 mm., July 5, 1959, 2 avg. 12.2 x 7.6 mm. It is possible that this iguanid deposits its eggs in response to summer rainfall (see discussion under *Sceloporus undulatus*).

## Locality records:

MCKINLEY CO.: 5.5 mi. S. Thoreau (CU 5624); 4 mi. ENE. Prewitt (CU 5456); Upper Nutria (UMMZ 123135); VALENCIA CO.: Grants (MCZ 6824\*); Point of



Malpais (UMMZ 86613); Acoma Pueblo (USNM 44696); Lava Beds (USNM 44697); 8 mi. SE. Thoreau (UMMZ 122889).

Comparative material examined:

*H. m. campi*.—NEW MEXICO: SAN JUAN CO.: 1 mi. N. Chaco Canyon Nat. Mon. (UMMZ 120277); ARIZONA: APACHE CO.: 7 mi. N. Springerville (UMMZ 121722). *H. m. approximans*.—NEW MEXICO: OTERO CO.: 3 mi. S. Alamogordo (UMMZ 64690, paratype of *H. m. ruthveni*); QUAY CO.: 3 mi. S. Montoya (UMMZ 69068–69); TORRANCE CO.: Pedernal (UMMZ 67850); LINCOLN CO.: Carrizozo (UMMZ 70080).

*Sceloporus undulatus tristichus* Cope x *S. u. elongatus* Stejneger

Some attention has been given to the occurrence of *S. undulatus* in northwestern New Mexico. The possibility that the widespread form *S. u. tristichus* might intergrade with the northern subspecies, *S. u. elongatus*, was suggested by Burt (1933, p. 242). He considered *S. u. consobrinus* as the plateau lizard occurring in western McKinley County rather than *S. u. tristichus*, a name which he ascribed to intermediates between *S. u. elongatus* and *S. u. consobrinus*. Smith (1938, p. 16) defined *S. u. tristichus* in the sense employed here and outlined some intergrade populations in southern Utah and Colorado. He mapped *S. u. elongatus* as being present north of the Zuni but did not indicate specimens examined or published records from this part of the state. *S. u. elongatus* has been collected since at several localities in San Juan County, New Mexico, and Apache County, Arizona, the closest to the study area being Chaco Canyon National Monument (CU 5618) and Canyon de Chelly National Monument (UMMZ 120278).

The Zuni sample is clearly intermediate between *S. u. tristichus* and *S. u. elongatus* (table 6). An arithmetical measure of subspecific difference proposed by Ginsburg (1938) was revived to clarify this situation. With data drawn from Smith's study (1938, table 2), the following may be noted. For the best diagnostic character, i.e., number of dorsal scales from occiput to rump, the smallest overlap between *S. u. elongatus* and *S. u. tristichus* is 10.6 percent. This value is 18.1 percent when *S. u. elongatus* and the Zuni series are compared and 51.6 percent when *S. u. tristichus* and the Zuni material are compared. As regards the next best character, number of scales around midbody, overlap (intergradation) values are 23.0, 30.4, and 33.4 percent respectively. In both features Zuni specimens are nearer *S. u. tristichus*.

Plateau lizards from the vicinities of San Rafael, Paxton Springs, and El Morro National Monument, Valencia County, are most representative of *S. u. tristichus*, while those taken near Crownpoint, Prewitt, and Gallup, McKinley County, are closer to *S. u. elongatus*. Series collected around Thoreau, McKinley County, are intermediate



TABLE 6.—Frequency distribution of scale counts in *Sceloporus undulatus tristichus*, *Sceloporus undulatus elongatus*, and the Zuni population of *S. undulatus*<sup>1</sup>

	Dorsals																				N	$\bar{x}$				
	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54			55			
<i>S. u. tristichus</i>	1	0	5	4	15	26	30	29	28	22	21	14										195	42.1			
<i>S. u. elongatus</i>							7	5	7	5	11	28	37	34	41	32	23	29	6	3	3	251	48.1			
Zuni population				1	1	1	3	7	14	8	15	7	5	2								63	44.1			
	Scales around midbody																				N	$\bar{x}$				
	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59		
<i>S. u. tristichus</i>	1	0	3	4	11	16	14	18	24	25	26	15	13	8	8	5	0	1							192	44.6
<i>S. u. elongatus</i>								4	10	5	24	22	29	27	28	20	10	17	7	8	1	0	3	1	216	49.3
Zuni population							1	2	6	11	12	8	10	4	1										55	46.1

<sup>1</sup> Data in part from Smith (1938).



in most respects. This northwest-southeast cline may be extended west through the Defiance Plateau, Apache County, Arizona, where I also have taken *S. u. tristichus* x *S. u. elongatus* (UMMZ 120280), to Grand Canyon National Park, Coconino County, Arizona (Williams, 1960, p. 26).

In view of this cline, one might question the retention of *S. u. tristichus* and *S. u. elongatus* as distinct subspecies. Other salient ecological-morphological differences in New Mexico populations, however, prevent me from lumping these races. With the exception of a few nearly unicolor specimens,<sup>4</sup> most *S. u. elongatus* from San Juan County, New Mexico, lack distinct dorsolateral and lateral light stripes and the spotted lateral pattern figured by Smith (1946, pl. 53 E, G) for *S. u. tristichus*; furthermore, adults are larger (45–83,  $\bar{x}$  64 mm. snout-vent, 25 San Juan County specimens) and possesses more fourth-toe lamellae (22–25,  $\bar{x}$   $23.3 \pm 0.29$ ) than *S. u. tristichus* x *S. u. elongatus* (cf. table 5). They are decidedly more scansorial, frequenting large boulders and cliff situations in contrast to marked terrestrial propensities in typical individuals of *S. u. tristichus* and the Zuni population.

Although *Sceloporus undulatus* was the most ubiquitous reptile studied, it did not enjoy the wide elevational range of *Phrynosoma douglassi* or *Thamnophis elegans* (fig. 3). The species was most abundant in Roughlands associations, especially the pinyon-juniper. While found to a limited extent at the upper edge of the Plains-Roughlands continuum, *S. undulatus* usually was outnumbered by *S. graciosus*, *Crotaphytus collaris*, and *Cnemidophorus velox* in this habitat. Specimens were conspicuously absent from cliffs inhabited by *Urosaurus ornatus*. They were uncommon on large boulders and the lower trunks of trees. Most individuals utilized elevated sites such as fallen tree trunks for sunning purposes and as apparent vantage points but were distinctly terrestrial in foraging habits. Body temperatures of 10 individuals foraging at 7400 feet were 29–37, ( $\bar{x}$   $33.1 \pm 0.98$ )° C.

Evidence presented by Anderson (1960, p. 66), Martin (1958, p. 57), and others indicates that reproductive activity in certain reptiles is correlated with the beginning of summer rains. Similar observations on *S. undulatus* have prompted the following remarks. Plateau lizards carrying well-developed eggs have been found as early as June 13, 1957. Most females over 40 mm. snout-vent held eggs when collected before mid-July, but none taken in August contained eggs.

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<sup>4</sup> A polychromatic variant occurs, usually uniform dark brown or gray but occasionally with slightly darker or lighter lateral stripes (e.g., see Legler, 1960, p. 181; Smith, 1946, p. 217). It has been found in the Guadalupe Mountains, New Mexico (UMMZ 121745), but not in the Zuni region.



It is possible that the onset of July rainfall provides these lizards and *S. graciosus*, *Urosaurus ornatus*, and *Holbrookia maculata* with optimum conditions for oviposition. Ten eggs of *S. undulatus*, averaging 12.5 x 8.5 mm., were recovered from a one-inch depression beneath a small sandstone slab July 23, 1956 at 7300 feet. The substrate was damp, loose sand, and the eggs were not buried.

Large eggs taken from females often contained embryos with well-developed eyes as did all eggs from the clutch obtained July 23, 1956. Similar predepositional embryonic growth was reported for *S. undulatus* in Arizona and *S. orcutti* (Stebbins, 1954, pp. 240-244). This might be expected if fertilized eggs are retained for an extended length of time as suggested here. The phenomenon may be adaptive in a semiarid region like the Zuni; i.e., to insure annual reproduction within the limits of optimum activity temperatures, post-depositional development thus can be completed in a relatively short time when oviposition is keyed to adequate summer moisture conditions. Hatchlings, 23-28 mm. snout-vent, have been collected as early as July 26, August 9, and August 12 in different summers.

#### Locality records:

MCKINLEY CO.: 5.5 mi. S. Thoreau (CU 5623); 6 mi. S. Thoreau (CU 5088-9 5448, 5622, 5681, 5697; UMMZ 121919, 122885-7); between Thoreau and Continental Divide (UMMZ 120311); Gallup (CU 5843); 14 mi. N. Gallup (UCM 6630-37); Ft. Wingate (USNM 14406-7, 8250, 8491, 9548; UCM 6638); Manuelito (USNM 87031); 5 mi. SE. Baca (UIMHN 39685-6\*); 4 mi. NNE. Prewitt (UMMZ 120284); 11 mi. W. Ramah (UMMZ 122884); VALENCIA CO.: Cubero (USNM 87032-4); El Morro Nat. Mon. (KUMNH 15121-6\*; UMMZ 122794); 2 mi. W. El Morro Nat. Mon. (CU 5606); 2.5 mi. E. Laguna Pueblo (KUMNH 28065\*); 8 mi. SE. Thoreau (UMMZ 122890); Shuman's Ranch (UMMZ 86608); 15 mi. E. Grants (KUMNH 15294-5\*); 10.4 mi. S. Grants (CU 5608); 1.5 mi. S. Grants (UMMZ 86609); 4 mi. WSW. Grants (UMMZ 86610); 18 mi. SW. Grants (UMMZ 86611); 17 mi. SW. Grants (UMMZ 86612).

#### Comparative material examined:

*S. u. elongatus*.—NEW MEXICO: SAN JUAN CO.: Chaco Canyon Nat. Mon. (CU 5618; UMMZ 122896); 7 mi. E. Blanco (UCM 7337-47); 43 mi. SSE. Bloomfield (UCM 7350-55); 2 mi. S. Colo.-N. M. state line on U.S. Rt. 666 (UCM 13294-13301); ARIZONA: APACHE CO.: 10 mi. W. Window Rock (UMMZ 120280, intergrades with *S. u. tristichus*); Canyon de Chelly Nat. Mon. (UMMZ 120278, 120281). *S. u. consobrinus*.—NEW MEXICO: EDDY CO.: 2 mi. NW. Carlsbad Caverns Nat. Park, headquarters area (UMMZ 121745).

#### *Sceloporus graciosus graciosus* Baird and Girard

Sagebrush lizards, represented by the nominate subspecies, usually are considered to be widespread in northwestern New Mexico (Smith, 1946, p. 495; Stebbins, 1954, p. 317). Published records, however, are available only for Rio Arriba (Cope, 1900, p. 389; VanDenburgh, 1924, p. 205) and Sandoval (Maslin and others, 1958, p. 335) counties.



To these may now be added several localities in San Juan and McKinley counties (see below). It seems doubtful that *S. g. graciosus* is common south of the Colorado Plateau; specimens have yet to be found in Valencia County. Small, disjunct populations inhabit the sand dunes of Chaves County, New Mexico, and Ward and Winkler counties, Texas (Sabath, 1960).

Many herpetologists have followed VanDenburgh (1922, p. 262) in separating the three subspecies of *S. g. graciosus* as follows: *S. g. graciosus* has 42–53 ( $\bar{x}$  47.8) dorsal scales from occiput to rump, *S. g. gracilis* has 52–68 (60.8), and *S. g. vandenburghianus* has 48–66 (54.8). It is significant that the dorsal scale count is high in Zuni material (table 5). The same is true of San Juan County specimens, for 16 from the vicinity of Blanco (CU 5617, UCM 7274–79) have 51–58 ( $\bar{x}$   $54.3 \pm 0.57$ ) dorsals and 10 taken south of Bloomfield (UCM 7280–87, 7348–49) have 51–58 ( $54.9 \pm 0.86$ ). Zuni and San Juan County series approximate *S. g. vandenburghianus* in number of dorsal scales, but the males resemble *S. g. graciosus* with their widely separated, bright-blue belly patches and distinctly striped dorsum.

The specimens at hand represent variation that remains to be studied thoroughly. The entire polytypic complex is in need of revision as further evidenced by specimens from northern Arizona (Durham, 1956, p. 222) with equally high dorsal scale counts and by "nominate *graciosus*" from northeastern Utah (Legler, 1960, p. 180) with confluent belly patches. It is possible that Colorado Plateau specimens are subspecifically distinct from those of the Great Basin; hence, the present racial allocation is tentative.

Since a pallid, arenicolous form of *S. g. graciosus* is known from southeastern New Mexico and adjacent Texas, it is of interest to report similar variation in northwestern New Mexico. Specimens collected on white sand along Choukai Wash, San Juan County (UMMZ 120283), approximate the description of *S. g. graciosus* provided by Sabath (1960). The dark-brown dorsal stripes seen in Zuni specimens are lacking or are indicated only faintly. These sagebrush lizards are light beige but retain the four white dorsal stripes. Two males have very light belly patches and throat mottling; the latter feature is apparently absent in southeastern New Mexico (Sabath, 1960).

The terrestrial nature of *S. g. graciosus* is well documented (Eaton, 1935, p. 12; Woodbury and Woodbury, 1945) and is particularly evident in the Zunis, where this lizard was observed in open, relatively level situations marked by the saltbush-sage association or pure stands of big sagebrush and loose clay or moderately sandy soil. In only one instance was *S. g. graciosus* abundantly associated with *S. undulatus*. At the base of the Vermilion Cliffs north of Prewitt, it was at least five times more common than its congener



in patches of spiny saltbush in the Plains-Roughlands ecotone. *Cnemidophorus velox* also was present but uncommon.

Females, 54 and 55 mm. snout-vent, collected June 10, 1957, each contained four eggs averaging 12.0 x 7.5 and 13.5 x 8.0 mm. respectively. Three others, 50, 52, and 57 mm., held, respectively, three (avg. 12.9 x 6.0), four (avg. 12.3 x 7.2), and four (avg. 12.0 x 6.0) eggs on July 9. Eight females taken July 23, 1959, had deposited their annual egg clutches, possibly in response to the onset of summer rainfall. No hatchlings were ever observed.

#### Locality records:

MCKINLEY CO.: 3 mi. N. Thoreau (CU 5699); 3 mi. NE. Thoreau (CWGF); 4 mi. NNE. Prewitt (CU 5452, 5600, 5698; UMMZ 120282); Lizard Canyon, Satan Pass (ANSP 20987\*); 14 mi. N. Gallup (UCM 6608-11); 5 mi. S. Manuelito (UMMZ 122888).

#### Comparative material examined:

*Sceloporus g. graciosus*.—NEW MEXICO: SAN JUAN CO.: 1 mi. N. Chaco Canyon Nat. Mon. (UMMZ 120283); Chaco Canyon Nat. Mon. (UMMZ 122902); Blanco Trading Post (CU 5617); 7 mi. E. Blanco (UCM 7274-79); 34-43 mi. SSE. Bloomfield (UCM 7280-87, 7348-49); 2 mi. S. Colo.-N. M. state line on U. S. Rt. 666 (UCM 13292); 0.5 mi. S. Colo.-N. M. state line on U. S. Rt. 17 (UCM 1303-4).

#### *Uta stansburiana stansburiana* Baird and Girard x *U. s. stejnegeri*

Schmidt

This is apparently another species with a north-south pattern of subspecific intergradation in the Zuni region; however, the present allocation must remain tentative until a series can be secured and the races of *U. stansburiana* are better characterized. Zuni specimens have 88 and 100 dorsal scales between the interparietal plate and posterior edge of the thighs. One has contiguous prefrontals; the other has the prefrontals separated by two small scales (see Smith, 1946, p. 277).

Based on present subspecific concepts in *U. stansburiana*, this intergrade zone extends north into San Juan County, New Mexico. Five specimens from Chaco Canyon National Monument (CU 5619; UMMZ 122909) have 94-106 ( $\bar{x}$  99.2 $\pm$ 1.5) dorsals; 6 from seven miles east of Blanco (UCM 7392-97) have 106-112 (108.7 $\pm$ 0.67), and 10 taken two miles south of the New Mexico-Colorado state line (UCM 13377-86) have 100-114 (107.4 $\pm$ 2.0). The large number of dorsals and prefrontal contact in only one San Juan County specimen indicate that influence from *U. s. stejnegeri* is relatively slight.

The apparent rarity of *Uta* in the Zunis is difficult to explain. The two precise localities, at 6900 and 7100 feet, are relatively open grassland with sandy soil, rabbitbush, snakeweed, and scattered one-seed junipers. The localities lie at the northwestern edge of mixed grass-



land that extends along the Rio San Jose from the Rio Grande valley (see Castetter, 1956, fig.). This ground uta is more abundant in eastern Valencia county at lower elevations and is common in the San Juan Basin to the north.

Locality records:

MCKINLEY CO.: Thoreau (CWGF); 4 mi. ENE. Prewitt (CU, specimen lost);  
VALENCIA CO.: (KUMNH 12192\*).

*Urosaurus ornatus linearis* Baird x *U. o. wrighti* Schmidt

*Urosaurus* has been the subject of considerable taxonomic debate. This genus was lumped with *Uta* by Schmidt (1953), Stebbins (1954), and Oliver (1943) subsequent to separation of the two genera by Mittleman (1942). Other authors such as Smith (1946), Smith and Taylor (1950a), and Stejneger and Barbour (1943) followed Mittleman. Although reasons for dividing *Uta* (in the sense of Mittleman, 1942) are equivocal as demonstrated by Savage (1958), arguments for this split advanced by the latter author appear well founded. I consider *Urosaurus* as the proper generic name for forms occurring in the Zuni region and specifically allied with *Uta ornata* Baird and Girard (1852).

The problem of discerning geographic variation in *Urosaurus ornatus* seems to result from Mittleman's failure (1942) to use significant quantitative methods in defining the various forms. This was demonstrated by Oliver (1943), whose method of treating *U. ornatus* was followed with modification by Langebartel and Smith (1954, pp. 130-133). Murray (1953) questioned the use of degree of dorsal scale carination as a taxonomic character and, in addition to Duellman (1955, p. 8) and Gehlbach (1956, pp. 367-368), reported the failure of color to characterize subspecies in *U. ornatus*. Williams (1960, pp. 27-28), experiencing difficulty with Mittleman's diagnoses, followed Langebartel and Smith (1954, pp. 130-133) in lumping *U. o. linearis* under *U. o. schotti* but recognized *U. o. wrighti*.<sup>5</sup>

Mittleman (1942, pp. 138, 146) recorded *U. o. wrighti* from McKinley and San Juan counties, New Mexico, and *U. o. linearis* from "generally south of Lat. 35° [in New Mexico] except for the southeastern quarter of the state." Within the Zuni region, *U. ornatus* exhibits variability that, at first glance, suggests intergradation between *U. o. linearis* and *U. o. wrighti* (Gehlbach, 1956, p. 368); however, examination of series of supposedly typical individuals reveals that most characters currently in use do not adequately separate these subspecies. Clinal variation is present in at least one important char-

<sup>5</sup> I provisionally consider *linearis* as a separate subspecies in view of the distinctiveness of specimens from south-central Arizona (fig. 8). A thorough examination of variation in *U. ornatus* from the Arizona-Mexico border region would clarify this situation but that is beyond the scope of my discussion.



acter (fig. 8). Since *U. ornatus* is greatly in need of a modern systematic revision, I hold subspecific allocation of Zuni specimens tentative at this time.

Using Oliver's methods (1943, pp. 100–101), the following may be noted in *U. ornatus* from the Zunis. Enlarged dorsal scales are present in two distinct rows on each side of the smaller vertebrals in 28 percent of a series of 29 specimens; they are in two rows with additional enlarged dorsals tending to form a third outer row in 66 percent and in three quasi-distinct rows in 6 percent. Carination of these scales varies from a flat, weak keel to a sharp raised point with all types of intermediate forms observable. Similarly, complete gradation in the merging of dorsal tail-base scales with adjacent scutes is present. Thirty-one percent of the specimens have the enlarged dorsals separated by two rows of small vertebral scales, while 69 percent possess only one row of vertebrals.

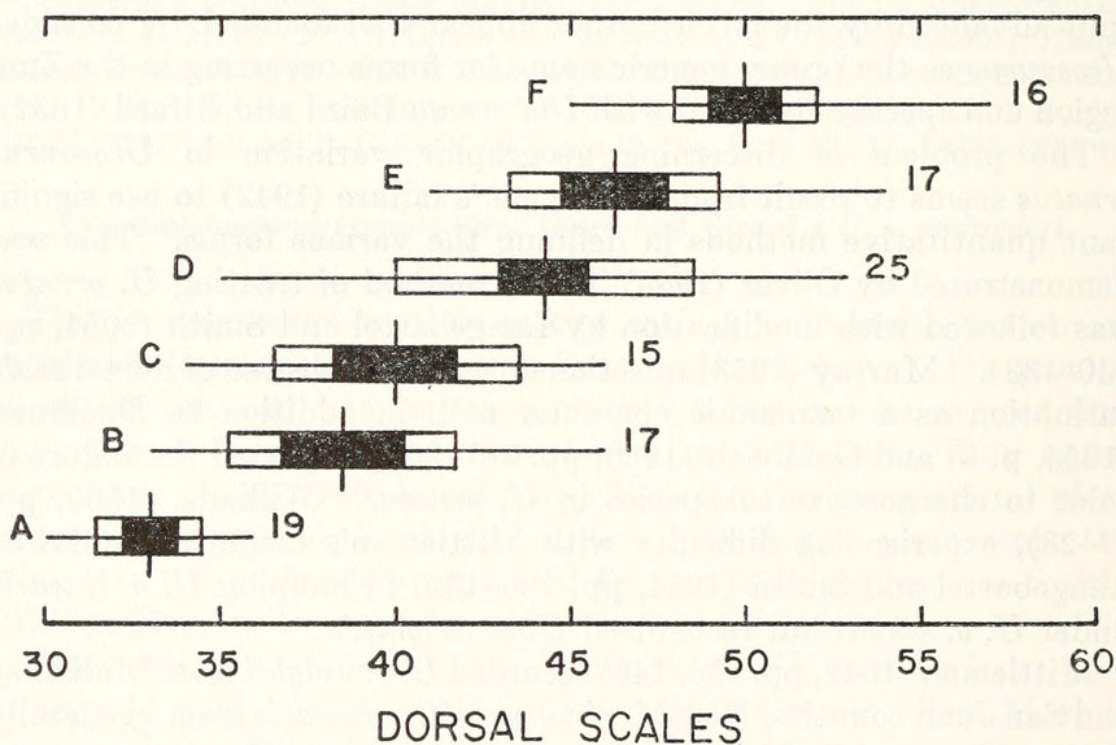


FIGURE 8.—Variation in the number of enlarged dorsal scales of *Urosaurus ornatus* from Arizona, New Mexico, and Utah. (Horizontal line=range; vertical line=mean; solid bar=two standard errors of the mean; hollow bar=one standard deviation. Sample size to right of range; provenance of sample to left: A, Pima and Santa Cruz Counties, Arizona; B, Cochise Co., Arizona; C, Yavapai Co., Arizona; D, McKinley and Valencia Counties, New Mexico; E, Kane Co., Utah; F, San Juan Co., Utah.)

Thirteen individuals from the northeast of the Zuni Mountains have 40–53 ( $\bar{x}$  44.5  $\pm$  0.96) enlarged dorsals from the anterior insertion of the forelimbs to anterior insertions of hindlimbs; 16 from the southwest side have 35–47 (42.3  $\pm$  0.95). If these counts are compared with those of *U. ornatus* from Utah and Arizona, a north-south



cline may be visualized (fig. 8). This gradient of increasing scale size extends into Sonora, Mexico (cf. Oliver, 1943, fig. 1). Two rows of enlarged dorsals on each side of the vertebrae are present in about 80 percent of *U. ornatus* from southern Arizona. In approximately 90 percent of those from northern Arizona and Utah, there is a partial or complete third, outer row.

The rock uta is abundant on mesa edges and cliffs in the Roughlands and lower Montane Life Belts. Its local distribution is determined apparently by the availability of large boulders or by areas of broken, exposed rock; hence, elevational limits are imposed only by the lack of such habitat. Each mesa partially isolated by level grassland is inhabited by a distinctive population marked by close resemblance to local rock color. While these utas usually were observed in a vertical position, they were found rarely in standing trees and shrubs. Characterization of *Urosaurus* as a plant-dwelling genus (see Lowe, 1955b) does not hold for *U. ornatus* in the Zunis. This is well illustrated by its occurrence in montane canyon-head situations and absence from ridgetops. Arboreal vegetation is present in both places, but large rocks or outcrops are not prevalent in the latter.

Data on reproduction indicates that the oviposition of *U. ornatus* may coincide with adequate summer moisture conditions. Gravid females with the following snout-vent length, date of collection (1959), and egg number and size provide circumstantial evidence: 54 mm., June 13, 5 avg. 6.7 mm. diameter; 47 mm., July 14, 3 avg. 12.8 x 7.0 mm.; 45 mm., July 16, 4 avg. 10.6 x 5.9 mm.; 48 mm., July 16, 2 avg. 12.2 x 6.1 mm. Specimens taken July 23, 1959, had laid their eggs as had *Sceloporus graciosus* and *S. undulatus* at the same locality. Hatchlings, 25 and 26 mm. snout-vent, were found on August 10; three more, 24, 25, and 27 mm., were collected on August 25, the following summer.

#### Locality records:

MCKINLEY CO.: 5.5 mi. SE Thoreau (CU 5625); 6 mi. S. Thoreau (CU 5129; UMMZ 120292); 7 mi. S. Thoreau (CU 5610, 5628); 8 mi. S. Thoreau (CU 5449); 5 mi. NE. Thoreau (CU 5686); between Thoreau and Continental Divide (UMMZ 120310); 4 mi. NNE. Prewitt (CU 5451, 5599; UMMZ 120203); 14 mi. N. Gallup (UCM 6092-93); VALENCIA CO.: 8 mi. SE. Grants (UMMZ 86614); 17 mi. SW. Grants (CU 5127, 5695); 25 mi. S. Grants (MCZ 62308\*); 2.5 mi. E. Laguna Pueblo (CU 5678); El Morro Nat. Mon. (CU 5605); 2 mi. W. El Morro Nat. Mon. (CU 5445).

#### Comparative Material Examined:

*U. o. linearis*.—ARIZONA: COCHISE CO.: Carr Canyon, Huachuca Mts. (CU 3539); 5 mi. SE. Sunnyside (CU 5126); Cave Creek Canyon, Chiricahua Mts. (CU 2469, 5122); YAVAPAI CO.: 1 mi. N. Yarnell (CU 3036, 3513). *U. o. schotti*.—ARIZONA: PIMA CO.: Arivaca (CU 1789); 5 mi. NE. Arivaca (CU 2461); SANTA



CRUZ CO.: 3.5 mi. E. Patagonia (CU 5504); 9 mi. E. Sonoita (CU 877-8); Trench Mine Station (CU 5514). *U. o. wrighti*.—UTAH: KANE CO.: near Kanab (UMMZ 73380-84); SAN JUAN CO.: near Moab (UMMZ 68573-78).

*Phrynosoma douglassi hernandesi* Girard

The Zuni Mountains are the type locality of *Tapaya ornatissima* Girard (1858) by restriction (Reeve, 1952, p. 928). Presently known as *Phrynosoma douglassi ornatissimum*, this lizard and the closely related *P. d. hernandesi* have been reviewed most recently by Reeve (1952), who based the above locality restriction on Stejneger's designation (1890, p. 113) of neotypes of *P. d. ornatissimum*. Critical examination of 29 adult (table 5) and 17 subadult topotypes and the neotypes reveals that the Zuni population is composed actually of individuals with the characters of both *P. d. ornatissimum* and *P. d. hernandesi* (as defined by Girard, 1858, pp. 395-396; Reeve, 1952, pp. 924-928).

With regard for diagnostic features, the adult specimens have: (1) temporal spines shorter than their basal diameter in 65 percent and about equal to basal diameter in 35 percent; (2) head width at jaw angle exceeding temporal width in 6 percent, about equal to temporal width in 44 percent, and less than equal in 50 percent; (3) dorsal dark spots light bordered mesially in 45 percent; and not light bordered in 55 percent. Only the first character favors allocation with *P. d. ornatissimum*; numbers two and three are more typical of *P. d. hernandesi*. These adults might be considered intergrades, but the added characterization of subadults and all specimens with special regard for locality data demonstrates that the above features vary ontogenetically as well as environmentally.

Seventeen subadults, 24-45 mm. snout-vent, resemble *P. d. hernandesi* in color pattern as do five larger adults from the Montane Life Belt. Vivid dorsal coloration is virtually absent in these specimens; their dorsal blotches lack light mesial borders. In contrast, adults from Roughlands and Plains localities are bright orange or reddish brown in general aspect (brighter ventrally) and possess mesially and posteriorly light bordered blotches as in *P. d. ornatissimum*. Tail length/snout-vent length is 0.369-0.471 ( $\bar{x}$  0.429) in subadults, 0.429-0.542 (0.470) in adults; hence, absolute tail length is unacceptable for comparative purposes as proposed by Reeve (1952, pp. 924, 928) unless ontogenetic variation is accounted for. Furthermore, it appears that adults have relatively broader heads and longer temporal spines than subadults. None of the latter have the jaw angle width greater than the temporal width or have temporal spines equaling their basal diameter in length.

The idea that environmental gradients produce both *P. d. hernandesi* and *P. d. ornatissimum* in a single geographic area is not new.



Cope (1900, p. 417), concerned with *P. d. ornatissimum*, stated: "According to Stejneger this is the desert form of the species. In Arizona Dr. Merriam only found it on the Painted Desert, while he found the *P. d. hernandesi* in the cedar and pine belts in the San Francisco Mountain region." Bailey (1913) included both races in his New Mexico, Upper Sonoran Life Zone, but only *P. d. hernandesi* in the Transition Zone. Eaton (1935, p. 16) commented on his inability to distinguish *P. d. ornatissimum* from *P. d. hernandesi* in northern Arizona, and Durham (1956, p. 222) described specimens of both "subspecies" from the Grand Canyon. Bragg and Dundee (1949, p. 57) and Lowe (1947) observed color variation correlated with ecological differences near Las Vegas and Socorro, New Mexico, respectively. In view of past and current difficulties in separating the two forms, I suggest that *P. d. ornatissimum* be placed in the synonymy of *P. d. hernandesi*, which has page priority (see Girard, 1858, pp. 395-396).

Short-horned lizards are certainly the most eurytopic reptiles of the Zuni region if not of New Mexico. They could be observed readily in all major vegetational associations except the spruce-fir but were most abundant in the pinyon-juniper savanna. Specimens were taken in the alpine-tundra association at 11,300 feet on Mt. Taylor (La Mosca Lookout), a greater elevation than attained by any other species studied (fig. 3). This is possibly the highest occurrence of any reptile or amphibian in the Southwest.

The birth of ten young (24-26,  $\bar{x}$  24.8 mm. snout-vent) was observed in a clump of rabbitbush at 6400 feet, 11:00 a.m., August 14, 1957. All were extruded within ten minutes and, with freedom from their investing membrane, immediately buried themselves in the loose, sandy soil. They were medium gray with only the dark-brown dorsal spots of the salient color pattern. Other dates (1957) of parturition and accompanying brood size are June 25 (15), July 11 (8), July 20 (6), August 3 (21), August 10 (11) for females taken between 7000 and 7500 feet and maintained in outdoor cages at 7200 feet. A single juvenile, 20 mm. snout-vent, was collected on August 12 at 8200 feet. Specimens with ova, 0.6-1.5 mm. in diameter, were found throughout the summer months; one from 11,300 feet contained 11 eggs averaging 4.2 mm. on July 17, 1956.

#### Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (CU 5119, 5233, 5447, 5632, 5703, 5709; UMMZ 120409); Ft. Wingate (USNM 14396, 14408); Prewitt (KUMNH 28063\*); Rio Puerco, Continental Divide (AMNH 62853-4); Seven Lakes (CU 5620); Gallup (CU 5841); 10 mi. N. Gallup (TNHC 11654-5); VALENCIA CO.: Grants (MCZ 6791\*; USNM 44805); 10.4 mi. S. Grants (CU 5601); La Mosca Lookout, Mt. Taylor (CU 5453); Mark Elkin's Ranch, Mt. Taylor (KUMNH 28062\*);



Shuman's Ranch (UMMZ 86617); El Morro Nat. Mon. (KUMNH 11298-9\*); Ojo Redondo (CU 5707); Mt. Sedgwick (USNM 44566); McCartney's (USNM 16000-1); Lava Beds (USNM 44702).

*Cnemidophorus velox* Springer

Lowe and Zweifel (1952, p. 229) have characterized appropriately the systematics of whiptail lizards: "Perhaps there is no genus of lizard occurring in North America today that has been studied and continues to be studied with as much uncertainty and confusion as *Cnemidophorus*." In keeping with this statement, *C. velox* was, for many years, an unrecognized species. Probably it was reported in New Mexico by Yarrow (1875, p. 558) as *C. octolineatus* and by Hallowell (1854, p. 145), Cope (1900, p. 603), and VanDenburgh (1924, p. 213) as *C. gularis*. Burt (1931, p. 124) included it under *C. sexlineatus perplexus* and listed Zuni specimens from Grants and Gallup. Lowe (1955a) reviewed the nomenclatorial history of this Colorado Plateau species that Burger (1950a, p. 4) and others had confused with *C. exsanguis*, formerly known as *C. sacki* (Duellman and Zweifel, 1962). Maslin and others (1958, p. 342) reported *C. velox* from San Juan, Taos, Rio Arriba, and San Miguel Counties, New Mexico. Duellman and Zweifel (1962, fig. 10) utilized my distributional data on this species in their review of the "*sexlineatus*" group of *Cnemidophorus*.

*C. velox* may be separated from *C. exsanguis* primarily on the basis of size and color pattern (pl. 3; table 7). Adults of the former are never spotted conspicuously, have more widely separated paravertebral light stripes and predominantly blue or blue-gray tails in contrast to the spotted brown to greenish (distally) tailed adults of *C. exsanguis*. The two species are similar in scutellation (table 7). They are sympatric presumably in northern Arizona (Lowe, 1955a, p. 3), but this relationship is not certain in the Zunis. On two occasions a large seemingly spotted whiptail was seen foraging with typical adults of *C. velox* near Thoreau. Neither individual was collected, and other differences were not noted. Since some large *C. velox* develop light areas at the anterior ends of adjoining scales in the lateral dark stripes, these observations cannot be cited as indicating sympatry in the Zunis.

Among the striped whiptails of New Mexico west of the Rio Grande, the scale counts of *C. velox* are closest to those of *C. exsanguis* and furthest from *C. perplexus* and *C. inornatus*; such features adequately separate *C. velox* from *C. burti*, a much larger spotted species (table 7). Unlike *C. velox*, *C. perplexus* is spotted as an adult and often has a wavy middorsal light stripe. *C. velox* and *C. inornatus* are the only unspotted species in western New Mexico. Both have blue tails, but *C. inornatus* is not larger than 67 mm. snout-vent, typically has a



bluish venter, and rarely (4 out of 37 New Mexico specimens) lacks the middorsal light stripe. In *C. velox* the venter is usually white, although occasionally tinged with blue, and the middorsal stripe is more often incomplete or absent (table 8). The condition of this stripe apparently remains constant during ontogeny (pl. 3A).

TABLE 7.—Comparison of range and mean of meristic characters of striped whiptails (*Genus Cnemidophorus*) present in western New Mexico<sup>1</sup>

Species	Dorsal scales around midbody	Scales between paravertebral stripes	Femoral pores	Maximum snout-vent length mm.	Spots
<i>C. burti</i>	98-115(104.7)	5-11(8.0)	32-44(38.3)	130	yes
<i>C. exsanguis</i>	62-86(74.8)	2-8(4.6)	30-44(36.8)	101	yes
<i>C. inornatus</i>	55-78(62.0)	7-11(8.6)	33-39(35.0)	67	no
<i>C. perplexus</i>	71-80(74.9)	9-13(10.2)	34-40(37.3)	86	yes
<i>C. velox</i>	67-80(72.5)	5-10(7.9)	28-38(32.9)	84	no

<sup>1</sup> Data in part from Duellman and Zweifel (1962).

There is relatively little geographic variation in *C. velox* (table 8). It is perhaps significant that populations from the immediate vicinity of the San Juan Basin are somewhat more uniform in structure and closer to the species mode than those to the south and west. Specimens from Catron County, New Mexico, have the fewest dorsal scales<sup>6</sup> and are smallest in size, closely approaching *C. inornatus* in these characters. Specimens from Kane County, Utah, have the largest number of dorsals and, including Navajo County, Arizona, and San Juan County, Utah, femoral pores. The four samples most peripheral to the San Juan Basin, those from the Zunis, Catron, Apache, and Kane Counties, show the greatest separation of paravertebral light stripes and incidence of a complete middorsal stripe.

Maslin (1959, p. 44) identified two specimens (UMMZ 76881) as syntypes of *C. velox* although he added that they were reidentified as *C. stictogrammus* by Richard G. Zweifel. Zweifel (in litt.) said that he had no notes on these specimens; he later examined and tentatively determined them as *C. sexlineatus*. I concur with this identification. Clearly the specimens in question are not syntypes of *C. velox*. Even their locality data, Lee's Ferry, Coconino County, Arizona, differs from that given by Springer (1928, p. 103) for the four original syntypes: "Three were taken at Oraibi, Arizona, and one at Pueblo Bonito, New Mexico." Some mixup is indicated since *C. sexlineatus* reaches its westernmost limits in San Miguel County, New Mexico, and cannot be expected at Lee's Ferry.

<sup>6</sup> I agree with Zweifel (1959, p. 66) that the number of dorsal scales around midbody is a more accurate count than the number from occiput to rump. This may be seen in the degree of variation in the Zuni population (table 5).



TABLE 8.—Range, mean, and standard error (latter of dorsal scales and femoral pores only) in *Cnemidophorus velox*

Locality	N	Snout-vent length	Dorsal scales around midbody	Femoral pores	Scales between para-vertebral stripes	Middorsal stripe complete
Apache Co., Ariz.	5	48-69(62.2)	69-75(71.2±1.1)	30-36(31.8±2.4)	8-10(9.2)	0
Navajo Co., Ariz.	5	55-71(61.6)	72-75(73.8±0.4)	33-35(34.2±0.3)	6-8 (7.0)	80%
Catron Co., N.M.	8	49-68(58.4)	67-75(69.5±0.9)	30-35(32.6±1.6)	6-9 (8.1)	75%
Rio Arriba Co., N.M.	15	53-73(63.6)	71-76(73.2±0.56)	30-36(32.7±1.9)	6-9 (7.2)	33%
San Juan Co., N.M.	15	37-79(60.9)	68-76(72.6±2.6)	28-37(32.4±2.3)	6-9 (6.9)	7%
Zuni region, N.M.	20	53-80(65.0)	68-76(71.7±0.85)	30-36(31.8±1.8)	6-10(8.1)	60%
Kane Co., Utah	15	57-80(68.9)	74-80(76.7±0.65)	31-35(33.5±1.1)	8-10(9.1)	61%
San Juan Co., Utah	7	52-84(72.0)	68-75(71.4±0.75)	31-38(34.4±2.2)	5-10(7.6)	43%
Total sample	90	37-84(64.1)	67-80(72.5±1.6)	28-38(32.9±0.4)	5-10(7.9)	45%



Of the 90 specimens of *C. velox* examined during this study, none were males. Comparative dissections revealed only females of *C. exanguis* and *C. tessellatus*, but bisexual samples of *C. inornatus* and *C. tigris* were noted. This problem is complicated further by the existence of two kinds of nonspotted whiptails in the Zuni region. One is typical of *C. velox* as previously characterized and has, in addition, abruptly enlarged scales preceding the gular fold. The other is represented by two males (UCM 6579-80) from 14 miles north of Gallup that resemble *C. inornatus* in having the bright-blue venter and smaller scales in front of the gular fold. These specimens, with 68 and 75 dorsal scales around midbody, could be the males of *C. velox*, or they might represent *C. inornatus* in sympatry with *C. velox*; indeed, when more specimens become available and this perplexing situation is studied further, present species concepts involving *C. velox* and *C. inornatus* may be altered radically.

In the Zunis, Colorado Plateau whiptails were most common in open areas of the Roughlands Life Belt especially where the saltbush-sage association occurred in isolated patches in the pinyon-juniper savanna. They were associated occasionally with *Sceloporus undulatus* in these habitats and with *Sceloporus graciosus* where scattered spiny saltbush and one-seed junipers dominated a sandy area at the lower edge of the Roughlands near Prewitt. Although seldom found above the Roughlands-Montane continuum, they sometimes occurred in ponderosa pine stands in open, logged-off spots or along dry creek beds to approximately 7800 feet.

Gravid females with the following snout-vent length, date (1939) of collection, and egg number and size give some estimate of local reproductive capacity in this whiptail: 77 mm., May 28, 3 avg. 6.5 x 15.2 mm.; 80 mm., June 13, 4 avg. 11.2 x 16.0 mm.; 73 mm., June 22, 4 avg. 8.2 x 15.2 mm. A specimen collected June 30, 1956, had an enlarged oviduct but only small eggs measuring 0.5-1.5 mm. in diameter. None of the individuals taken in July held enlarged eggs; hence, *C. velox* apparently does not oviposit coincidentally with summer rainfall. A hatchling, 34 mm. snout-vent, was collected August 13; another, 37 mm., on August 20, 1957.

#### Locality records:

MCKINLEY CO.: 4 mi. S. Thoreau (CU 5450); 5.5 mi. SE. Thoreau (CU 5614); 6 mi. S. Thoreau (CU 5675; UMMZ 120410, 120289); 7 mi. S. Thoreau (CU 5626); 4 mi. NNE. Prewitt (UMMZ 120286); between Thoreau and Continental Divide (UMMZ 120309); Ft. Wingate (USNM 16762-63, 80357); 16 mi. S. Gallup (CU 5609); 10 mi. W. Gallup (MVZ 65805); 14 mi. N. Gallup (UCM 6578-80); Gallup (UMMZ 120287); Crownpoint (UNMCV 1162); VALENCIA CO.: 8 mi. SE. Paxton (UMMZ 86619); 1 mi. N. Cebolleta (UMMZ 86620); 4 mi. W. McCartey's (UMMZ 86618); 11.5 mi. SSE. Grants (CU 5458).



## Comparative material examined:

*C. velox*.—ARIZONA: APACHE CO.: Little Colorado River (UMMZ 85054); NAVAJO CO.: 1 mi. N. Winslow (UMMZ 74025); NEW MEXICO: CATRON CO.: 3 mi. NE. Horse Springs (UCM 6095-6102); RIO ARriba CO.: 7 mi. N. El Rito (UMMZ 69081); SAN JUAN CO.: 7 mi. E. Blanco (UCM 7250-59); 43 mi. SE. Bloomfield (UCM 7260-62); 1 mi. N. Chaco Canyon Nat. Mon. (UMMZ 120288); Chaco Canyon Nat. Mon. (UMMZ 122915); UTAH: KANE CO.: 6-7 mi. NW. Kanab (UMMZ 73323-24); SAN JUAN CO.: 3 mi. W. Monticello (UMMZ 121484-85); Natural Bridges Nat. Mon. (UMMZ 120285).

*Eumeces multivirgatus multivirgatus* Hallowell x *E. m. epipleurotus*  
Cope

The taxonomic status of southwestern members of the *E. multivirgatus* complex recently has been discussed by Lowe (1955c), Maslin (1957), Mecham (1957), Heyl and Smith (1957), and Tanner (1957). These authors are in essential agreement that *E. gaigeae* (= *E. m. epipleurotus*; see Axtell, 1961) and *E. taylori* are pattern variations of *E. multivirgatus*, but their opinions diverge as to the proper allocation of the three available names. Mecham (1957, pp. 113-116) proved that *E. taylori* is simply an allelomorphic pattern variant of *E. multivirgatus*; thus, there is no reason, in the interest of biosystematics, for retaining *E. m. taylori* as a nongeographic subspecies as Lowe (1955c) and Tanner (1957 p. 116) do. Maslin (1957, p. 87) and Mecham (1957, p. 112) suggested that *E. gaigeae* represents a stage in the ontogenetic pattern change of *E. multivirgatus*. Such loss of color pattern is well documented in the *E. fasciatus* group but has not been demonstrated effectively in the many-lined skinks.

A series of 25 adults and 5 juveniles of *E. m. multivirgatus* from the Zuni region corroborates previous suggestions concerning the derivation of the color pattern of *E. m. epipleurotus*. Complete pattern reduction can be observed in this variable sample and is comparable to Tanner's diagrams B through D (1957, fig. 1). An adult female, collected August 12, 1960, lost the mid-dorsal light stripe in 21 months of captivity.

To test possible correlation of pattern change with increasing size, and presumably age, the hybrid index method of Sibley (1950, p. 112) and others was adapted for present use. The characters examined were middorsal light line, dorsal dark line on the first and/or second scale rows, lateral light line on the sixth and/or seventh scale rows, and tail color pattern. The degree of intensity of each stripe was graded per specimen on a scale of 0 (=present, as in typical *E. m. multivirgatus*) to 3 (=absent, as in typical *E. m. epipleurotus*). Tail color-pattern change (from blue to blue gray with lines, to brown with lines, and ultimately to brown with lines and spots) was graded in like manner. By adding the character values for a specimen, a



total of 0 indicated *E. m. multivirgatus*, 12 denoted *E. m. epipleurotus*, and 1–11 indicated ascending degrees of intermediacy. The specimen totals plotted against snout-vent length show ontogenetic change of color pattern from *E. m. multivirgatus* to *E. m. epipleurotus* with increasing size irrespective of sex (fig. 9).

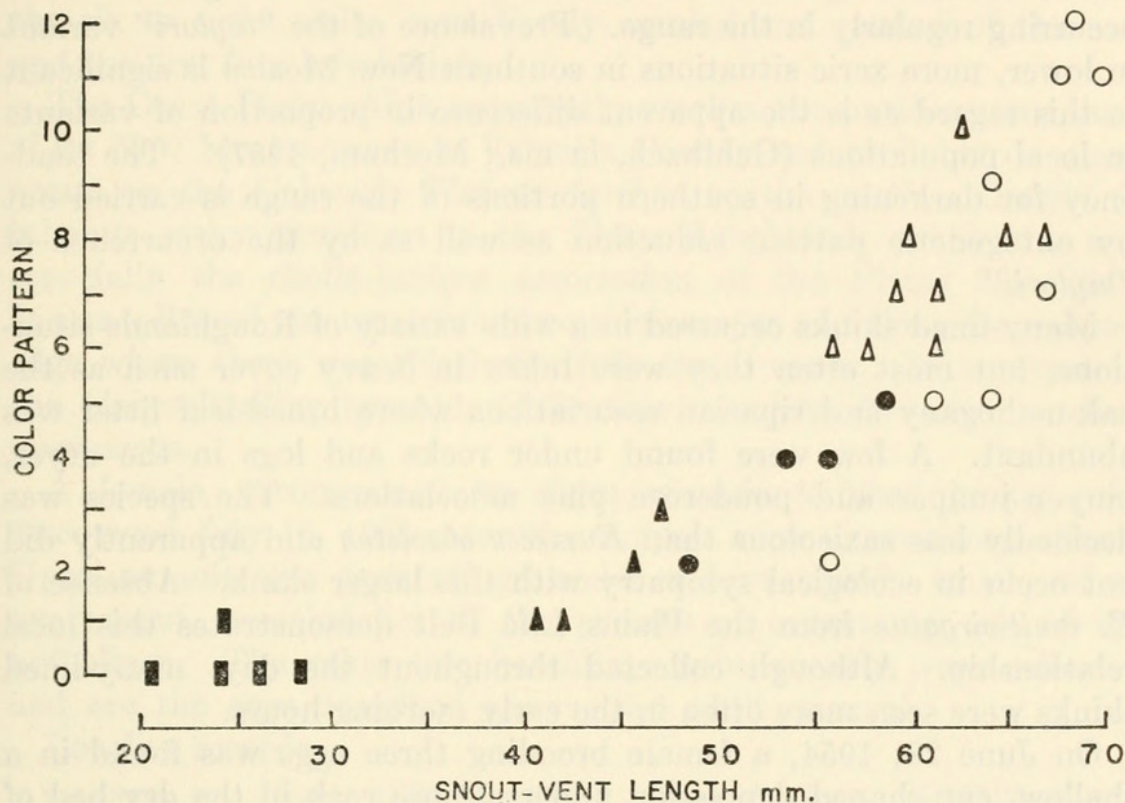
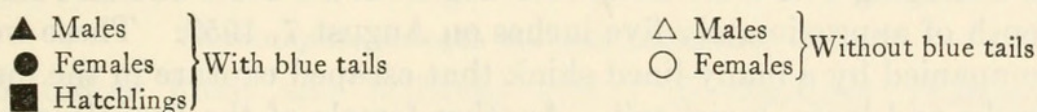


FIGURE 9.—Relationship of color-pattern to snout-vent length in *Eumeces multivirgatus* from the Zuni region. (The color-pattern of nominate *multivirgatus* is 0, that of *epipleurotus* is 12.)



Suggested bases for retaining *E. m. epipleurotus* as a southern race of *E. multivirgatus* are: (1) ontogenetic pattern reduction (not present in nominate subspecies; Maslin, 1957; Mecham, 1957); (2) distinctive juvenile pattern (see Maslin, 1957, fig. 1E); (3) posterior border of last supralabial confluent with posterior border of last infra-labial (supralabial projecting caudad at least 15 percent of its length in nominate subspecies; Maslin, 1957, p. 89). The first and second criteria apply to the Zuni skinks; however, for the third, only 38 percent of the adults possess the labial feature of *E. m. epipleurotus* on both sides of the head and 25 percent resemble *E. m. multivirgatus*, with the remainder being asymmetrical. While this third criterion remains to be tested in other New Mexico populations, some influence from the northern race is expected if physiographic and ecologic



factors operating in this situation are similar to those effecting north-south intergradation in other Zuni reptiles.

Polychromatism in *E. multivirgatus* presents an interesting possibility for increased adaptation. It would be of distinct advantage for this skink, a wide-ranging form, to possess a variety of phenotypes each of which is superior in adaptive value to others in a given habitat occurring regularly in the range. Prevalence of the "*taylori*" variant in lower, more xeric situations in southern New Mexico is significant in this regard as is the apparent difference in proportion of variants in local populations (Gehlbach, in ms.; Mecham, 1957). The tendency for darkening in southern portions of the range is carried out by ontogenetic pattern reduction as well as by the occurrence of "*taylori*."

Many-lined skinks occurred in a wide variety of Roughlands situations, but most often they were taken in heavy cover such as the oak-mahogany and riparian associations where broad-leaf litter was abundant. A few were found under rocks and logs in the dryer, pinyon-juniper and ponderosa pine associations. The species was decidedly less saxicolous than *Eumeces obsoletus* and apparently did not occur in ecological sympatry with this larger skink. Absence of *E. multivirgatus* from the Plains Life Belt demonstrates this local relationship. Although collected throughout the day, many-lined skinks were seen more often in the early morning hours.

On June 28, 1954, a female brooding three eggs was found in a shallow, cup-shaped depression under a loose rock in the dry bed of Cottonwood Creek at 7200 feet. The soil was damp only around the eggs, which measured 14.0 x 9.5, 14.5 x 8.5, and 15.0 x 7.8 mm. Five eggs averaging 14.2 x 8.6 mm. were dug from a Pueblo Indian ruin at a depth of approximately five inches on August 7, 1957. These were accompanied by a many-lined skink that escaped capture in the maze of rocks and loose, moist soil. Another female of the "*epipleurotus*" type and four recent hatchlings, 22 to 27 mm. snout-vent, were taken together on August 17. These hatchlings and one other, 29 mm., collected July 29, have the sharply contrasting juvenile pattern of *E. m. epipleurotus*.

#### Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (CU 5435, 5596, 5615, 5693; UMMZ 123529); 8 mi. S. Thoreau (CU 5145); Ft. Wingate (USNM 16015-17); 10 mi. N. Ramah (UMMZ 122883); VALENCIA CO.: 8 mi. SE. Thoreau (UMMZ 120408); 8 mi. NE. Grants (CU 5436); 17 mi. SW. Grants (CU 5607); 1.5 mi. S. Lookout Mt. (CU 5691); 3 mi. SW. Page (CU 5692); 2 mi. W. El Morro Nat. Mon. (CWGF).

#### *Emueces obsoletus* Baird and Girard

Burt (1929) and Taylor (1935, pp. 205-220) have reviewed geographic variation in this species. Adult specimens collected in the



Zunis fit their descriptions of New Mexico and Arizona material; however, two hatchlings differ slightly from published accounts of juvenile coloration. They are 35 and 36 mm. snout-vent, with a glossy-black ground color that is equally as intense on the venter as on the dorsum. White spots on the head are confined to the upper labials, outside edges of the parietals, prefrontals, and supranasals, the six to eight scales immediately cranial and caudad of the ear, and the first four infralabials.

The Great Plains skink apparently reaches the northwestern limit of its New Mexico range in Valencia County and probably does not occur on the Colorado Plateau further to the north. Locally it inhabits rocky situations in the Plains-Roughlands continuum and especially the cholla-juniper association of the Plains Life Belt. It was collected among rock outcrops in arroyos and along the malpais edge where there was relatively little shrub cover. In contrast to the plains-dwelling iguanid, *Holbrookia maculata*, it seems to shun open areas.

A female, accompanied by three recently hatched young, was discovered July 18, 1956, near the malpais edge on scoriaceous lava. Upon pursuit, she took refuge under a lava chunk, which, when overturned, revealed her in the process of consuming one of the hatchlings. The other two hatchlings subsequently were collected and are the ones described above; the adult escaped.

#### Locality records:

VALENCIA CO.: Grants (USNM 44806); 1.5 mi. S. Grants (UMMZ 86621); 11.5 mi. SSE. Grants (CU 5455); 8 mi. SE. Paxton (UMMZ 86623); 4 mi. W. McCartey's (UMMZ 86622).

### Suborder Serpentes

#### *Thamnophis dorsalis dorsalis* Baird and Girard

I follow Fitch and Milstead (1961) in replacing *Thamnophis cyrtopsis* Kennicott with the older Baird and Girard name. This arrangement is not entirely convincing because the black-necked gartersnakes, *T. dorsalis*, *T. eques*, and *T. marcianus*, of the Southwest and Mexico have been confused widely (see Wright and Wright, 1957, p. 770); Fitch and Milstead (1961) admit that the original description of *T. dorsalis* is not sufficiently diagnostic to identify the missing type with certainty.

The single male of *T. d. dorsalis*, collected during the present study, was found while I was investigating a breeding aggregation of *Scaphiopus hammondi* and *Bufo punctatus* on the eastern edge of the Grants malpais at 6400 feet (Gehlbach, 1956, p. 369). This locality is at least 10 miles from the nearest stream of appreciable size, the Rio San Jose. The specimen has 174 ventral scales, 76 subcaudals, and 19-19-17 dorsal scale rows. It is unlike most *T. d. dorsalis* in that it



shows no dorsal spotting caudad of the neck region and has a very low subcaudal count (see Milstead, 1953). Reduction of posteriordorsal dark spots has been observed in specimens from Farmington, San Juan County (UMMZ 66973-4), and Pinos Altos, Grant County (UMMZ 75626), New Mexico, but this reduction was not of the magnitude seen in the Zuni snake.

*T. dorsalis* is not as abundant as *T. elegans* in northwestern New Mexico. It does not occur frequently in the pinyon-juniper association and, therefore, is separated somewhat ecologically from *T. elegans*. In addition to the Farmington specimens, others from the Acoma Indian Reservation (UNMCV, specimen lost), Suwanee, Valencia County (UNMCV 44, 117), Aztec (AMNH 5298), and junction of the Los Pinos and San Juan rivers, San Juan County (A. Harris, in litt.), were taken below 6000 feet. Milstead's record (1953, p. 372) from ten miles north of El Rita [sic], Rio Arriba County, is questionable; I consider the specimens (UMMZ 84330) to be juveniles of *T. elegans*.

Locality records:

VALENCIA CO., 11.5 mi. SSE. Grants (CU 5053).

#### *Thamnophis elegans vagrans* Baird and Girard

Of all snakes represented in the Zuni region by a single geographic race, *T. elegans* exhibits the greatest morphological variation and widest range both geographically and altitudinally (fig. 3). Variation is especially apparent in the number of ventral and subcaudal scutes of both sexes (table 9). The means of these features approximate those given by Fitch (1940, figs. 3, 4), but the ranges are greater than his combined Arizona-New Mexico sample. Six specimens have 23 anterior scale rows and one has divided preoculars, traits which Fitch (1940) considered rare in *T. e. vagrans*.

Color pattern is subject to extremes of manifestation in the Zuni population. Certain individuals are nearly uniform olive brown dorsally with only a trace of the middorsal light stripe and dark dorsal spots. Others are marked with brilliant lemon-yellow stripes and clear black spots. In these the dark postparietal crescentic marks are strikingly similar to those of *T. dorsalis* and may have been part of the reason for misidentification in other studies. Black spots along the belly midline are present in varying degrees. Although a great variety of colors and patterns can be observed, no specimen possesses the ash-gray ground color seen by me in *T. e. vagrans* in southern Utah; all are some shade of brown.

Juveniles usually are spotted distinctly, with the dorsal and lateral light stripes reduced in intensity and the black nuchal crescents clearly indicated. To my eye, juveniles are colored more cryptically than adults, which are generally less spotted. There is apparently



TABLE 9.—Scale counts and color pattern measurements (range, mean, standard error) of some Zuni snakes<sup>1</sup>

Species	N	Ventrals	Subcaudals	Dorsals-midbody	Body blotches	Tail blotches
<i>Diadophis punctatus</i> (♂)	2	211, 214	72		—	—
“ “ (♀)	2	230, 231	69(2)	17(4)	—	—
<i>Pituophis melanoleucus</i> (♂)	7	229-240(233.6 ± 2.1)	57-72(65.8 ± 2.5)	29-31(30.3 ± 0.39)	44-63(51.2 ± 2.4)	13-18(14.6 ± 0.28)
“ “ (♀)	2	230, 234	53, 62			13, 14
<i>Thamnophis elegans</i> (♂)	19	161-176(166.3 ± 1.1)	78-96(86.8 ± 1.1)	19-21(20.9 ± 0.14)	—	—
“ “ (♀)	12	159-171(163.7 ± 1.0)	71-90(75.5 ± 1.6)			
<i>Crotalus atrox</i> (♂)	3	185, 192	22, 24, 25	25-26(25.3 ± 0.24)	35-40(37.0 ± 0.76)	6, 5(2)
“ “ (♀)	4	184, 187, 189	19(2), 20(2)			3(2), 4(2)
<i>Crotalus viridis</i> (♂)	13	171-178(174.6 ± 0.65)	23-28(24.9 ± 0.47)	23-27(25.2 ± 0.22)	34-44(39.1 ± 0.65)	6-10(8.5 ± 0.11)
“ “ (♀)	10	172-180(174.9 ± 1.0)	19-22(20.4 ± 0.27)			5-8(7.0 ± 0.10)

<sup>1</sup> Dorsal scale row and body blotch counts of both sexes are combined for each species.



some ontogenetic change in the color pattern of this subspecies, but the variety of polychromatism renders its interpretation especially difficult.

Twenty young born on August 26, 1957, to a female, 1051 mm. in total length, are 142–160 ( $\bar{x}$  152) mm. snout-vent, 49–58 (55) mm. tail length. It is noteworthy that the above female is the largest *T. e. vagrans* on record; her brood averages considerably larger than those reported by Wright and Wright (1957, p. 799). Other dates of birth and brood size are July 11 (13) and July 2 (15) for females measuring 744 and 979 mm. total length, respectively. All brood records are from specimens captured at 7200 feet in the riparian association bordered by oak-mahogany and pinyon-juniper associations. The adults were maintained in outside cages at the same elevation.

As indicated by Coues (1875, pp. 614–615) in observations made along the Zuni River, the wandering garter snake is typically semi-aquatic in the Zunis. Specimens of all sizes were encountered frequently in riparian situations where the amount of exposure varied according to elevation. The form was most abundant in Montane and Roughlands Life Belts, but a few individuals were found on the plains in or near arroyos stemming from the uplands. Of 23 specimens with food in their stomachs, 17 had eaten *Rana pipiens*, both adults and larvae; 6 contained *Sceloporus undulatus* and *Bufo woodhousei*; 2 held *Peromyscus* species; 1 held *Perognathus flavus*; and 1 each had eaten *Phrynosoma douglassi* and *Ambystoma tigrinum*. On several occasions, this garter snake was seen chasing anuran larvae under water.

#### Locality records:

MCKINLEY CO.: Thoreau (MCZ 62258–64, 62454–70\*); 6 mi. S. Thoreau (CU 5054, 5444, 5586, 5616, 5668); Ft. Wingate (USNM 16764–5, 14397–14401); 15 mi. N. Gallup (MVZ 63704\*); 5 mi. SW. Ramah (UMMZ 123132); VALENCIA CO.: 1.5 mi. SW. San Mateo (UMMZ 86626–7); 4 mi. W. McCartey's (UMMZ 86628); 4 mi. WSW. Cebolleta (UMMZ 86624–25); Pagate (UMMZ 86629); Canyon Lobo Ranger Station, Mt. Taylor (UMMZ 86630); 7 mi. W. San Fidel (AMNH 74501, 74786, 75966); El Morro Nat. Mon. (KUMNH 8557\*); 7.8 mi. SE. Grants (UMMZ 123131).

#### *Diadophis punctatus regalis* Baird and Girard

Confusion in applying the name *regalis* has resulted apparently from a scarcity of museum specimens. Blanchard (1942, pp. 56, 62) considered *D. regalis regalis* as distinct from *D. regalis laetus* by absence or great reduction of the neck ring. Only two New Mexico specimens were available to him, however. Wright and Wright (1957, p. 161) followed Blanchard, although Schmidt and Smith (1944, pp. 89–90) previously had regarded presence or absence of the neck ring as anomalous and size and ventral scale counts as more



significant. These latter authors synonymized *D. r. laetus* with *D. r. regalis* but named *D. regalis blanchardi*. They were followed by Stebbins (1954, p. 489), who further suggested, as had Garman (1883, p. 73), that perhaps all ringneck snakes constitute a single species.

Another rearrangement was fostered by Smith and Taylor (1945, p. 48), who maintained Blanchard's views on *D. regalis* and *D. r. laetus* in "view of the paucity of data on these snakes" but synonymized *D. r. blanchardi* with nominate *D. regalis*. Brown (1950, p. 145) supported their position. The form *D. dugesi* had been linked subspecifically with *D. regalis* (Taylor and Smith, 1938, p. 240) and *D. punctatus* (Villada, 1878) but was considered as a distinct species by Blanchard (1942, pp. 51-54). Utilizing new material from western Texas and southeastern New Mexico, Mecham (1956) combined *D. regalis* with *D. punctatus* but left subspecific boundaries in question.

Taxonomic appraisal of Zuni ringneck snakes and others from New Mexico necessitated the following brief review of variation in southwestern and Mexican *Diadophis*. I have been fortunate in seeing more material than was available to previous workers. Series from single localities, nevertheless, are nonexistent; hence, certain morphologically similar specimens were grouped politically (Arizona, Utah, Chihuahua). Further evidence for considering the montane forms *D. regalis* and *D. dugesi* as subspecies of *D. punctatus* has been found. The racial boundaries left open by Mecham (1956) can now be approximated, and *D. r. laetus*, along with *D. r. blanchardi*, may be placed in the synonymy of *D. p. regalis*.

As suggested by Cope (1900, pp. 544-545), the neck ring is a polychromatic character with dominance in some areas and variable manifestation in others. It occurs in some individuals from Sandoval County (New Mexico), Yavapai County (Arizona), and Chihuahua (Mexico), but is absent in others. Zuni specimens have neck rings (pl. 4) as do those from Catron, Sierra, and Grant Counties in southwestern New Mexico. Material examined from central and southeastern New Mexico usually lacks the ring, but one individual from Eddy County has it interrupted middorsally (Mecham, 1956). Incomplete neck rings also occur in the prairie race, *D. p. arnyi* (= *D. p. docilis*, Mecham, 1956), and specimens from Utah, Trans-Pecos, Texas (Blanchard, 1942, pp. 63, 73; Mecham, 1956), and Jalisco, Mexico (UIMNH 47866). Most specimens from Utah and Trans-Pecos, Texas, lack the ring, whereas most Arizona and Mexican individuals have it well developed.

Similarly, extent of the yellow color of the venter on the dorsal scale rows varies from a single spot on a few anterior scales of the first



row to nearly complete coverage of the first or first and second rows; for example, one of the three Zuni specimens has yellow limited to a spot on each scale of the first dorsal row, while the others have the first row nearly covered with, and the second row spotted with, yellow (pl. 4). Most Arizona and New Mexico ringnecks show the former condition; most Utah snakes, the latter. In *D. p. dugesi* the yellow pigment is confined usually to the ventrals, but specimens from Hidalgo (UIMNH 17635), Jalisco (AMNH 3711-12), and Nayarit (AMNH 19724) resemble anteriorly those from Arizona-New Mexico. An individual from Durango, Mexico, (ISM, uncataloged) has faint yellow spots on the first dorsal row and thus appears to be intermediate between *D. p. dugesi* and *D. p. regalis*. A similar specimen from Chihuahua (BYU 14243) has yellow confined to the venter caudad of the neck region.

The Guadalupe Mountains population (Eddy Co., N. M.-Culberson Co., Tex.) also exhibits intermediacy in coloration as well as certain meristic features described below. One specimen from Walnut Canyon (CCNP 2197) has yellow spots on all scales of the first dorsal row, thus resembling most Arizona-New Mexico ringnecks. Another (CCNP 2201) has such spots only on the anterior quarter of the body, while a third has a uniformly gray dorsum. The McKittrick Canyon snakes have no yellow pigment dorsally except in the region of the partial neck ring, where it reaches approximately the fifth scale row on each side. Restriction of yellow pigmentation to the ventral scales is supposedly typical of *D. p. arnyi* (Stebbins, 1954, pp. 360, 489) as well as *D. p. dugesi* (Blanchard, 1942, p. 51).

In southwestern and Mexican *Diadophis*, the number of labial scales (usually 7/8), loreals (1-1), and pre- and postoculars (2-2) is geographically stable, although often asymmetrical. By contrast, body length and three of four other meristic characters vary clinally (table 10). Two steps in the temporal and dorsal scale row clines are important because they fall at major breaks in the range of nonclinal ventral scale variation (fig. 10). One of these steps occurs in the Guadalupe Mountains south through the Sierra Vieja and Chisos Mountains, Trans-Pecos, Texas, between the ranges of *D. p. arnyi* in west Texas and *D. p. regalis* in central New Mexico. The other lies between the ranges of *D. p. regalis* in Chihuahua, Mexico, and *D. p. dugesi* in southern Mexico. The steps are indicated by changes in frequency involving 15-15 and 17-17 dorsal scale rows and 1-1 temporals.

That certain meristic characters exhibit clines in different directions is evident. Ringneck snakes from the Sierra Vieja-Chisos region are closest to *D. p. arnyi* in dorsal and temporal counts but resemble *D. p. regalis* in number of ventrals. Almost the opposite situation exists



TABLE 10.—*Variation of Diadophis punctatus in the Southwest and Mexico*<sup>1</sup> (Dorsal scale counts are from midbody and anal regions; unusual deviations are omitted as are asymmetrical temporal counts. Range and mean are given for subcaudal scale counts and body length. Provenance and size of samples: A=west Texas other than Trans-Pecos (21); B=Guadalupe Mountains, Eddy County, N.M., and Culberson Co., Texas (10); C=Sierra Vieja and Chisos Mountains region, Trans-Pecos, Texas (12); D=central and western New Mexico (16); E=Arizona (22); F=Utah (16); G=Chihuahua, Mexico (8); H=Mexico south of Durango (22))

Counts	A	B	C	D	E	F	G	H
Subcaudals (♂)	49-58(52.0)	47-61(51.4)	53-67(60.2)	69-72(71.0)	63-74(70.7)	72-81(75.7)	62-71(65.6)	52-61(56.2)
" (♀)	41-57(49.0)	39-47(43.2)	54-59(55.7)	60-69(64.0)	62-68(64.5)	64-73(67.8)	55-67(59.7)	45-56(52.1)
Dorsal scales	15-15(55%)	15-15(50%)	15-15(60%)	15-15(1%)	17-17(35%)	17-17(5%)	17-17(20%)	17-17(53%)
	17-15(27%)	17-15(38%)	17-15(40%)	17-15(87%)	17-15(55%)	17-15(90%)	17-15(80%)	17-15(32%)
Temporal scales	1-2(rare)	1-2(29%)	1-2(10%)	1-2(47%)	1-2(60%)	1-2(44%)	1-2(40%)	1-2(43%)
	1-1(usual)	1-1(71%)	1-1(90%)	1-1(33%)	1-1(10%)	1-1(31%)	1-1(40%)	1-1(10%)
Body length (mm.)	98-422	147-358(255)	222-445(372)	162-545(374)	325-645(434)	167-602(381)	239-510(381)	143-433(297)

<sup>1</sup>Data in part from Blanchard (1942), Fouquette and Lindsey (1955), Jameson and Flury (1949), Mecham (1956), Minton (1959), Schmidt and Smith (1944), Smith (1943a), and Tanner (1941).



in the Guadalupe, where most specimens approximate *D. p. arnyi* in dorsal and ventral counts and *D. p. regalis* in frequency of temporal combinations; however, a male from Walnut Canyon is closest to *D. p. regalis* in having 206 ventrals. On the basis of clinal variation and intermediate coloration, ringneck snakes from the Guadalupe

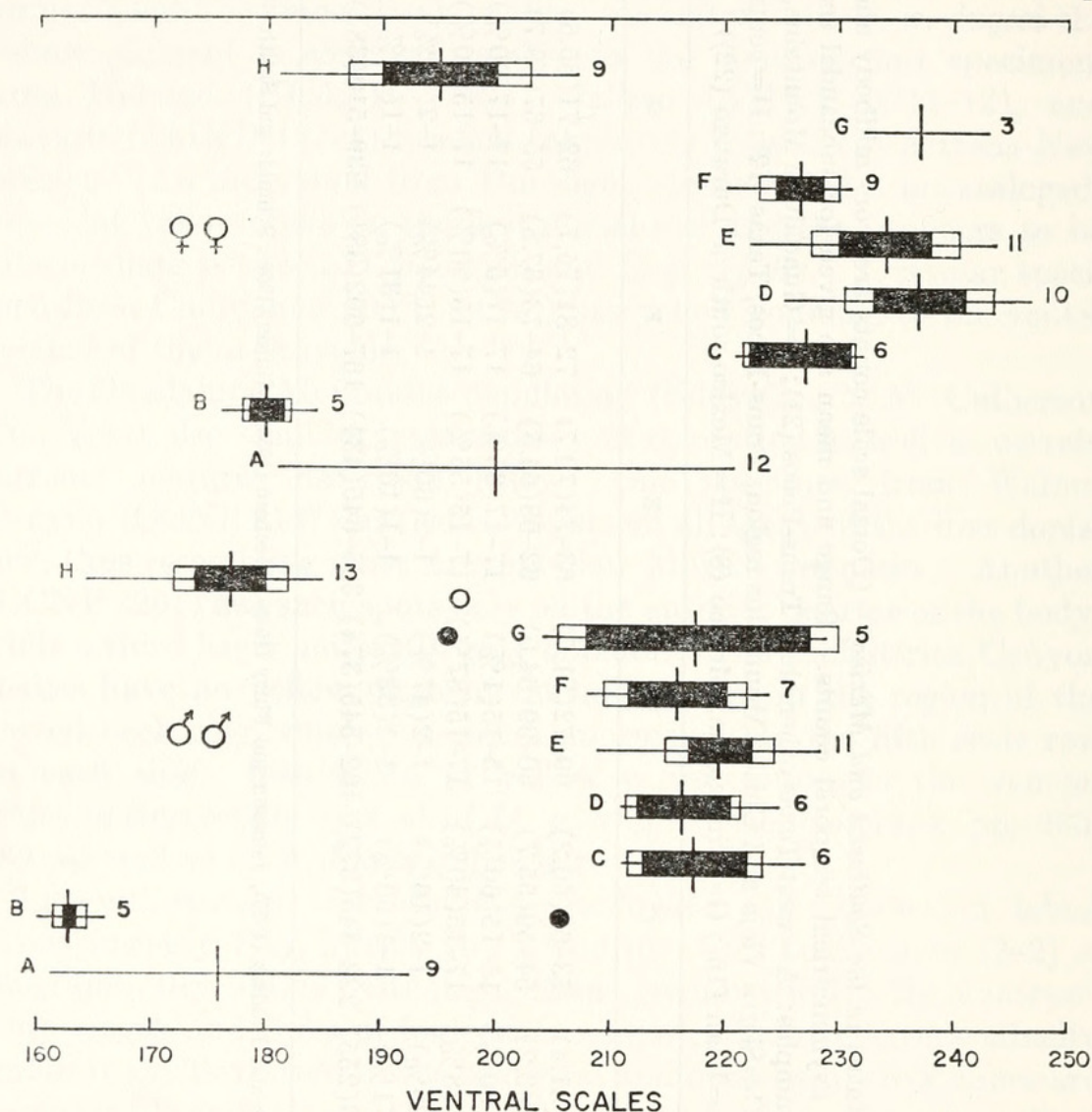


FIGURE 10.—Variation in the number of ventral scales of *Diadophis punctatus* from the Southwest and Mexico. (Solid circles=intergrades; hollow circle=a specimen from Durango. See table 10 for other provenance data and figure 8 for explanation of diagram.)

Mountains south through Trans-Pecos, Texas, are considered intergrades between *D. p. arnyi* and *D. p. regalis*. Perhaps this zone of intergradation extends further north. Bragg and Dundee (1949) reported *D. p. arnyi* seven miles south of Las Vegas, San Miguel County, New Mexico; typical *D. p. regalis* occurs 65 miles to the west in Sandoval County.

West of the Guadalupe Mountains, ventral scale counts are uniformly high among specimens from central and western New Mexico, Arizona, Utah, and northern Chihuahua (fig. 10). Zuni ringnecks



are thus allocated with *D. p. regalis*, which is best distinguished by the large, sexually dimorphic number of ventrals. Thirty-three females have 220–247 ( $\bar{x}$  233.9 $\pm$ 1.3) ventrals, while 28 males have 204–229 (217.3 $\pm$ 1.2). Over a range of 43 ventrals there is only a nine-scale overlap between the sexes. On the other hand, 25 males have more subcaudals (62–81,  $\bar{x}$  70.9 $\pm$ 0.98) than 28 females (55–73, 64.8 $\pm$ 0.73). Here the overlap, 11 scales in a range of 26, is relatively greater, rendering number of subcaudals inferior to number of ventrals as an external criterion of sex. Equally striking sexual dimorphism obtains in *D. p. arnyi* and *D. p. dugesi*, which have fewer ventrals than *D. p. regalis* (fig. 10).

A single ringneck from southern Chihuahua (BYU 14243) has only 196 ventrals, suggesting intergradation with *D. p. dugesi* (Tanner and Robison, 1960, p. 68). It further resembles *D. p. dugesi* in number of dorsal scale rows (17–17) and the coloration described above. A specimen from Durango is likewise intermediate in ventral count and color (see above and fig. 10) but is closest to *D. p. regalis* from Chihuahua in number of dorsals (17–15) and temporals (1–1). Unfortunately, the other Durango specimen (UMMZ 102527) is in such poor condition that exact analysis of its scutellation is impossible. The Durango ringnecks and the above-mentioned individual from Chihuahua are considered intergrades since they bridge the previous morphologic and geographic gap between *D. p. regalis* in Chihuahua and *D. p. dugesi* in Nayarit.

Martin and Harrell (1957, p. 469) listed *D. punctatus* among vertebrates that may have dispersed between the eastern United States and Mexico. The relationship of *D. p. dugesi* to *D. p. arnyi* through intergradation with *D. p. regalis* implies that dispersal via the Sierra Madre Occidental and the montane Southwest deserves equal consideration. Lower ventral and subcaudal scale counts in *D. p. dugesi* and *D. p. arnyi* could be considered convergence in view of the distributional hiatus in northeastern Mexico. This hiatus may not be real, however, because a specimen described by Blanchard (1942, p. 59) from San Luis Potosi, Mexico, appears to be somewhat intermediate between *D. p. arnyi* and *D. p. regalis* and indicates that other such individuals occur in the region and possibly to the north also. Blanchard (1942, pp. 129–132) described breaks in range, considered by him important in maintaining *D. p. regalis* and *D. p. dugesi* as distinct species, that recently have been filled in.

The secretive nature of *Diadophis* can be cited as a reason for its seeming rarity in the Southwest and Mexico. In the Zunis, a male collected August 17, 1959, was crawling over sandstone rubble near a small stream at 9:45 a.m. Although the locality, in pinyon-juniper-ponderosa ecotone at 7200 feet, had been worked intensely



in preceding summers, ringneck snakes previously had not been found there. Another individual found in the riparian association displayed typical tail-curling behavior as did the above specimen (pl. 4). A female found September 13, 1958, at 6400 feet in an area of broken lava and sandstone contains 18 eggs, the largest being 2.5 mm. in diameter. It is 650 mm. in total length and has three divided ventrals, including the first one anterior to the divided anal plate.

Three live specimens from Cottonwood Gulch (6 mi. S. Thoreau) suggests that some color change may occur during the growth of *D. p. regalis*. The smallest, 268 mm. total length, collected June 29, 1961, has a yolk-sac scar and is slate gray above with a bright-yellow belly and the characteristic red subcaudal surface. Another, 377 mm., is similar to the juvenile ventrally but has a greenish-gray dorsum. The largest specimen, 478 mm. with a stub tail, has an orange-yellow belly that shades into coral red in the region of the vent and is also greenish gray dorsally. Its individual dorsal scales are mottled with black and have a black spot at the anterior end (pl. 4). In each of these three ringnecks, the belly is moderately to heavily spotted with black as in all other southwestern and Mexican specimens.

#### Locality records:

MCKINLEY CO.: 6 mi. S. Thoreau (UMMZ 120276, 122627, 122947); VALENCIA CO.: 6 mi. E. Grants (UNMCV 158).

#### Comparative material examined:

*D. p. regalis*.—NEW MEXICO: BERNALILLO CO.: SW $\frac{1}{4}$ , Sec. 22, T9N, R4E (UNMCV 412); Jaral Canyon, Sandia Mts. (UNMCV 36); CATRON CO.: 3 mi. N. Glenwood (BYU 13976); DONA ANA CO.: Mesilla Valley (USNM 22376); GRANT CO.: Mogollon Creek, above falls (UNMCV 159); LINCOLN CO.: 12 mi. NW. Carrizozo (UMMZ 66774); SANDOVAL CO.: E. Sandia Pueblo (UNMCV 413); Pena Blanca (UNMCV 131); 25 mi. N. Albuquerque (UNMCV 163); SIERRA CO.: Lake Valley (ANSP 10786); TORRENCE CO.: Mountainair (UNMCV 411); ARIZONA: COCHISE CO.: 0.5 mi. SW. Portal (UMMZ 119029); Bisbee (CU 4694-5); Pinery Creek, Chiricahua Mts. (AMNH 80807); 2 mi. W. Ft. Huachuca (USMN 102201); Ft. Huachuca (USNM 21061); GILA CO.: Roosevelt (UNMCV 2698-9); PINAL CO.: Camp Grant (USNM 8019); NAVAJO CO.: Ft. Apache (USNM 8427); PIMA CO.: Sabino Canyon, Santa Catalina Mts. (USNM 62569); Sycamore Canyon, Baboquiviri Mts. (ANSP 17998); Otero Canyon, Baboquiviri Mts. (ANSP 17953); Ft. Buchanan (ANSP 3465); SANTA CRUZ CO.: Madera Canyon, Santa Rita Mts. (AMNH 64428); 10 mi. N. Nogales (AMNH 67253); YAVAPAI CO.: White River Canyon (USNM 10199); Camp Verde (AMNH 4202, 62240); UTAH: SAN PETE CO.: Freedom (UMMZ 63999); UTAH CO.: S. Fork West Canyon (BYU 13775, 14168-9, 14672-3); WASHINGTON CO.: Pine Valley (CU 3836); MEXICO: CHIHUAHUA: Maguarichic (UMMZ 118929); 6 mi. E. Barraganes (AMNH 73749); Norogachi (AMNH 73751); 10 mi. W. San Francisco del Oro (BYU 14251); 7 mi. SW. Pacheco (MVZ 46685). *D. p. dugesi*.—MEXICO: HIDALGO: 8 mi. N. Pachuca (UIMNH 17635); JALISCO: 10 mi. W. Guadalajara (UIMNH 46578, 47866); Guadalajara (AMNH 3711-12); W. Ocotlan (AMNH 19723); MEXICO: (AMNH 62827); 3 mi. S. Villa Obregon (UMMZ 99540); MICHOACAN: 2 mi. E. Morelia (AMNH 62827);



15 km. W. Morelia (UIMNH 17634); 5 mi. E. Lake Patzcuaro (UIMNH 17636); NAYARIT: La Labor (AMNH 19724); 7 mi. S. Compostela (AMNH 80590). *D. p. regalis* x *dugesii*.—MEXICO: CHIHUAHUA: 2 mi. E. Cerocahui (BYU 14243); DURANGO: 20 mi. NW. Los Coyotes (UMMZ 102527); 40 mi. SW. Cd. Durango (ISM uncataloged). *D. p. regalis* x *arnyi*.—NEW MEXICO: EDDY CO.: Walnut Canyon, Guadalupe Mts. (CCNP 2197, 2201; UMMZ 122949); TEXAS: BREWSTER CO.: near Alpine (CU 869, 883); near Panther Pass, Chisos Mts. (UNMCV 2701); Upper Green Gulch, Chisos Mts. (UNMCV 2700); CULBERSON CO.: McKittrick Canyon, Guadalupe Mts. (UMMZ 121825, 122948, 122955; BCB 8702).

*Masticophis flagellum lineatulus* Smith

Since the description of *M. f. lineatulus* (Smith, 1941), in which the specimen from Laguna, Valencia County, was indicated as a paratype, only one additional individual, to my knowledge, has been collected in the Zuni region. It comes from the Plains Life Belt at 6300 feet, where narrow-leaved yucca and one-seed junipers are prevalent. This coachwhip snake may reach the approximate northwestern limit of its New Mexico range at the eastern end of the Zunis. It is presently unknown in McKinley and San Juan Counties, although Maslin (1959, p. 57) saw what he presumed to be *M. flagellum* in adjoining Montezuma County, Colorado.

The recent specimen, an adult male, 1070 mm. in total length, has longitudinal dark lines on the dorsal scales but retains dark anterior cross bands and lacks the diagnostic red subcaudal color. Its subspecific allocation is, therefore, tentative. I must agree with Wright and Wright (1957, pp. 437–438), who remarked on the difficult southwestern members of the *M. flagellum* complex and considered Smith's contribution (1941, pp. 394–397) as tentative.

Locality records:

VALENCIA CO.: Laguna (USNM 4388); 8 mi. E. Grants (TNHC 4487).

*Masticophis taeniatus taeniatus* Hallowell

Smith and Taylor (1950b, p. 359) apparently overlooked historical circumstances in restricting the type locality of this whipsnake to Shiprock, San Juan County, New Mexico. The actual type locality cannot be determined exactly, but it can be clarified by the following facts. S. W. Woodhouse, accompanying the 1851 Sitgreaves Expedition, collected the form described by Hallowell (1852, p. 181) as *Leptophis taenita* [sic] and later stated by him (Hallowell, 1854, p. 134) to have come from "New Mexico, west of the Rio Grande." Woodhouse came no closer than 100 miles of Shiprock in his journey from Albuquerque to the Zuni Pueblo, but he could have taken *M. t. taeniatus* anywhere in the Rio Grande basin between El Paso and Zuni (Hallowell, 1854, p. 147). Apparently he did not collect snakes west of Zuni, for he was incapacitated partially by a bite from *Crotalus viridis* in that locality.



In color and scutellation the few Zuni specimens do not deviate appreciably from *M. t. taeniatus* as defined by Ortenburger (1928, pp. 25-35); however, two juveniles, 525 and 672 mm. in total length, lack the usual reddish suffusion on the subcaudal surface and have clear, undivided, dorsolateral white stripes on the posterior half of the body. Three individuals were collected or observed in the pinyon-juniper savanna, and one came from the cholla-juniper association. Judging from sight records, this whipsnake is more abundant in open Roughlands environments than the number of museum specimens indicates. The species is particularly adept at escaping capture.

Locality records:

VALENCIA CO.: 5 mi. E. Grants (CU 3052); 10.4 mi. S. Grants (CU 5602); MCKINLEY CO.: Nutria (USNM 8432).

*Salvadora grahamiae grahamiae* Baird and Girard

Records of *S. g. grahamiae* on the southeastern edge of the Zuni Mountains and at Santa Rosa, Guadalupe County, New Mexico (Bogert, 1939, p. 189), provide the northernmost stations for this species in the United States. Mountain patch-nosed snakes were reported previously from Valencia County by Charles M. Bogert (see Wright and Wright, 1957, p. 649), who informed me (in litt.) that he examined a specimen taken one mile east of Laguna.

The present Zuni specimens are from 6400 feet in a cholla-juniper-dominated section of the Plains-Roughlands continuum. Both have a high number of ventral scales, 199 and 196 for the male and female respectively; subcaudals are 100 and 97, dorsal scale rows are 19-17-13, and the labials are 9/9 except for 8 in the left upper series of the female. The smaller male has no trace of lateral dark stripes, and its dorsal stripes disappear on the basal third of the tail. The female has definite, dark lateral stripes that become diffuse at the anus.

Hartweg (1940) noted that one of two specimens from near Mimbres, Grant County, New Mexico, lacked the lateral stripes, as did specimens from Trans-Pecos, Texas, and southeastern Arizona. Stebbins (1954, p. 501) stated that Bogert had seen intermediates between *S. g. grahamiae* and *S. g. lineata* (sometimes considered a distinct species) in southern Chihuahua and Durango, Mexico. I examined a specimen (UMMZ 118446) from near Sombrerete, Zacatecas, Mexico, that was also intermediate. Thus, it seems that the two races intergrade over an unusually broad area, or that polychromatism exists; I favor the latter explanation.

Locality records:

VALENCIA CO.: 10.4 mi. S. Grants (CU 5655).



*Pituophis melanoleucus affinis* Hallowell x *P. m. deserticola* Stejneger

In the Zuni region, gopher snakes present a situation resembling the one already described for *Phrynosoma douglassi*. Although the type locality of *P. m. affinis* is probably about five miles from the Pueblo of Zuni (see Woodhouse, 1854, p. 34), the gopher snake population inhabiting this area actually contains intermediates between *P. m. affinis* and *P. m. deserticola*. Klauber (1947, p. 41) reviewed the circumstances of Hallowell's (1854, p. 146) original restriction of type locality to "near the Zuni River, New Mexico." Smith and Taylor (1950b, p. 359) further restricted it to Zuni, McKinley County, New Mexico, apparently overlooking Woodhouse's statement concerning the provenance of the type of *P. m. affinis*.

When Klauber (1947, p. 44) noted that *P. m. affinis* from the Flagstaff-Gallup area was atypical, he seemingly did not consider that intergradation between it and *P. m. deserticola* might extend that far south. Instead, he believed the blend zone to be in the vicinity of the Hopi villages east to Canyon de Chelly, Arizona, on the basis of intermediate specimens available to him. It now appears that the *P. m. affinis* x *P. m. deserticola* zone is much broader. Considering the characters cited by Klauber (1947), examples of both *P. m. affinis* and *P. m. deserticola* have been taken in San Juan and McKinley Counties (Gehlbach, 1956, p. 370), and intermediates come from the Zunis and 33 miles southeast of Laguna, Valencia County (UMMZ 121490). Thus, at least part of the intergrade area extends south and east of the San Juan Basin.

Zuni specimens are intergrades on the basis of color and body and tail blotch counts (table 9). These characters are intermediate when compared to those given by Klauber (1947, table 4) for *P. m. affinis* and *P. m. deserticola*. With the exception of two individuals, reddish-brown anterior dorsal blotches predominate in the sample, but the influence of *P. m. deserticola* is invariably present in the black tail blotches. Two specimens, one with reddish and one with black anterior blotches, have these markings interconnected so that the light interspaces appear as isolated spots. Specimens least typical of *P. m. deserticola*, in having the highest number of dorsal blotches, have black blotches, thus indicating their intermediate status. In view of the sample as a whole, intergradation in every character may be observed, but *P. m. affinis* influence is probably the strongest overall.

Only *Thamnophis elegans* and *Crotalus viridis* were more evident than gopher snakes in the Zunis. *P. melanoleucus* was found usually in the lower two life belts, being least abundant in Roughlands associations. More specimens were taken and observed in saltbush-sage than in any other vegetational type. In the Roughlands life



belt, gopher snakes were encountered in open pinyon-juniper savannas. Two individuals came from a cholla-juniper section of the Plains-Roughlands ecotone, where they were secreted in pack rat nests built among Indian Ruins. A juvenile, 385 mm. total length, collected July 23, 1957, at 7100 feet, was undoubtedly a hatchling as it had a fresh yolk-sac scar.

Of the variety of food items palpated from newly caught specimens, *Sceloporus undulatus*, *Peromyscus* species, *Neotoma* species, *Thomomys bottae*, and various passerine birds predominated. One gopher snake, extracted by the tail from a gopher burrow at 10:35 a.m., was coiled tightly around an adult *Thomomys bottae*. Juveniles sometimes fed upon lizards in the manner of a garter snake, i.e., without first constricting their prey.

Locality records:

MCKINLEY CO.: 4 mi. S. Thoreau (CU 5611); 4 mi. NNE. Prewitt (CU 5589); Ft. Wingate (USNM 8658, 16766-7); Black Rock (CWGF); VALENCIA CO.: 6 mi. SE. Grants (CU 5612); 8 mi. SE. Grants (UMMZ 86632); 16 mi. S. Grants (UMMZ 86631); 5 mi. SSW. U. S. Rt. 66 on N. M. Rt. 117 (CU 5769); 2.5 mi. NE. Ramah (CU 5454); 2 mi. W. El Morro Nat. Mon. (CWGF); El Morro Nat. Mon. (CWGF).

*Hypsiglena torquata texana* Stejneger x *H. t. ochrorhyncha* Cope  
x *H. t. loreala* Tanner

In New Mexico, as throughout the Southwest, some subspecies of *H. torquata* seem to me to be poorly defined. This fact and the paucity of specimens from the Zuni region demand that the present intergrade zone be considered provisional. Stebbins (1954, p. 492) has mapped this zone, utilizing subspecies boundaries defined by Tanner (1944). I likewise follow Tanner (1944) but with reservation, in light of the preceding discussion. Bogert and Oliver (1945, pp. 378-381) and others have presented evidence for lumping the species *H. ochrorhyncha* under *H. torquata*.

The Zuni snake, a male, has 172 ventrals, 47 subcaudals, 21-21-17 dorsal scale rows, 1-1 loreals, and approximately 49 large, dark body blotches, all characteristic of *H. torquata texana*, while the Los Lunas specimen, with about 52 body blotches, resembles *H. torquata texana* in color-pattern and *H. t. loreala* or *H. t. ochrorhyncha* in having 15 dorsals posteriorly. UNMCV 79 is also intermediate; it has 2-2 loreals as in *H. t. loreala*, 16 posterior dorsals, and about 69 small dorsal blotches, similar in size (involving less than 20 scales) to those of *H. t. loreala* or *H. t. ochrorhyncha*. Ventral scale counts of the three specimens, 165, 172, and 177, approximate those of *H. torquata texana* or possibly *H. t. ochrorhyncha* rather than *H. t. loreala* (see Tanner, 1944, table 2):



Features in common include the light-tan ground color and medium-olive or brown blotches ringed in interrupted fashion by dark-brown spots. Some dorsal blotches are broken into a zigzag row of separate or annectant spots as in other spotted night snakes examined from New Mexico. The light-tan coloration differs, however, from the medium gray manifest in *H. torquata* from limestone areas in southern New Mexico. Both UNMCV 79 and CU 5067 have continuous neck bands, a feature found in three of seven specimens at hand from southern New Mexico. A complete band is presumably less frequent in *H. torquata texana* than in *H. t. loreala* or *H. t. ochrorhyncha* (Tanner, 1944).

The single Zuni specimen was taken beneath a tan sandstone slab (Wingate) near the lower edge of the pinyon-juniper association at 6800 feet. Large boulders, steep-sided canyons, and such reptiles as *Urosaurus ornatus* and *Crotaphytus collaris* typified the terrain. Another individual was seen in a nearly identical situation at 7200 feet, two miles south of Thoreau, McKinley County, but escaped into a deep crevice.

Locality records:

MCKINLEY CO.: 3 mi. NE. Thoreau (CU 5067).

Comparative material examined:

*H. torquata* subspecies.—NEW MEXICO: VALENCIA CO.: Los Lunas (USNM 107347); SAN JUAN CO.: Chaco Canyon Nat. Mon. (UNMCV 79); EDDY CO.: Carlsbad Caverns Nat. Park (UMMZ 86163, 121785; CCNP 2409, 2416); CATRON CO.: 1 mi. N. Glenwood (UNMZ 78231); 13 mi. SE. Glenwood (UMMZ 78232-33).

***Crotalus atrox* Baird and Girard**

A characteristic member of southwestern desert and desert-grassland herpetofaunas, *C. atrox* is another species that probably reaches the northwestern limit of its New Mexico range in the Zuni region. Here it is found only in open plains situations but may range into the Plains-Roughlands continuum. Ecological restriction to the cholla-juniper association was observed south of Grants, where diamondback rattlers were found between the lava flow and edges of surrounding uplands. This snake was absent from the high soil-covered malpais near El Morro National Monument, where *C. viridis* was abundant; a similar situation was observed on the rough Grants malpais. A large adult, collected by William L. Chenoweth on October 17, 1957, was dead on the road in the short-grass association near Prewitt, when the air temperature was about 55° F.

Yarrow (1875, p. 529) first recorded *C. adamanteus atrox* from Ft. Wingate; Cope (1900, p. 1163) and VanDenburgh (1924, p. 227) mentioned this locality, the latter placing it in McKinley County. While diamondback rattlers occur in southeastern McKinley County,



it is doubtful that the specimen in question, if identified correctly, came from the present Ft. Wingate, which is located in the pinyon-juniper association. On the basis of known distribution, it probably originated near San Rafael, Valencia County, where Ft. Wingate formerly was located (Hoffmeister, 1951, p. 34); however, it is possible that the specimen was misidentified, for it was sent alive to the U.S. National Museum by R. W. Shufeldt and, seemingly, was never preserved (D. M. Cochran, in litt.).

Locality records:

MCKINLEY CO.: Prewitt (UMMZ 79308); 8 mi. ESE. Prewitt (CU 5884);  
VALENCIA CO.: 8 mi. SE. Grants (UMMZ 86633); 10.4 mi. S. Grants (CU 5591);  
11.5 mi. SSE. Grants (CWGF); San Rafael (CWGF).

*Crotalus molossus molossus* Baird and Girard

Chenoweth (1950, p. 534) first indicated that the black-tailed rattlesnake might be present in the Zuni region. Previously, the northernmost New Mexico record was Laguna (LMK 3197), although a smashed individual was seen on the road near Cubero, Valencia County, by Charles M. Bogert (L. M. Klauber, in litt.). This species may range somewhat further north. James S. Findley (pers. comm.) informed me that *C. molossus* has been reported by other observers in the Sandia Mountains, Sandoval County, and near Cuba, Rio Arriba County.

The single specimen, found during the present survey, was dead on the road in Lobo Canyon at approximately 7000 feet on Mt. Taylor. Its anterior color pattern is typical of *C. molossus* from south-central New Mexico, but there are only 12 distinct dorsal blotches, the entire posterior half of the body being uniform olive brown. The specimen has 27 dorsal scale rows at midbody; other counts cannot be ascertained because of its damaged condition.

Locality records:

VALENCIA CO.: 8 mi. NE. Grants (CU 5868); Laguna (LMK 3197\*).

*Crotalus viridis viridis* Rafinesque x *C. v. nuntius* Klauber

Prairie rattlesnakes in the Zuni region present an east-west intergrading situation similar to that of *Crotaphytus collaris*. Specimens collected east of the Apache County, Arizona-McKinley County, New Mexico, border have been considered nominate *C. viridis* previously (Gehlbach, 1956, p. 371; Klauber, 1935, p. 85). In describing *C. v. nuntius* of the Hopi Indian country, Klauber (1935) stated that easterly intergradation of it with nominate *C. viridis* was gradual over a broad zone. He considered specimens from Gallup closest to *C. v. viridis* in coloration but with low ventral scale counts.

When compared with comprehensive data presented by Klauber



(1956, table 2.7), a series of prairie rattlers from the Zunis approximates *C. v. nuntius* in six of eight meristic characters: number of subcaudal scales and tail rings in males, number of ventral scales and tail rings in females, and total scale row and body blotch counts (table 9). Of the remaining two, only the female subcaudal count favors assignment to *C. v. viridis*; the male ventral count is intermediate. Further indications of affinity with *C. v. nuntius* are the number of midtail scale rows (11–15,  $\bar{x}$  12.3  $\pm$  0.21) and ground color, which is predominately tan or brown rather than greenish.

Fifteen adults average 653 mm. in total length. The largest is 926 mm. and is the only decidedly greenish individual collected or observed. A female, 620 mm. total length, gave birth to six young, measuring 212–228 ( $\bar{x}$  219) mm., on September 21, 1957. Klauber's (1956, table 4.1) data for average size at birth indicate that these young are approximately intermediate between *C. v. viridis* and *C. v. nuntius*.

It is not surprising to note the light-tan to yellow ground color of *C. v. concolor* in a few Zuni specimens. This feature has been reported in San Juan County, New Mexico (Gehlbach, 1956, p. 371). Intergrades between *C. v. viridis*, *C. v. nuntius*, and *C. v. concolor* probably occur in the San Juan Basin, but this is difficult to demonstrate since *C. v. concolor* is distinguishable from *C. v. nuntius* only by means of coloration.

Two prairie rattlers, UMMZ 121413 from Canyon de Chelly National Monument, Apache County, Arizona, and UMMZ 121412 from White Canyon, San Juan County, Utah, are pertinent to this discussion. Both are small adults, 540 and 485 mm. in total length respectively, alike in their pinkish-brown coloration. The Arizona specimen differs by having white borders around its anterior dorsal blotches and head markings and a dark-brown stripe across the snout. The Utah snake could be *C. v. nuntius* x *C. v. concolor* in view of its color, pattern, and locality, but several of the larger Zuni specimens also lack white-bordered markings. Legler (1960, p. 182) states that dorsal markings are obliterated gradually with age in *C. v. concolor*. Apparently *C. v. viridis* does not penetrate northwestern New Mexico and adjacent Arizona and Utah as mapped by Klauber (1956, fig. 2.6).

Prairie rattlesnakes inhabit a wide range of Zuni environments. While many individuals were taken on lava flows and in the short-grass and saltbush-sage associations, a smaller number were collected in the Roughlands Life Belt. One was found in the ponderosa pine association of the lower Montane Life Belt. *C. viridis* seemingly was outnumbered by *C. atrox* in the lower, more open grassland, especially that dominated by cholla cactus. Juveniles were uncommon in the Plains Life Belt, suggesting that they might be born in the vicinity



of hibernation sites located in rocky uplands. Both juveniles and adults were often active during early morning and late afternoon hours; they contained recently ingested lizards as well as rodents. Two taken at 9:00 and 10:35 a.m., July 7, 1956, at 7200 feet had eaten *Sceloporus undulatus*.

Jon A. Peterson and field companions described (in litt.) a "combat dance" involving two large individuals at 9:00 a.m., July 14, 1959, near Tinaja, Valencia County. The rattlesnakes, each about three feet long, were situated in bright sunlight in the open grassland of the Miocene lava plain at 7400 feet. A few junipers and pinyons were nearby. The snakes were twisted about each other anteriorly in a position vertical to the ground. After several minutes of observation (photographs were taken, which I have seen), the snakes were disturbed; they were not collected.

#### Locality records:

MCKINLEY CO.: 4 mi. S. Thoreau (CWGF); 6 mi. S. Thoreau (CU 5046, 5446, 5603); 10 mi. NW. Thoreau (CU 5673); 5 mi. NE. Thoreau (CU 5674); 4 mi. NNE. Prewitt (CU 5457, 5633); Prewitt (UMMZ 79392); Ft. Wingate (USNM 8399); 2.5 mi. N. Upper Nutria (KUMNH 45765); 11 mi. W. Ramah (UMMZ 122882); VALENCIA CO.: 1.5 mi. S. Grants (UMMZ 86635); 8 mi. SE. Grants (UMMZ 86634); 10.4 mi. S. Grants (CU 5590); 25 mi. S. Grants (MCZ 62267\*); Tinaja (CU 5604); Acoma Pueblo (USNM 44483); El Morro Nat. Mon. (CWGF).

#### Species of Questionable Occurrence

Certain amphibians and reptiles that may occur in the Zuni are currently unrecorded. This undoubtedly obtains for medium to small colubrid snakes in view of the late discovery of *Diadophis punctatus* in the region. *Arizona elegans*, *Elaphe guttata*, *Lampropeltis dolia*, and *Opheodrys vernalis* are present in north-central New Mexico and southwestern Colorado or adjacent Utah and eventually may be collected in or near the Zuni region. The latter two species can be presumed to occur on the basis of observations by local residents. *A. elegans*, collected near Farmington (A. Harris, in litt.), is the only one of these snakes recorded from San Juan County, New Mexico: it has been taken near Madrone, Valencia County (UNMCV 407).

*Sceloporus magister*, *Crotaphytus wislizeni*, and *Cnemidophorus tigris* also occur in north-central New Mexico and southwestern Colorado. The latter two lizards and *Heterodon nasicus* are characteristic of a type of sandy habitat seemingly lacking in the Zuni. *C. wislizeni* is present near Laguna (USNM 4274), but *C. tigris* has been taken no closer than nine miles south of Shiprock (AMNH 77530) and Blanco, San Juan County, New Mexico (A. Harris, in litt.). *H. nasicus* was collected between Laguna and Correo, Valencia County (UNMCV 391). *S. magister* is known from Montezuma



County, Colorado (Maslin, 1959, p. 30), and Los Lunas, Valencia County (Smith, 1949, p. 156); its apparent absence in the Zunis is enigmatical.

A number of species present in Chihuahuan desert-grassland in extreme eastern Valencia County might be found as far west as Laguna but cannot be expected on the Colorado Plateau. Of these, *Phrynosoma modestum* (UNMCV 1170) and *Cnemidophorus tessellatus* (UNMCV 1169) have been taken near Correo. Semiaquatic forms such as *Thamnophis sirtalis* and *Chrysemys picta* seem more closely restricted to the Rio Grande. *T. sirtalis* was reported from Los Lunas, Valencia County, by Fitch and Maslin (1961, p. 299), and a relict colony of *C. picta* (UMMZ 64916-17) also exists there. That turtles were formerly present in the Zunis is suggested by paintings of them on Zuni Indian pottery (Whipple, 1856, p. 66).<sup>7</sup>

*Hyla eximia* (= *H. wrightorum*?) listed from Nutria (McKinley County?) New Mexico, by Yarrow (1875, p. 524) has not been collected during the present study. One of the two original specimens (USNM 8508; the other apparently is lost) was examined, but identity could not be verified owing to its poor state of preservation. Also, *P. modestum* and *Bufo cognatus*, recorded from Cottonwood Gulch by Chenoweth (1950), have not been rediscovered despite intensive field work in and around that locality. Since these records are based on one specimen each and the locality is the site of a boys' summer camp, the records are thought to represent introduced individuals.

### Zoogeography

The Zuni region is situated on the southeastern edge of the Colorado Plateau adjacent to the northeastern limits of the Basin and Range physiographic province. Its zoogeographic importance is demonstrated by the fact that eight amphibians and reptiles exhibit limited gene flow between intergrading subspecies that are associated better with the Colorado Plateau and other northern areas or the Basin and Range. It is similarly important that six species reach their northern limits of range in the area. To facilitate discussion of these regional patterns, the Zuni herpetofauna may be arranged according to present centers of distribution (table 11); nevertheless, interpretation of past events and causal factors in distribution rests entirely on paleoecological inference in the absence of local fossil records.

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<sup>7</sup> Some shells of *Chrysemys picta* (AMNH 19888, 20580) from the pueblo ruins of Hawikuh, 12 miles southwest of Zuni, Valencia County, recently came to my attention. They have not been dated with precision, but it is known that Hawikuh was abandoned around 1670 A. D.



TABLE 11.—*Present centers of distribution of the Zuni herpetofauna*

Transcontinental North America	
<i>Ambystoma tigrinum</i>	<i>Sceloporus undulatus</i>
<i>Bufo woodhousei</i>	<i>Diadophis punctatus</i>
<i>Pseudacris triseriata</i>	<i>Masticophis flagellum</i>
<i>Rana pipiens</i>	<i>Pituophis melanoleucus</i>
Western North America	
<i>Scaphiopus intermontanus</i>	<i>Eumeces multivirgatus</i>
<i>Crotaphytus collaris</i>	<i>Thamnophis elegans</i>
<i>Sceloporus graciosus</i>	<i>Masticophis taeniatus</i>
<i>Uta stansburiana</i>	<i>Hypsiglena torquata</i>
<i>Urosaurus ornatus</i>	<i>Crotalus atrox</i>
<i>Phrynosoma douglassi</i>	<i>Crotalus viridis</i>
<i>Cnemidophorus velox</i>	
Mexican Plateau	
<i>Scaphiopus hammondi</i>	<i>Thamnophis dorsalis</i>
<i>Bufo punctatus</i>	<i>Salvadora grahamiae</i>
<i>Hyla arenicolor</i>	<i>Crotalus molossus</i>
<i>Holbrookia maculata</i>	
Great Plains	
<i>Scaphiopus bombifrons</i>	<i>Eumeces obsoletus</i>

### Patterns of Distribution

Three widespread species, *Sceloporus undulatus*, *Urosaurus ornatus*, and *Hypsiglena torquata*, contain one geographic race restricted to the greater Colorado Plateau region and another to the southeastern Basin and Range province. These intergrade in the Zunis and elsewhere along the southern border of the Plateau.<sup>8</sup> *Bufo woodhousei*, *Pseudacris triseriata*, *Uta stansburiana*, *Eumeces multivirgatus*, and *Pituophis melanoleucus*, from the same distributional groups (transcontinental and western North America), have similar patterns of restricted gene exchange, but their northern subspecies are in no sense limited to the Plateau. It is significant that a past or present break in the gene flow of these eight eurytopic forms coincides with the Colorado Plateau-Basin and Range border.

*Scaphiopus bombifrons* and *Eumeces obsoletus*, the two Great Plains species, and *Salvadora grahamiae* and *Crotalus molossus*, centered on the Mexican Plateau, are at or near the northern limits of the southwestern portions of their range in the Zunis. They have not penetrated Colorado Plateau highlands except along a few major river valleys. The five other species allied with the Mexican Plateau range somewhat further north but not beyond the upper Colorado River

<sup>8</sup> *Holbrookia maculata* and *Crotalus viridis* also may fit this pattern in part, but the Colorado Plateau subspecies involved are defined inadequately at present.



basin. *Crotalus atrox* and possibly *Masticophis flagellum* also reach northern limits in the Zuni region. They are the only two species from the transcontinental and western North America groups that inhabit semiarid lowlands south of and, in the case of *M. flagellum*, east and west of the Colorado Plateau.

No species of reptile or amphibian present in the Zuni is restricted to the Colorado Plateau, and none are definitely limited to it at their southern edge of range. *Cnemidophorus velox* is distributed largely within Plateau boundaries but also ranges into the Basin and Range province. The main distribution of *Sceloporus graciosus* apparently coincides with the southern border of the Plateau in New Mexico although relict colonies exist much farther south. *Scaphiopus intermontanus* may reach its southern limits in the Zuni region, but is known too poorly in New Mexico to be of zoogeographic value. It appears, therefore, that Colorado Plateau environments have been more effective in limiting northward dispersal than in preventing movement southward.

Physiographic continuity of the southern Plateau (Datil and Navajo Sections) across the Zuni region is in sharp contrast to the north-south break between the Plateau and Basin and Range south and, to some extent, southeast of this area. This situation does not favor east-west geographic differentiation but allows gene flow between subspecies that previously might have been better isolated. The intergradation patterns, thus, of *Crotaphytus collaris* and *Crotalus viridis* might be expected to differ in degree from those of the aforementioned species. There is reason to suspect that relatively smooth character gradients are present in the east-west pattern and that sharper breaks are involved in the more common north-south pattern.

The remaining eurytopic species, *Ambystoma tigrinum*, *Rana pipiens*, *Phrynosoma douglassi*, *Thamnophis elegans*, *Diadophis punctatus*, and *Masticophis taeniatus*, are distributed throughout the Zuni, the Colorado Plateau, and bordering Basin and Range province with little apparent regional differentiation. While geographic variation occurs elsewhere, the demonstrated local barriers to dispersal are relatively unimportant in each of these species.

#### Paleoecology and Dispersal

As indicated by species adaptation and rather close restriction to modern environments, development of the Zuni herpetofauna—indeed, that of the entire Southwest—followed closely upon the formation of recent topography and semiarid vegetation in the late Cenozoic. Differentiation of the Colorado Plateau from a relatively flat plain began in the Miocene, and epeirogenic uplift has continued into the Pliocene and Pleistocene, raising the Plateau above basins to the



south and west (Hunt, 1956, pp. 73-86). The ranges of certain widespread species undoubtedly were fragmented first by these upheavals and by the climatic changes that followed.

Dry, warm, middle Pliocene climates produced grassland and subdesert environments of great extent (Axelrod, 1948). Present regional adaptations such as time of egg-laying may have originated then in response to increasing aridity. It is probable that ensuing dry conditions permitted northward dispersal of amphibians and reptiles adapted to vegetative environments of the expanding Madro-Tertiary Geoflora and that montane species associated with forests of the Arcto-Tertiary Geoflora simultaneously were limited. Axelrod (1950, 1958) and Darrow (1961) have reviewed the history of these major geofloras.

Many neontologists, including myself, believe that present plant and animal distributions were slightly to highly modified by violent climatic fluctuations during the Pleistocene. Considerable modification of the extent of plant communities characterized this epoch. Evidence presented by Antevs (1954), Clisby and Sears (1956), Leopold (1951a), Murray (1957), and Wendorf (1961) in New Mexico suggests that grassland and desert species withdrew southward at or about the time of glacial advance and that woodland forms then dispersed across former semiarid zones.

Periglacial deposits are extensive on Mt. Taylor (Hunt, 1956, p. 38), indicating that the Zuni region was not excluded from Pleistocene climatic change. Glacial deposits have been recognized along the north, east, and south sides of the Colorado Plateau; these extend down to 7000 or 8000 feet in some areas (Hunt, 1956, p. 35). Martin, Sabels, and Shutler (1961, p. 115) postulated that during a cool-moist interval the pinyon-juniper savanna was displaced downward 1700 feet in the Grand Canyon, Arizona, or, in terms of life zones, was 2000-4000 feet below its present lower limits. If Zuni life belts were uniformly lower by 4000 feet at such a time, as Antevs (1954) has estimated for lowered life zones at Santa Fe, then the present Plains Life Belt with its characteristic species did not exist.

Zuni life belts probably fluctuated in a manner similar to those diagrammed by Martin (1961, fig. 2); thus, plains species like *Scaphiopus bombifrons* and *Holbrookia maculata* were absent when cool-moist conditions favored heavy forests or open woodland at low elevations but may have been present prior to such forestation. Coincidentally, woodland-canyon species such as *Hyla arenicolor* or *Eumeces multi-virgatus* were provided new pathways for dispersal. The opposite situation existed during warm-dry intervals; hence, woodland forms have had the most limited gene flow in Hypsithermal time and presumably within the past century. While such "alternating



genetic currents" are purely speculative, they are in accord with paleoecological and neoecological evidence. It is significant that the north-south patterns of Pleistocene climatic change and local physiographic differentiation augment each other in affecting dispersal.

If cool-moist intervals limited the northward movement of widespread, grassland species, they were equally potent in restricting desert and desert-grassland forms like *Crotalus atrox*. No great changes in drainage pattern have occurred on the Colorado Plateau since the late Pliocene (Hunt, 1956, p. 85), but the Rio Grande valley of southern New Mexico did not exist as a lowland pathway for north-south dispersal prior to early mid-Pleistocene time (Ruhe, 1960). Are some species that reach their northern limits in the Zuni region, therefore, postglacial invaders? Dowling (1956) accounted for the presence of similar xerically adapted species in Arkansas by postulating recent immigration from the Great Plains during a Holocene arid interval.

What about the distribution of such vagile forms as *Ambystoma tigrinum* and *Thamnophis elegans*? It seems possible that at least some of them remained locally at lower elevations on the Colorado Plateau during the Pleistocene climatic shifts. This is suggested by Tihen's description (1942) of neotenic *A. tigrinum* in Great Plains glacial deposits and typical metamorphosed individuals in interglacial sediments. Many of the other widespread species are equally adaptable and some like *Phrynosoma douglassi*, in addition to *A. tigrinum* and *T. elegans*, are relatively abundant in both Montane and Plains Life Belts.

### Summary

Between 1951 and 1961, the systematics, ecology, and life history of 30 species of amphibians and reptiles were studied in the Zuni Mountains region, McKinley and Valencia Counties, New Mexico. This area, characterized by extremes of temperature and midsummer rainfall, contains Plains, Roughlands, and Montane Life Belts, and extensive lava flows. Elevations range from 5794 feet at Laguna on the eastern end of the study area to 11,389 feet at the top of Mount Taylor. Unfortunately, man has drastically altered natural environments. Drought pervades the recent climatic history of the region.

Of 19 common species, no two have the same vertical distribution or relative abundance. Five lizards of similar adult size have different morphological and physiological adaptations and occupy different habitats. In the Iguanidae, scansorial species such as *Urosaurus ornatus* have more lamellae than terrestrial species like *Phrynosoma douglassi*. Oviposition in *Holbrookia maculata*, *Sceloporus undulatus*, *Sceloporus graciosus*, and *U. ornatus* seems to be correlated with



the onset of summer rainfall. *Scaphiopus hammondi*, *Crotaphytus collaris*, and *U. ornatus* are darkly colored on lava. Similarly, *H. maculata* and *S. graciosus* are very light on white sand, but none of these species exhibit geographically unique coloration.

*Scaphiopus bombifrons*, *Scaphiopus intermontanus*, *Eumeces obsoletus*, *Salvadora grahamiae*, *Masticophis flagellum*, *Crotalus atrox*, and *Crotalus molossus* reach their limit of range in the Zuni region. Sub-specific intergradation occurs in *Bufo woodhousei*, *Pseudacris triseriata*, *Crotaphytus collaris*, *Sceloporus undulatus*, *Uta stansburiana*, *Urosaurus ornatus*, *Eumeces multivirgatus*, *Pituophis melanoleucus*, *Hypsiglena torquata*, and *Crotalus viridis*. In certain cases, distributional patterns may have been modified by climatic changes and the Colorado Plateau-Basin and Range physiographic break located immediately south and southeast of the Zuni region. The Plains Life Belt apparently was eliminated during cool-wet periods of the Pleistocene, and woodland environments were restricted during warm-dry intervals.

*Ambystoma tigrinum stebbinsi* and *A. t. utahense* are synonymized with *A. t. nebulosum*, *Holbrookia maculata ruthveni* with *H. m. approximans*, and *Phrynosoma douglassi ornatissimum* with *P. d. hernandesii*. *Diadophis regalis* and *D. dugesi* are considered to be subspecies of *D. punctatus*; the ranges of these forms and the western limits of *D. p. arnyi* are clarified. Detailed accounts of variation in *A. t. nebulosum*, *Cnemidophorus velox*, and southwestern and Mexican *Diadophis* are presented. Environmental and ontogenetic variation are given special emphasis, and a graphic method for illustrating the latter is offered in the discussion of *E. multivirgatus*.

### Addenda

In preparing the account of recent environmental changes, I overlooked an important paper by Leopold (1951b) containing a highly pertinent summary of some nineteenth-century observations of Zuni environments. Also instructive are two photographs (Leopold, 1951b, fig. 1) of an area near Fort Wingate showing encroachment of sagebrush on grassland between 1901 and 1946.

The revised manuscript was completed in December 1961. Since then, Smith and Williams (1962) have shown that the names *Eumeces multivirgatus gaigeae* and *Thamnophis cryopsis* are conserved by application of the nomen oblitum rule of the 1961 International Code of Zoological Nomenclature.

McCoy (1962) corrected Maslin's record (1959) of *Crotalus viridis viridis* in Montezuma County, Colorado; he identified three specimens from Mesa Verde as *C. v. nuntius*. Additional support for intergradation between the subspecies *C. v. viridis*, *C. v. nuntius*, and *C. v. concolor*



in the San Juan Basin of northern San Juan County, New Mexico, and adjacent Colorado was offered by Dean and Stock (1961).

New evidence for considering *Diadophis dugesi* as a subspecies of *D. punctatus* was presented by McCoy (1964), who recorded a female from Durango, Mexico. His specimen is intermediate between the subspecies *D. p. regalis* and *D. p. dugesi* in ventral count (212) but resembles the latter in number of subcaudals (68) and dorsal scale rows (17–17). As I have shown, number of ventral scales is the most diagnostic feature separating southwestern and Mexican races of ringneck snakes.

Dean and Stock (1961) reported *Crotaphytus collaris auriceps* in extreme northern San Juan and Rio Arriba Counties, New Mexico (San Juan Basin). If *C. c. auriceps* is indeed recognizable, then Zuni specimens seem to show a slight relationship with this form based on labial counts. It would be desirable to pursue other meristic features that might distinguish *C. c. auriceps*.

A brief report by Maslin (1962) on all-female species of *Cnemidophorus* includes *C. velox*. The possibility of parthenogenesis is suggested; and two males of *C. velox*, possibly the ones I examined and thought close to *C. inornatus*, are mentioned. Maslin also considers their allocation questionable.

Harris (1963) contributed data on the ecological distribution of reptiles and amphibians in the San Juan Basin. He recorded *Scaphiopus bombifrons* and *Cnemidophorus inornatus* in San Juan County, New Mexico, and elaborated other records contained herein and attributed to him. That the taxonomic relationships of *S. bombifrons* with *S. intermontanis* and *C. velox* with *C. inornatus* need investigation becomes increasingly apparent.

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