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THE AMPHIBIANS AND REPTILES OF THE LOS ALAMOS NATIONAL ENVIRONMENTAL RESEARCH PARK

Introduction

Naturalists knew virtually nothing about the fauna of New Mexico until the Southwest became open to American exploration after the Mexican War. Not long after the Treaty of Guadalupe Hidalgo was signed in 1848, the federal government was sponsoring expeditions to explore the terrain ceded to the United States. In 1850 a commission led by John R. Bartlett set out to survey the boundary between the United States and Mexico. The year after this survey was launched, in 1851, Capt. Lorenzo Sitgreaves began a reconnaissance that extended from El Paso to Santa Fe and across northern New Mexico to the Zuñi River before the expedition continued its journey to San Diego, California. Members of these expeditions assembled some of the first collections to reach the United States National Museum.

Members of the medical profession were among the eminent naturalists of the day, and many of them not only collected animals, but provided the reports that dealt with the collections. Dr. Samuel W. Woodhouse, an Assistant Surgeon with the U. S. Army Medical Corps, served as naturalist with the Sitgreaves Expedition. Elliott Coues, who went on to achieve fame as an ornithologist, was officially designated " Assistant Surgeon in the U.S. Army," and "Surgeon and Naturalist to the Northern Boundary Commission." Although a physician, Dr. T. H. Webb, accompanied the Mexican Boundary Commission, Lt. Col. James D. Graham, a member of the Corps of Topographical Engineers, who served as chief astronomer and head of the scientific corps under Commissioner Bartlett, was evidently the one who preserved and documented the amphibians and reptiles that reached collections in Washington, D. C. A patchnosed snake, _Salvadora grahamiae_, was named in honor of Colonel Graham before the Boundary Commission finished its work in 1853.

In the years following the Mexican war the main objective of the Corps of Topographical Engineers consisted in finding suitable routes across the Southwest. Emigrants headed for California were seeking ways to avoid rugged mountains and arid deserts. Beyond such immediate needs, however, the Corps was anxious to find a practicable route for a transcontinental railroad that would eventually connect the Mississippi River with the Pacific provinces. Several American explorers had found ways to reach California following routes far to the north of the Mexican Boundary, and such expeditions as those of John C. Fremont and Colonel John J. Abert in 1945, had materially broadened the scope of such undertakings. They continued their studies of the physiography, geology and meteorology, but their interest was no longer restricted to the physical aspects of the environment. They went to great lengths to assemble collections of the plants and animals they found. From then on expeditions were expected to maintain records of the fauna and flora observed in the areas they traversed, documented with specimens and scientific data. Any well organized expedition setting out to explore the newly acquired terrain was expected to have scientists representing a wide range of disciplines on its staff.

Expeditions of the sort were commonly authorized by Congress and financed by the federal government. The explorations and surveys carried by the Corps of Engineers during the years 1871 to 1874 typified the work of the U. S. Army once it had focused its attention on the terrain west of the 100th meridian. Such well known scientists as Edward Drinker Cope, Elliott Coues, and Henry Wetherbee Henshaw participated in the field work during the four years that Lt. George M. Wheeler was in charge. The extensive collections assembled by members of the expeditions, not only in New Mexico, but in portions of five other states, materially broadened our knowledge of the animals in this portion of the United Stats.

Vast quantities of scientific data and other information obtained by the Wheeler expeditions are summarized in several impressive volumes. The fourth volume deals with fossils, and the fifth, published in 1875, is restricted to the zoological collections. It contains reports prepared by more than a dozen experts, including naturalists who had participated in the field work. Their summaries of the various groups require more than 1000 pages of text, divided into 16 chapters. The volume is lavishly illustrated. There are 45 lithographed plates with several of the more brightly pigmented birds, reptiles and insects portrayed in color. Over 700 pages are devoted to the vertebrates, and the rest of the volume contains chapters dealing with the insects, molluscs, and the fresh-water leeches represented in the collections.

Two naturalists contributed reports dealing with the amphibians and reptiles. One prepared by Elliott Coues, better known for his ornithological investigations, deals largely with the collections he made in Arizona in 1864 and 1865, although he provides notes on specimens he had obtained in northwestern New Mexico, at Fort Wingate and along the Zuñi River. The other report was written by Henry C. Yarrow, who had participated in the field work of the Wheeler Expeditions in 1872 and 1874. Yarrow had collected amphibians and reptiles, as well as other vertebrates, while he was serving as surgeon and zoologist to the Expeditions, first in Utah and Nevada, and later Colorado and in New Mexico. His report covers collections obtained in all six of the states included in the survey. Yarrow notes in his summary that some of the specimens remained to be identified, but he believed that the collection contained representati[ves] 17 species of amphibians and 70 species of reptiles. His report, nevertheless, contains discussions under specific or subspecific names for only 16 amphibians, 32 lizards, 24 snakes and three turtles. Specimens from the state of New Mexico, as viewed by Yarrow, were referable to 31 species, or subspecies, six of which were amphibians, 14 were lizards, and 11 were snakes. The collections studied by Yarrow contained only five specimen[s] of turtles, all from Arizona and assigned to three species. No turtles had been obtained in New Mexico, where at least 10 men, most of them naturalists, had collected the specimens covered in Yarrow's report.

Well over a dozen localities are listed as the sources of the specimens, many of which came from well-known places. Few of the collectors had worked in southern New Mexico although one bullsnake had been captured by Henshaw at Fort Bayard, near Silver City. Such place names as the source of a spadefoot toad listed by Cope as "Alto dos Utas," seem to have escaped the attention of cartographers. Detailed maps may have been available for the settled areas along the Rio Grande, but a lieutenant who captured a frog and a garter snake in the northwestern corner of the state indicated only that they came from the "San Juan River." In some instances tags were lost or separated from specimens that wound up cataloged as having been taken in "New Mexico."

Fortunately collectors often stayed in or near Indian or Spanish settlements, such as San Ildefonso, Santa Fe and Abiquiu, with names that had been in use for at least two centuries before Wheeler's expeditions reached the area. Herpetological specimens from the Southwest had been accumulating in eastern museums for at least 25 years by the time Yarrow prepared his report. At this stage, nevertheless, taxonomists had only fragmentary notions of distributions of even the commonest, most readily collected species. In some respects it seems curious that Yarrow could assign most of the species he lists to the same families recognized today. Most of the generic names that Yarrow used for the amphibians and lizards are still in use, but systematists were still struggling to work out the relationships of the snakes. Well over half a century later systematists still lacked suitably large and representative samples of the snakes in North America. Extensive investigations remained to be carried out before students could define the species and group them satisfactorily in genera. A large percentage of the specific names employed by Yarrow are in use today, although some have been relegated to subspecific status. No fewer than 16 of the 24 species of snakes that Yarrow listed, however, have since been referred to other genera.

Yarrow credits two of the ablest herpetologists of his day, E. D. Cope and S. F. Baird, with having assisted him in the identification of the species and subspecies included in his report. Moreover, Yarrow adds, Cope supplied the descriptions of the species believed to be new, and he criticised and revised the entire manuscript. With the limited knowledge of the variations and distributions of the species in the Southwest then available, some specimens would inevitably be erroneously identified. In some instances species remained to be recognized and described long after they had been represented in collections. Others were so inadequately described earlier in the century that naturalists were sometimes misled in their efforts to apply names. Thus we find Yarrow listing eight specimens from Arizona and New Mexico as examples of the Texas horned lizard, <u>Phrynosoma cornutum</u>, whereas two other horned lizards obtained in "southeastern Arizona" are referred to <u>P. planiceps</u>. An excellent plate depicting the form leaves no doubt it was a Texas horned lizard, described as <u>P. cornutum</u> 27 years before the name <u>planiceps</u> was inadvertently applied to the same species.

Ontogenetic changes in proportions and more especially in the patterns of some of the lizards led to their misidentifications. There is no reason to question the identity of the 18 specimens, including five from Santa Fe, that Yarrow lists as collared lizards, <u>Crotaphytus collaris</u>. One additional specimen from Santa Fe, however, is identified as the reticulate collared lizard, <u>C. reticulatus</u>. Decades later it finally became apparent that this species is restricted to the Lower Rio Grande Valley of southern Texas and the adjacent states in Mexico. As late as 1900, however, Cope could cite only two specimens of <u>C. reticulatus</u>, both from near Laredo, Texas. He must have become aware of Yarrow's erroneous identification, which had escaped Cope's attention 25 years earlier. For Cope (1900:255) observed that "Any approach to the reticulation described [for <u>C. reticulatus</u>] is never seen in <u>collaris</u>, except in very young specimens---" It seems virtually certain that Yarrow was led astray when he compared five adult or subadult collared lizards with a juvenile, and concluded that the juvenile belonged to another species.

Some of the specimens listed by Yarrow in 1875 were assigned to other species by Cope in 1900. For example, Yarrow listed "2 Y" (presumably meaning two young or juveniles) from San Ildefonso under the name Phrynosoma cornutum. Cope (p. 436) listed them under the same name, whereas two others that Yarrow had obtained at the same place at approximately the same time were referred by Cope to another species, P. modestum. The roundtail horned lizard, P. modestum, which Yarrow failed to recognize, has recently proved to be represented as far north as Bandelier National Monument. Hence it could have occurred near San Ildefonso a century ago, and it may be gratuitous to assume that the population there was exterminated. Reeve (1952:870) evidently found one of Yarrow's specimens still extant, but two other localities plotted on his map (fig. 4) are not substantiated in his text.

It is appreciably more difficult to explain Cope's records of the Texas horned lizard, P. cornutum, in the upper Rio Grande Valley, where Yarrow and others collected. For in addition to San Ildefonso, Cope included Santa Fe, Abiquiu, and Taos in his tabulation of sources. Within recent decades, however, the species seems not to have been taken north of Albuquerque on the Rio Grande drainage. In the plains east of the Sangre de Cristo Mountains the Texas horned lizard is relatively abundant as far north as most of Kansas, and records for southeastern Colorado have been verified. Nevertheless, Cope's record of P. cornutum from "Pagosa, Archuleta County, Colorado, has been rejected for valid reasons, and Conant (1975) omits this record, as well as those for the upper Rio Grande Valley of New Mexico from his map. Reeve (1952), who plotted the four localities mentioned above, credits their source to Van Denburgh (1924). No specimens were cited by either author to substantiate the records. Cope, however, noted that he, Yarrow and another naturalist, W. G. Shed, who participated in the Wheeler expeditions, were the collectors of the Taos specimen. It is impossible to say whether it was misidentified or carelessly labelled, although it seems most improbable that P. cornutum would have been taken north of Albuquerque at four localities where it has not been taken or reported since.

Yarrow's identifications of the garter snakes that had been obtained in New Mexico were equally confused. He indicates that three species were obtained at San Ildefonso, namely the species now recognized as Thamnophis elegans, T. sirtalis, and T. marcianus. The first two are readily found in the area today, but the third species, marcianus, which ranges northward to Kansas east of the Sangre de Cristo Mountains, has not been found north of Albuquerque on the Rio Grande drainage. A third species, the blackneck garter snake, T. cyrtopsis, though mentioned by Yarrow as "not seen," is among the snakes most commonly seen around San Ildefonso today. Without additional information one might suspect that T. cyrtopsis had replaced T. marcianus in the upper Rio Grande. Ruthven (1908:62) left little doubt, however, that Yarrow had failed to recognize cyrtopsis. Two specimens in the United States National Museum, Nos. 8416-8417, from San Ildefonso, although labeled marcianus and so listed by Cope (1890:1046), are actually T. cyrtopsis.

As might be expected, most of the reptiles that Yarrow reported for San Ildefonso are the relatively abundant, widely distributed species currently inhabiting the area. In addition to the three species of garter snakes, Yarrow reported one bullsnake, Pituophis melanoleucus, and a western hognosed snake, Heterodon nasicus. In view of the occurrence of two species of rattlesnake, Crotalus atrox and C. viridis in the vicinity of San Ildefonso, it seems odd that the only rattlesnakes from New Mexico mentioned by Yarrow were taken in the northwestern portion of the state. Lizards commonly abroad and foraging during the day, were more readily found than snakes, and not surprisingly Yarrow obtained specimens of the lesser earless lizard, Holbrookia maculata, the collared lizard, Crotaphytus collaris, and two species of horned lizard, the relatively ubiquitous short-horned lizard, Phrynosoma douglassi and the roundtail horned lizard, P. modestum. As noted earlier, P. modestum may not occur in the immediate vicinity of San Ildefonso today, although it is known to inhabit an area that extends into the southern boundary of Bandelier National Monument, less than 15 km to the southwest of San Ildefonso.

It proves to be impossible to verify the occurrence at San Ildefonso of other species reported by Yarrow, who must have misidentified some of the relatively nondescript lizards now abundant and easily obtained in the area. Yarrow lists fence lizards, Sceloporus undulatus, from other areas, including one from Taos now regarded as a valid subspecies, S. u tristichus, which occupies most of central New Mexico. This race of the fence lizard is perhaps more commonly seen around San Ildefonso than other lizards, Although Yarrow failed to list it,. it is improbable that he failed to see it. Similarly, Yarrow listed no tree lizard from San Ildefonso, although the nominate subspecies, Urosaurus o. ornata, inhabits rocky areas and cliffs in the immediate vicinity. One can only guess whether Yarrow confused one or both of these species with the side-blotched lizard, Uta stansburiana, specimens of which are listed for both San Ildefonso and Tierra Amarilla, although the species is not found even as far north as Bandelier National Monument. Yarrow could scarcely have been expected to apply the correct name to the whiptail lizard he listed as "Cnemidophorus octolineatus" for whiptails continued to be erroneously identified by most herpetologists until recent decades. The lizard Yarrow obtained may have been either C. neomexicanus or C. velox.

What Yarrow had to report concerning the Gila monster, Heloderma suspectum, however, reveals how little was known about the distributions of reptiles at this stage in the herpetological exploration of the Southwest. Yarrow expected to find Gila monsters at San Ildefonso, for he states that while he was camped on the Rio Grande near the village "a large lizard, presumably of this species, visited camp, but was not secured, owing to the fact that its sudden appearance frightened the packer, who supposed it to be an alligator." The nearest place where alligators could have been found was in the humid portions of eastern Texas, and to this day the nearest authenticated records for the Gila monster in New Mexico are on the headwaters of the Gila River, from the vicinity of Red Rock in Grant County. If Yarrow knew little about the distribution of the lizard, however, he was more seriously misinformed concerning its bite, which he described as "neither painful nor dangerous."

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ANNOTATED LIST OF THE SPECIES RECORDED

Class Amphibia

Order Caudata: Salamanders

Family Ambystomatidae: Mole Salamanders

Tiger Salamander, _Ambystoma tigrinum_ Green

Field investigations in the spring and summer of 1978, a year characterized by meager precipitation during the warmer months, failed to reveal any salamanders in the Los Alamos National Environmental Research Park. The spring of 1979, however, was characterized by unusually heavy precipitation in the area, even though air temperatures were abnormally low until the last week in May. While I was inspecting the ponds in Pajarito Canyon on June 1 air temperatures in the area during the middle of the day ranged from 11.8°C to approximately 16° C. The previous days had been warmer, with enough solar radiation reaching the ponds to raise water temperatures to levels approximating 20°C.

Tiger salamanders, as well as Rocky Mountain Toads, _Bufo w. woodhousei_, had evidently deposited their eggs in the pools sometime in May, and Chorus Frogs, _Pseudacris triseriata_, were still issuing their mating calls. The larvae of tiger salamanders were readily found in pools on both sides of the stream not far below the junction of Threemile Canyon at an elevation of 2050 m. Larvae were present in channels wherever the current moved slowly enough to permit them to rest on the bottom without effort. There was a tendency for larvae in the deeper ponds to form aggregations near the margins where the water was presumably warmer. The greatest concentrations, insofar as I could determine, were in the shallow ponds, roughly 10 to 15 cm in depth. Large numbers of larvae inhabited the ponds farther down stream, roughly two km northwest of the outskirts of White Rock.

The larvae captured on June 1 included one with a head-body length of 22 mm, with limbs in rudimentary stages of development. The majority of the larvae obtained were appreciably larger, with well developed limbs and head-body lengths of at least 30 mm; overall lengths ranged from 70 to 80 mm. I was unable to obtain additional specimens of the smaller larvae, but the disparity in length between the one obtained and the minimum dimensions of the others leaves little doubt that tiger salamanders had initiated their breeding activities weeks earlier, with at least two migrations to breeding sites in Pajarito Canyon.

Only one adult salamander was discovered in the area on June 1. It had found shelter beneath a large, thick wooden disk that had been rolled into the channel near the upper end of a pool where the water was shallow. The disk was resting on coarse grass, and the salamander was at least 60 cm from the outer edge of the disk, not far from the small stream of water that flowed into the pool. The salamander seemed to be healthy although it was abnormally thin. It may well have participated in the mating activities at an earlier date, but its emaciated condition can probably be attributed to the abnormally dry terrain resulting from the subnormal precipitation [redacted] the previous summer. Adult tiger salamanders are seldom encountered on the surface except at the time of the year when they are en route to breeding sites or engaged in the brief courtship that precedes the deposition of their eggs. Little is known about their foraging activities, but ordinarily salamanders would not be expected to be abroad and active, even at night, unless the surface was wet or with showers continuing. Unlike many species of lungless salamanders (of the family Plethodontidae) that find shelter in moist situations, either in rotting logs or under rocks, boards or logs, tiger salamanders must normally avoid the loss of moisture by seeking cover in the burrows of animals, where the relative humidity commonly approaches levels of 95%, even in arid regions.

Perhaps the adult found under the wooden disk was too emaciated to find shelter in normal fashion. It had an overall length of 186 mm and head-body dimensions of 98 mm, proportions similar to those of adult salamanders in the general area.

Eleven larvae obtained in the same ponds on June 26 were roughly the same size as the larger larvae found on June 1. They varied in head-body lengths from 30 to 43 mm, with overall dimensions that ranged from 65 to 83 mm. The pond that had contained the greatest concentration of larvae on June 1 was now almost dry. Many larvae had presumably moved to the stream, remaining in the areas where the current was sluggish, and there were larger concentrations of larvae in the ponds farther down the stream. The water in the lower ponds was much deeper, and cooler (little above 16°C) than it had been in the shallower ponds more then three weeks earlier.

By the end of the first week in July many larve in the upper ponds and the adjacent stream had metamorphosed. On July 7 Mr. William Atkins, telephoned me in the evening from his home in White Rock to report that a relatively heavy rain had fallen in the area that afternoon. I asked Mr. Atkins to inspect the road by driving his car slowly up the pavement, at least as far as the upper ponds. Later in the evening Mr. Atkins reported that he had discovered transformed tiger salamanders crossing the road, along with hordes of recently metamorphosed Rocky Mountain toads, Bufo woodhousei, another species of toad, Bufo punctatus not previously encountered in the area, and a spade-foot toad, Spea multiplicata. Two recently transformed salamanders found leaving the ponds had head-body measurements of 56 and 62 mm, respectively, roughly two thirds the size of the adult individual obtained on June 1. When environmental conditions force tiger salamanders to dispense with their gills and shift to terrestrial habitats it is plainly advantageous for them to be able to complete their growth on land.

When the few upper ponds that remained were visited again on July 26, tiger salamanders were still present in moderate numbers. Some of them retained conspicuous gills, others only vestiges, but at least half of them had completely transformed. The water was so shallow, seldom more than 20 cm in depth in the deepest portions, that its exposure to solar radiation had resulted in its reaching levels of 34.0° to 37° C. At such temperatures larvae with or without gills were making frequent forays to the surface to gulp air. The dimensions of three salamanders obtained on July 26 differed little from those of the two transformed individuals Mr. Atkins had found on the road on July 7. One that retained vestiges of gills had head-body measurements of 62 mm and overall dimensions of 117 mm. The other two, which lacked gills as well as the tail fins lost at metamorphosis, had nearly identical head-body measurements of 57 mm; the tip of the tail was missing on one, but the other had a head-body length of 85 mm.

Whereas the adaptability of tiger salamanders may permit the larvae of the populations breeding in Pajarito Canyon to transform at head-body lengths of 50 to 60 mm, an abundance of summer rain may often permit them to delay their metamorphosis and continue foraging in their aquatic habitat until September or October in favorable years. I have seen transformed tiger salamanders with head-body lengths barely exceeding 50 mm that were taken on the east side of the Rio Grande, at Rio en Medio and Nambe. Limited data for other populations in the general area, however, suggests that tiger salamanders under favorable conditions transform at dimensions comparable to those of the adult found in Pajarito Canyon. On June 9, 1979, Dr. Philip L. Shultz provided me with a large larva taken the day before from the fish pond maintained near the Shultz residence in Tesuque. This large larva was maintained in a small aquarium, into which I introduced the two transformed salamanders Mr. Atkins found on the road in Pajarito Canyon on July 7. Two days later it became evident that the larva from Tesuque was losing its gills, which disappeared in three or four days. The tail fin was noticeably reduced a few days later, but the changes in pigmentation that began to reveal a pattern approximating those of adults in the area required at least l5 days. The much larger size of this larva may be attributable to its having remained in the fish pond throughout the winter. Dr. Shultz informs me that the pond was not drained, and this larva may have emerged from an egg deposited in late winter or early in the spring of 1978.

Transformation of tiger salamander larvae under natural conditions probably is most often stimulated by the shrinkage of ponds, or more directly by the depletion of the oxygen supply as the temperature rises in increasingly shallow water. It is improbable that depletion of oxygen in the aquarium induced the transformation of the Tesuque larva. Under the conditions observed in Pajarito Canyon, however, it is plain that transformations triggered by deficiencies of oxygen in breeding ponds would greatly enhance the chances of survival of tiger salamanders whenever rainfall became deficient during the summer. It may be added that when the Tesuque salamander was preserved following its metamorphosis it had an overall length of 180 mm, and a head-body length of 99 mm, thereby approximating closely the dimensions of the adult from Pajarito Canyon.

Few salamanders tolerate the extremes of environmental temperature now reported for tiger salamanders. McClure (1943) found literally thousands of salamanders (presumably of the same subspecies, *Ambystoma t. mavortium*, inhabiting the eastern half of New Mexico) participating in what seemed to be a breeding migration in western Nebraska. The migration began on March 11, and reached its peak on March 12, when the mean air temperature was 3.9°C, and continued during a snow storm the following day when the air temperature was "below or just above freezing," with a mean of 1.7°C. Aside from coming to the surface to gulp air, the salamanders observed in the shallow pools in Pajarito Canyon on July 26, showed no sign of discomfort while foraging in water that reached 37.8°C.

Tolerance of such a wide range of environmental temperatures has permitted tiger salamanders to occupy habitats from near sea-level to elevations of at least 3000 m. Dunn (1940) regarded *Ambystoma tigrinum* as an extraordinarily adaptable species, with a disjunct distribution that extends from coast to coast in the United States. The very adaptability of tiger salamanders, ontogenetic changes, and meager samples of adult specimens from many parts of their range, have made it difficult to diagnose and define subspecies. Several have been recognized although insufficient data have been available to plot their distributions with much precision west of the Great Plains.

[illegible]bach (1965) has discussed some of the problems arising from the variations encountered in dealing with tiger salamander populations in northwestern New Mexico. Neoteny, or the retention of larval characters for prolonged periods, as well as paedogenesis, or breeding while retaining larval peculiarities, have further complicated efforts to define the subspecies in that part of the state. The situation may not be quite so complex in the populations inhabiting the area around the head waters of the Río Grande. It is evident, nevertheless, that recent handbooks have greatly oversimplified the distributional picture in this portion of the state.

All populations of Ambystoma tigrinum in the eastern half of New Mexico are commonly assigned to the subspecies mavortium, known as the "Barred Tiger Salamander." This name seems appropriate enough for the salamanders inhabiting the lowlands east of the Río Grande, at least from Río en Medio, Nambe, Tesuque, and Santa Fe. The tiger salamanders obtained in the Jemez Mountains, however, would more aptly be described as being spotted. Tiger salamanders taken at higher elevations in the Brazos Mountains, which are separated from the Jemez Mountains to the south by the lowlands along the Rio Chama, are even more distinctive. On succesive years samples of the tiger salamanders breeding in a pond eight kilometers south of Hopewell Lake in Río Arriba County proved to be uniformly slate gray on the dorsum, paler on the underside, but devoid of any markings remotely resembling the bars or spots of populations in the Jemez Mountains. The breeding pond in the Brazos Mountains is at an elevation somewhat above 2,800 m. Conceivably populations in the lowlands or foothills with characters that might be construed as intermediate may be discovered. Equally possible, however, the alpine populations may prove to be genetically isolated from those south of the Río Chama, and warrant recognition as a distinct species. Reliable conclusions can scarcely be reached, however, until detailed studies have been made of the breeding habits, behavior, and ontogenetic changes in representative populations both north and south of the Rio Chama. Pending such studies nothing is to be gained by applying subspecific names to tiger salamanders on the Rio Grande drainage.

Family Plethodontidae: Lungless Salamanders

Jemez Mountains Salamander, Plethodon neomexicanus Stebbins and Riemer

Two of the three species of salamanders known from New Mexico are lungless inhabitants of montane forests. One of the two species is known only from a few isolated populations in the Sacramento Mountains. The other is not only endemic to the Jemez Mountains, but restricted to a relatively small area centering around the Jemez Caldera. Other amphibians and reptiles inhabiting these mountains are widely distributed elsewhere, but the distribution of the Jemez Mountains Salamander is so restricted that the New Mexico Department of Game and Fish has valid reasons for regarding this amphibian as a 'threatened species.'

Reagan (1972), who studied the ecology of P. neomexicanus, managed to find the species in only seven of 41 sites where he had hoped to find it. He obtained specimens no farther west than the Seven Springs Fish Hatchery near the edge of the Caldera. Williams (1978), whose extensive studies of reproduction in this salamander revealed that females remain gravid for two years prior to oviposition, reports that the species is now known from 25 sites, 18 in Sandoval County and five in Los Alamos County. I have seen specimens obtained in Medio Dia Canyon at an elevation of approximately 2400 m on the southern flank of the Caldera, but little effort seems to have been made to ascertain how far north the range of the species extends. Much of the area is not readily accessible, but it seems probable that the distribution may prove to extend northward into Río Arriba County. It would not be surprising if a disjunct population proved to be represented on Tschicoma ('Chicoma' on Forest Service maps) Mountain, where habitats closely resembling those in the Sierra de los Valles are readily found. Williams indicates that the records in Sandoval and Los Alamos counties range from 2194 to 2743 m.

I managed to find the Jemez Mountains Salamander at only two sites, both of them in Los Alamos Canyon. On 28 June 1976 I found two specimens no more than 30 m above the Los Alamos Reservoir at elevations only slightly above 2300 m. One was discovered inside a wet, well decomposed log within five minutes after I began the search. The second one was not encountered until somewhat more than an hour later. Both salamanders were in logs resting on moist terrain, one within three meters of the stream and the other on a hillside roughly 25 m from the stream, [illegible]. The canyon above the reservoir is steep-sided, and densely covered mainly with quaking aspen, Douglas Fir and Engelmann spruce, as well as shrubs and forbs. The air temperature at mid-day in the canyon hovered around 18°C but the moist, rotting wood in the log where the second salamander was found had reached a level little above 12.°C.

Two days later, on 26 June, I attempted to find the species on the same drainage, but on slopes at elevations 2700 to 2850 m above sea-level, over 400 m. higher than the Los Alamos Reservoir. The area selected was on the northeastern flank of Pajarito Mountain, near the divide along the Sierra de los Valles that separates the Caldera drainage from the head waters of Los Alamos Canyon. I spent more than an hour in a well forested area, overturning logs and occasionally rocks. Many of the logs seemed to be sufficiently wet and decomposed to provide shelter for lungless salamanders, but none could be found. Two weeks later, on 10 July, after rain had fallen the previous day, I returned to the same area with Edward Collins, Keith Diezentanner, and Leon Fisher, all of whom are employees of the United States Forest Service. Mr. Collins found a salamander shortly after we began overturning logs at an elevation of approximately 2700 m, when the air temperature had reached 22.8°C at 9:50 a.m. At least seven salamanders were encountered within the next half hour as we worked our way up a relatively steep slope to a level approaching 2 850 m. We might well have found more specimens had we not [illegible] the temperature of the rotting wood adjacent to each salamander as soon as it was uncovered. Seven temperatures recorded all fell between 1[illegible] and 13°C, closely approximating the range of 11-13° C Reagan (supra cit.) reported for a much larger series.

When I returned to the area on 26 July, I had the assistance of Russell Holbrook, but a prolonged search failed to reveal any salamanders. The immediate area received little moisture during the ensuing weeks when precipitation was below normal. Nevertheless I had relatively little difficulty in finding moist logs on the slope when I again returned on 24 August, even though no salamanders could be found. It seems probable that their surface activity is largely restricted to nights during or following the receipt of enough rain to saturate the surface. Neither Reagan nor Williams mentions having seen P. neomexicanus on the surface at night. Reagan's examination of the stomach contents of 39 salamanders, however, revealed a diet consisting of an assortment of invertebrates, including some that would have been expected from nocturnal foraging, whereas others would probably have been found and consumed while the salamander was underground.

Our failure to find salamanders on three of the four occasions when we tried to find them on the slopes of Pajarito Mountain points to the probability that these amphibians are induced to approach the surface only when it is saturated. The unusually slender habitus of P. neomexicanus presumably facilitates movement in crevices, not only in piles of fragmented rock below the surface, but in rotting logs as well. The body diameter of the six salamanders obtained on 10 July varied from 10 to 12 percent of the length from snout to vent, which ranged from 62 to 67 mm. If a slender body is advantageous to salamanders that habitually forage in subterrestrial crevices, it could be disadvantageous in dry climates. The increase in the ratio of the surface to mass accompanying the elongation of the trunk implies that more skin is exposed to evaporation. Inasmuch as the skin is the principal organ of respiration in lungless salamanders, their very survival depends upon the maintenance of a moist integument. Unless the atmosphere on the soil surface is saturated, therefore, the Jemez Mountains Salamander can most readily avoid desiccation by retreating to habitats beneath the surface where any air encountered is likely to be saturated with moisture.

The very specializations that enhance the movements of P. neomexicanus in subsurface habitats, therefore, impose limits on surface activity. These limitations are reflected in other specializations. The eggs have not been found in the salamander's natural environment, but Reagan offers the valid suggestion that they are probably deposited in cavities in the talus beneath the litter on the forest floor. Williams notes that seasonal activity is largely restricted to June, July and August. The adaptive specializations of the female that permit her to deposit eggs every other year presumably compensate for the restrictions imposed by seasonal changes in the temperature in fir-spruce habitats at elevations that range from 2200 to well over 2800 m.

Various authors have realized that salamanders from the Jemez Mountains tentatively identified as "Eurycea multiplicata" were mentioned at least fifty years ago (Reagan, 1972) even though Plethodon neomexicanus was not described until 1950 by Stebbins and Riemer. An earlier reference to the species, as well as to other amphibians and reptiles, has been generally overlooked. Under the heading "Spelerpes multiplicata Cope (?)" Henderson and Harrington (1914) report: "We found a small salamander rather common under aspen logs near Valle Grande, in the Jemez Mountains. Specimens badly injured in transit were doubtfully identified as this species by Dr. Leonhard Stejneger. The Indians to whom it was shown were not familiar with it and had no name for it."

Order Anura: Tailless Amphibians, Frogs and Toads

Family Pelobatidae: Spadefoot Toads

New Mexico Spadefoot, Spea multiplicata Cope

Adult spadefoots are likely to be seen or heard in northern New Mexico only when they form breeding aggregations in pools formed by drenching summer rains. The minimum amount of rain required to induce spadefoots to venture to the surface long enough to mate and deposit their eggs must approximate 20 mm. Until data have accumulated over a period of at least a decade, however, no precise figure can be given. I found no evidence of any breeding on the Pajarito Plateau by spadefoots during the summer of 1978. Their breeding is as sporadic and uncertain as the rainfall in many arid and semi-arid portions of the West.

Spadefoots are usually encountered in open, more or less sandy terrain, often in flood plains. In the Peloncillo Mountains in the extreme southwestern corner of New Mexico, spadefoots shun the canyons and breed where water accumulates below the alluvial fans. Even though these toads can be heard calling occasionally around Santa Fe at elevations of 2200 m and sometimes breed in the stock tanks on La Bajada Mesa west of the city, it was uncertain whether the genus Spea would prove to be represented in the foothills of the Jemez Mountains.

All doubt was removed on the evening of July 7, 1979, however, when Mr. William Atkins found a specimen of S. multiplicata near the pools in Pajarito Canyon at an elevation of 2040 m, not far below the junction of Threemile Canyon. The spadefoot was crossing the paved road in the evening after a relatively brief but heavy rain had fallen at dusk. The ponds at the site of capture had formed weeks earlier, and they were surrounded by a dense growth of grass and weeds, unlike the open ponds where spadefoots ordinarily breed. The spadefoot taken on the road was a female that had already ovulated when I examined it the following day, for the eggs were visible through the thin translucent skin of the abdomen. When I investigated the pools on 8 July in the area adjacent to the site where the female had been captured, I was unable to find eggs in any of the pools. Unlike breeding sites in many areas frequented by breeding spadefoots, the water was clear, although plants were present in shallow areas. Tadpoles of the Rocky Mountain Toad, Bufo woodhousei had been thriving in these ponds for several weeks, but no tadpoles of spadefoots were ever detected even though I examined these ponds at [redacted] intervals until the end of September. Plainly the female found near the pools on July 7 was prepared for amplexus and deposition of her eggs. It seems highly unlikely that other spadefoots were not aroused by the same downpour that brought at least one female to the surface. Perhaps the amount of rain that fell in Pajarito Canyon barely reached the threshold of the minimum required to stimulate breeding activity in this population of Spea multiplicata. The precipitation was appreciably below normal during June and July in 1979, when over 10 cm would ordinarily approximate the mean for the two-month period.

The presence of spadefoots on the Pajarito Plateau can no longer be questioned. Much more remains to be learned about this population, however, although any effort to study these amphibians must await the advent of unusually heavy rains. Populations may well prove to inhabit most of the canyons. Such areas as the portion of Mortandad Canyon where State Highway 4 traverses it would seem to provide the relatively flat, open areas normally preferred by spadefoots. Conceivably they will also prove to be inhabitants of such flat areas as North Mesa, at least in areas where temporary pools form after thundershowers, and the soil is deep enough to allow spadefoots to burrow to the requisite depths. It would be of much interest if anyone could ascertain how far below the surface spadefoots actually descend. The adaptability of Spea multiplicata is reflected in its broad distribution, from Arizona, Colorado and the Panhandle of Oklahoma southward through western Texas and Mexican Plateau to the Valley of Oaxaca in southern Mexico. Its distinctive mating call in populations inhabiting the Mexican state of Jalisco is indistinguishable from calls heard in New Mexico. The call of S. multiplicata in Oaxaca is similar although spectrographic analysis reveals minor differences.

The spadefoot toads of California are superficially similar to the spadefoots east of the Colorado River, including populations in New Mexico, and until recently they were all referred to *Scaphiopus hammondi*. The situation in New Mexico Arizona, and elsewhere was confused owing to the hybridization between the spadefoots then called *S. hammondi* and the Plains Spadefoot, *S. bombifrons* where they occurred sympatrically. The situation was clarified by Brown (1976), however, after he had investigated the morphology, reproduction, breeding behavior (including mating call structure), and the genetic compatibility of populations on opposite sides of the Colorado River.

Brown found marked differences in the breeding habits, mating calls, thermal adaptations, as well as morphological differences when he compared allopatric populations. With considerable justification, therefore, Brown found it desirable to recognize populations in California and Baja California as belonging to the species that Baird had described from Californian specimens in 1859 as *Scaphiopus hammondi*. The populations from Arizona and New Mexico eastward into Texas and western Oklahoma, with a distribution extending southeastward as far as the east end of the Valley of Oaxaca in Mexico, were assigned to *S. multiplicatus*; this name had been applied by Cope in 1863 to specimens from "Valley of Mexico," later restricted to Coyoacan, in the Distrito Federal of Mexico. Although populations have inevitably diverged in external morphological characters, including coloration and markings, the mating calls of specimens at the southern extremity of the range are readily identifiable by anyone who has listened to choruses of the species in New Mexico. The specimens obtained in Pajarito Canyon had a reddish spot on each side of the anus. Similar, virtually identical markings were noted on specimens from Chapala, in the Mexican state of Jalisco, where these amphibians varied extensively in color, with extraordinarily dark individuals occurring in areas once probably covered with black volcanic ash. It remains to be ascertained whether this distinctive marking occurs consistently throughout the range of the species.

Family Bufonidae: Toads

Woodhouse's Toad, Bufo woodhousei Girard

No toads were seen in 1978 until 17 September, on the morning after a few millimeters of rain had fallen the previous night. An adult Woodhouse's Toad was found under a log at 9:45 (daylight-saving time) approximately two kilometers above the junction of the north fork of the Cañada del Buey. The soil under the log was dry, but evidently the toad had absorbed considerable moisture from wet surfaces for the contents of its bladder were expelled in repeated jets.

Woodhouse's Toad was breeding in Pajarito Canyon at least as early as the middle of May in 1979, for tadpoles of the species were abundant in the pools below the junction of Threemile Canyon on June 1. These pools were at an elevation of 2040 m., but pools from two to three kilometers farther downstream also contained tadpoles. During the ensuing weeks tadpoles diminished in abundance, presumably from predation by Wandering Gartersnakes, Thamnophis elegans and other animals, although tadpoles were leaving the water as they metamorphosed. After a moderately heavy rain on the afternoon of 7 July numerous immature toads were leaving the ponds, and presumably fanning out in all directions in search of feeding sites. Those most readily detected were on the paved road to the north of the ponds, moving toward the edge of the Mesita del Buey. Adult toads were inexplicably difficult to find although one large female was dead on the bank of the pool first examined on June 1. Two other adults were seen, one at the edge of the water in the uppermost pool, and another on the bank of a stream in a deep channel near the lowest pools.

Even though I failed to find the eggs of B. woodhousei, the breeding initiated in May must have continued for well over a month. Tadpoles were still to be found in the pools that persisted on the north side of the road at least as late as 14 August. Transformed toads were leaving the pools through most of July and August.

Virtually nothing seems to have been recorded concerning the distances travelled by immature toads dispersing from breeding sites. In mid-morning on 30 August an immature toad found on the north slope of the Mesita del Buey perhaps a kilometer northwest of Tshirege Ruins had almost certainly come from one of the breeding ponds in Pajarito Canyon. This small toad was active, presumably foraging, on the north side of a perpendicular outcrop, where the ground was moss-covered and moist from seepage. The toad taken in 1978 was found at least five kilometers to the northwest, in the bottom of the Cañada del Buey. I investigated this canyon from its mouth to the upper reaches of both of its branches without ever discovering any place where pools providing suitable breeding sites for toads might have formed. Their occurrence in the Cañada can most readily be explained, therefore, if it be assumed that each of these two toads had clambered up the talus on the south side of the Mesita del Buey, which they crossed before they descended into the Cañada. The one in the bottom of the canyon might have travelled three or four kilometers over rough terrain to reach the site where I found it.

A somewhat smaller, more recently transformed toad was found on 30 August in Mortandad Canyon in the humid, densely shaded area where it narrows to a few meters in width at an elevation of nearly 2050 m. No breeding sites could be found at the time, but suitable pools perhaps existed in the immediate area earlier in the month. Woodhouse's toads must be widely distributed below the 2000 m. contour throughout the upper Río Grande area, for they appear in truck gardens, green houses, or around lawns, almost wherever water becomes available on the surface. They are likely to be seen in large numbers when recently transformed young are leaving breeding sites after heavy rains, although the adults are occasionally plentiful under such conditions. Miss Chris Judson, who is familiar with Woodhouse's toad in Bandelier National Monument, informs me that when she visited the stream in Pueblo Canyon the evening after a heavy rain many adult toads of the species were abroad in the area. Woodhouse's toad is widely distributed from Massachusetts to parts of Washington, Oregon, and southeastern California. Subspecies are recognized, but the mating call varies from one local population to the next, and few morphological characters are consistent.

Red-spotted Toad, *Bufo punctatus* Baird and Girard

Of the 18 species of the genus *Bufo* in the United States, only the Red-spotted toad is adaptively specialized for arid environments. It is primarily an inhabitant of deserts, desert grassland, and the foothills of mountains bordering the deserts. It is less often seen in floodplains of washes than in rocky canyons. The flattened head and body of the species can be construed as adaptations that facilitate its seeking shelter in crevices. This toad ordinarily breeds in pools of intermittent streams, in reservoirs and cattle tanks. The only specimen obtained was a female in breeding condition that was found on the road near the ponds in Pajarito Canyon at an elevation of ca. 2000 m. It was abroad in the evening after rain had fallen late in the afternoon of 7 July. Despite the presence of this one female in the vicinity of the ponds, no evidence could be obtained that *B. punctatus* had succeeded in breeding, either in 1979 or during the previous year. Numerous transforming toads were in and around the pools, but all of them were readily identifiable as *B. woodhousei*.

Despite the scarcity of Red-spotted Toads on the surface on years with subnormal summer precipitation, it seems probable that the species will eventually prove to inhabit many canyons in the Pajarito Plateau that drain into the Rio Grande. This river has undoubtedly been the main avenue of dispersal, although Red-spotted Toads may not occur much farther north than Espanola in this drainage. Such toads cannot be expected much above the 2000 m level, and they shun heavily forested ares as well as humid climates. On the whole they are restricted to semiarid portions of Utah, Colorado, and Oklahoma at the northern edge of their range. Farther south the range extends from the deserts of California eastward to Texas, mainly west of the 100th Meridian, and thence southward in the arid and seasonally dry portions of Mexico as far as the state of Hidalgo.

The individual obtained in Pajarito Canyon is relatively large for the species, with a head-body length of 58 mm. Larger specimens have been recorded, and some populations, notably the one inhabiting Zion Canyon and adjacent parts of southwestern Utah, are conspicuously different in their morphology as well as in their mating calls.

Family Hylidae: Treefrogs and close relatives.

Canyon Treefrog, Hyla arenicolor Cope

Contrary to the implications of the vernacular name, this 'treefrog' is rarely seen in trees. In most parts of its range it is mainly an inhabitant of of boulder-strewn canyons, particularly those with permanent streams. Ordinarily it can be found resting on the cliffs or boulders bordering streams, where their color and markings permit them to blend into their surroundings. H. arenicolor has been reported from canyons in Bandelier National Monument at elevations ranging from 1700 to 2000 m, and a series in the collection of the University of New Mexico was obtained near the mouth of Ancho Canyon within the boundaries of LANERP at an elevation of ca. 1650 m. One found in this area on [illegible] September, 1979 was resting on a boulder in the Rio Grande not far from the edge of the stream. I had expected to find this frog near the 2000 m level in Sandia Canyon, where the stream, which continued to flow throughout the summers of 1978 and 1979, is bordered by bedrock or boulders. No frogs were ever found in Sandia, but they were finally discovered in other canyons, where they seemed to shun boulders.

One taken on the morning of 16 June was in the stream that emerges from the walled portion of Pueblo Canyon. Mr. William Atkins and I were searching for toads in the tall grass that grew in the shallow water bordering the stream, when an adult female Canyon Treefrog landed in open area at the edge of a pool. Mr. Atkins had a glimpse of the frog just before it jumped, and it apparently had been clinging to grass nearly a meter above the water. Ten days later I found an adult female in Pajarito Canyon at an elevation of 2000 m and it too was some distance away from any rocks or boulders. It was in short, relatively sparse grass near the edge of a shallow pool. A few minutes later, shortly after 9:00 a.m. (Mountain daylight saving time) I discovered a pair of H. arenicolor in amplexis. They were resting on a sandy bottom in water from 10 to 15 cm in depth, at a temperature of 14.5°C. Upon my return to my laboratory that evening I placed this mated pair in a small aquarium, with enough water in the bottom to permit them to submerge. When I looked the following morning on 27 June, the female had deposited her eggs. The species had evidently bred at an earlier date in the same ponds in Pajarito Canyon, for an incompletely transformed individual only 18 mm in head-body length, and with conspicuous vestiges of a tail, was found only a few meters away from the pair in amplexis.

The male of the mated pair measured 47 mm from snout to vent, and the female 53. The other female from Pajarito Canyon obtained on 26 June measured 51 mm, only a millimeter more than the adult female found near the mouth of Pueblo Canyon. More treefrogs might have been found if the area had received appreciably larger amounts of precipitation in July or August. Gehlbach (1965), who studied populations of this hylid in northwestern New Mexico, suggests that it may have two or more breeding seasons in that area. Heavy July rains initiated the issuance of mating calls in pools where no _H. arenicolor_ had been observed previously. Gehlbach observes that these treefrogs often breed in potholes shared with the larvae of toads, _Bufo woodhousei_ and leopard frogs, _Rana pipiens_. Thus far the presence of leopard frogs in LA/NERP has remained unsubstantiated, but the treefrogs were associated with _Bufo woodhousei_ in their breeding activities.

The Canyon Treefrog occupies an extensive range, from Colorado and Utah southward on both sides of the Continental Divide to the semiarid northern part of the Mexican state of Oaxaca. Owing to its dependence on riparian habitats in most parts of its range, its distribution can scarcely be continuous. These treefrogs are occasionally discovered far enough from streams to suggest that they may forage some distance away from breeding sites. In August, 1942 I was suprised to discover a canyon treefrog only a few meters from the summit of Mount Wrightson in the Santa Rita Mountains of southern Arizona. In this part of its range, therefore, it is evident that it reaches elevations above 2800 m. It is questionably whether it reaches levels much above 2000 m on the Pajarito Plateau.

Striped Chorus Frog, Pseudacris triseriata Wied

Few other frogs in the United States are quite so widely heard and yet so seldom seen as the chorus frogs. Under exceptional circumstances, particularly during the early spring when they are occasionally found breeding in the runoff from snowbanks, they call from open terrain. Later on, by day as well as by night, males are more often heard issuing their mating calls from clumps of grass or other vegetation growing in or near shallow water. Under such conditions they can be difficult if not virtually impossible to find.

I was not certain that I would find the Striped Chorus Frog on the Pajarito Plateau until I heard them calling from a shallow pond not far below the 2000 m contour in Pajarito Canyon on the morning of 1 June 1979. The site was typical for the species, for the frogs were well concealed in the clumps of vegetation. Males in uttering their calls were scattered around the middle of a pond roughly 20 m. in width, in which the water had reached 20°C. It was a relatively small chorus, with perhaps no more than 25 males participating. They called sporadically when one, prompted by some obscure stimulus, would soon be joined by others in the vicinity. The mating call of this species is not so penetrating as that of other members of the family Hylidae, and I would doubt that this small chorus would have been audible to human ears farther than 30 m from the pond. In the absence of concrete evidence that breeding was still in progress, the calls I heard on 1 June, however similar they seemed to be to the mating call of the species, may have played a significant role in the maintenance of territories. Other frogs are known to maintain their spatial configuration within breeding aggregations, with individuals in a chorus spaced at astonishingly uniform distances (Bogert, 1960). Frogs are almost invariably scattered, rather than concentrated in any one part of a breeding pond. Otherwise collectors, as well as predators, would have fewer difficulties in obtaining large samples. My efforts to find even one chorus frog in this breeding aggregation proved to be fruitless.

When I first visited the ponds in Pajarito Canyon in 1979 it was on the afternoon of 29 April, after I had spent the morning in Pueblo Canyon, where the air temperature had reached levels little above 14°C. Shortly after noon when I reached Pajarito Canyon, clouds began to gather as a storm moved in from the east, and the air dropped to 13°C before I left in the middle of the afternoon. If chorus frogs were calling in the ponds at this time I failed to notice them. Perhaps some mating had already taken place, or breeding in this population could have been initiated in May. Otherwise it would be difficult to account for my having found three recently transformed chorus frogs on 26 June. These were found in pools two or three kilometers below the pond where Pseudacris was calling on 1 June. These three frogs, with head-body measurements of 17, 18, and 22 mm, respectively fall within the range reported for adults of the species, from 19 to 38 mm. Recently transformed chorus frogs were not detected in the pond where they were calling on June 1 until 26 July, when I found one with head-body measurements of 19 mm that was feeding in shallow water. While I watched this frog it was just below the surface in water at a temperature of 38°C, and it lunged forward repeatedly, biting at something I was unable to see.

The distribution of the Striped Chorus Frog in New Mexico, largely because of the difficulties entailed in capturing specimens to document breeding choruses readily heard in mountainous areas. In my experience these frogs are most often encountered in swamps and shallow ponds at elevations ranging from slightly below 2000 m to approximately 3000 m. Large series of chorus frogs are seldom obtained and the decision to recognize two subspecies, the nominate subspecies in the White, Sangre de Cristo and Jemez mountains, and P. triseriata maculata only along the northern border of the state should be regarded as tentative until larger samples from all parts of the range in New Mexico become available. Gehlbach (1965), who examined a few small samples from northwestern New Mexico concluded that these were intermediate and he regarded them as intergrades. Chorus frogs inhabit swamps on both sides of the Rio Grande but the Pajarito Canyon population is close to the southeastern extremity of the range that extends into the state

Tree Lizard, Urosaurus ornatus Baird and Girard.

Degenhardt (1975) considers U. ornatus to be one of the three most widely distributed and abundant lizards in Bandelier National Monument, where it reaches elevations of 2100 m. In LA/NERP, however, the species is not abundant, and it seems to be restricted to canyons or rocky terrain with sparse vegetation. In Ancho Canyon specimens were obtained near the Rio Grande at 1640 m. elevation, and one was noosed as it basked on a rock near the dry stream bed over two km from the river, slightly above the elevation of 1800 m. Tree lizards were seen but not captured at Tsankawi Ruins, where they inhabited the rocks below the cliffs in the pinon-juniper woodland at 1950 m. Explorations above this level in nearly every canyon from Guaje southward to Ancho failed to reveal any Tree Lizards.

Despite the vernacular name, 'Tree Lizard,' which aptly describes U. ornatus in some parts of its range, the species is nearly always on rocks or cliffs where it occurs in the Jemez Mountains. The pattern and coloration of the species vary extensively from population to population over a moderately wide range that extends from areas bordering the Colorado River in California and Nevada eastward to central Texas, and from southwestern Wyoming southward well into northern Mexico. As many as nine subspecies have been recognized, but few of them are adequately defined. Gehlbach (1965) has shown that the variations in at least one character employed in diagnoses are clinal. The number of enlarged dorsal scales in U. ornatus varies from as many as 57 in San Juan County, Utah to as few as 30 in lizards found in Pima and Santa Cruz counties, Arizona. The number of enlarged dorsal scales on specimens from McKinley and Valencia counties in New Mexico ranged from 35 to 53, however, and the sample examined by Gehlbach is not readily assignable to any of the nominal subspecies. Gehlbach suggests that the availability of boulders or broken, exposed rock determines the local distribution of U. ornatus in McKinley and Valencia counties. He notes that this lizard inhabits "montane canyon-head situations," whereas it is absent from ridgetops, where rocks or rock outcrops are not prevalent. Trees are available in both areas. The situation is comparable to that in LA/NERP, where U. ornatus was never observed on any of the mesas between the canyons of the Pajarito Plateau, even where these mesas terminate on the cliffs above the Rio Grande in White Rock Canyon.

In some areas where Tree Lizards are observed they manifest a definite preference for rocks when trees are available. At the Humbug Gold Mine in Yavapai County, Arizona these lizards were obtained on rocks about ten times as often as they were found in trees. At Pine Lawn in Catron County, New Mexico, however, where 20 individuals were recorded, roughly half of them were on logs. At the Boyce Thompson Arboretum, near Superior, in Pinal County, Arizona only one of 21 U. ornatus was in a tree, and the others were on walls, cliffs, and the side of a concrete bridge, but only two were on rocks. Local conditions may well dictate the choice of habitat, however, for the only place I ever managed to find U. ornatus near Boulder City, Clark County, Nevada, was on the nearly vertical cliffs of El Dorado Canyon, where the waters of Lake Mead were rising behind Hoover Dam in 1938. As Gehlbach observes, there is no sound reason to characterize Urosaurus as "plant-dwelling" and the vernacular name now in use is inapt if not misleading.

Like most other species of the family Iguanidae, U. ornatus while abroad and foraging normally maintains the body temperature at levels that seldom drop below 30°C or rise above 40.0°C. The temperature of only one was obtained in LA/NERP. It was a male, taken shortly after 8:00 a.m. on May 26, 1978, while it was basking on a rock in Ancho Canyon had a cloacal temperature of 34.8°C, when the ambient air was at 18.3°C. The body (cloacal) temperature falls well within the range of 29.6° to 40.0°C recorded for 86 lizards of the species drawn from 20 populations in

Yavapai, Pinal, Pima and Cochise counties in Arizona, and from populations in Socorro and Catron counties in New Mexico. The mean for body temperatures in this composite sample is 36.2° C. It is of interest to note that virtually identical means and extremes have been reported by Brattstrom (1955) for two species of _Urosaurus_, _U. auriculatus_ and _U. clarionensis_ endemic to small volcanic islands off the Pacific Coast of Mexico. Although Brattstrom refers to the means for the body temperatures of the two species as "optimum" it became apparent some years ago that the mean for body temperatures within the range physiologically compatible with activity cannot safely be regarded as the optimum for sleep. Some lizards become paralyzed when maintained for prolonged periods (in some species little more than a week) at the thermal levels Brattstrom designated as being "optimum."

The population of _U. ornatus_ in LA/NERP is on the periphery of the range at this latitude. The species undoubtedly occurs in the rocky cliffs along the east bank of the Rio Grande, although I am unaware of published records or of specimens to substantiate its occurrence east of the river. It might be expected in such steep-sided canyons as the Caja del Rio scarcely three kilometers east of the Rio Grande in Santa Fe County southeast of Buckman, but the only lizards I have observed on rocks or cliffs in this area have invariably proved to be _Sceloporus undulatus_. _Urosaurus ornatus_ occurs west of the Rio Grande at Puye Cliff Dwellings at elevations somewhat above 2100 m, roughly the same elevation the species reaches in Bandelier National Monument.

Reptiles, Class Reptilia

Lizards, and snakes, Order Squamata

Lizards, Suborder Sauria

Iguanas and close relatives, Family Iguanidae

Fence Lizard, Sceloporus undulatus.

Few lizards in New Mexico are more adaptable than Sceloporus undulatus. The species is among the most wide distributed of the lizards in the United States, and in LA/NERP Fence Lizards occupy a wide range of habitats. Throughout the Research Park no other reptile is so commonly seen, from the first warm days of April and on clear or partly cloudy days through the summer until diurnal temperatures begin to drop around the end of September, or at times in early October, or even November.

Fence lizards range from little above 1640 m at the Rio Grande to the open hillsides and mesas with open stands of ponderosa pine near 2500 m. They are not ubiquitous, however, for their maintenance of body temperatures within the range of 32 to 38°C dictates the need for access to direct sunshine if they are to remain active. Fence lizards are seldom active at temperatures much below 32°C and they can tolerate thermal levels a few degrees above 38°C only for relatively brief periods. They absorb solar heat so efficiently, however, that on cool, clear mornings it was not unusual to find Fence Lizards foraging with the body temperature slightly more than 20°C above that of the ambient air.

The maintenance of body temperatures within a relatively narrow range/ physiologically compatible with normal activity, however, imposes restrictions on the lizard's choice of habitat. Fence lizards avoid shaded terrain and narrow canyons with dense vegetation. They are not seen in fir, spruce or aspen forests, where basking would be difficult, although they are sometimes present in clearings.

Occasionally Fence Lizards bask on the ground, but more often they find elevated sites, on rocks, logs, stumps, posts, tree trunks, or sometimes on fences. They also thrive around such man-made structures as stables, sheds, barns, wood piles, and rubbish heaps, all of which tend to attract the insects that comprise the major part of the their normal diet. They also prey to some extent on spiders and other small arthropods, but whatever their prey, these lizards depend largely, or perhaps exclusively, on their vision while foraging. Our observations would suggest that from suitably elevated basking sites these lizards can scan most of the terrain within a radius of two meters. The distance at which they detect the presence of their prospective prey would depend in part on its size, or other peculiarities, but ordinarily only moving arthropods attract the reptile's attention. Dead or immobilized creatures of suitable size may go unnoticed.

When inclement weather precluded the emergence of Fence Lizards they were readily found in suitable habitats by overturning logs or rocks, or such rubbish as old mattresses or plaster board left cluttering up the terrain by thoughtless workmen or residents of nearby areas. Wherever ponderosa pine has been cut by loggers decades earlier decaying logs left behind provide shelter, in crevices as well as under the bark. Lizards inactivated by body temperatures as low as 12° C were sometimes found in logs while other lizards of the same species were abroad with body temperatures well above the threshold of the normal activity range.

The Fence Lizards in the Jemez Mountains are members of a widely distributed species that occupies much of the United States from southwestern Utah eastward to parts of Pennsylvania, New York and the Pine Barrens of southern New Jersey. With the wide range of habitats available to Fence Lizards in New Mexico at least four subspecies have distributions that extend into the state, and a fifth is restricted to the White Sands area west of Alamogordo. The subspecies in the Jemez Mountains is Sceloporus undulatus tristichus, known also by the vernacular name of Southern Plateau Lizard.

Collared Lizard, *Crotaphytus collaris* (Say).

Throughout their extensive range Collared Lizards are most often seen on rocks, whether they consist of isolated chunks of stone, outcrops, rounded boulders, or such man-made structures as rock piles or cairns. Invariably they are in areas of sparse vegetation and away from trees. Collared lizards ordinarily select a rock or boulder that will afford them ready access to all available sunlight as well as an unobstructed view of the surrounding terrain. The place where they habitually station themselves must serve not only as a basking site, but as a lookout. It may be as little as 20 cm or well over a meter above the ground, but usually it is the most elevated site in the immediate area.

Basking Collared Lizards are constantly on the *qui vive*, not only to avoid such predators as hawks and roadrunners, but to detect the presence of the insects and other arthropods these lizards ordinarily consume. Casual observations suggest that Collared Lizards become aware of the movements of grasshoppers, cidadas, and prey of comparable size at distances exceeding three meters. When threatened, Collared Lizards sometimes scamper several meters away from the basking site to seek shelter, nearly always under a rock. When they bask on rocks or boulders not deeply imbedded in the substratum, however, they commonly excavate burrows under the rock into which they hastily retreat when enemies approach. These lizards find shelter in such burrows at night or even during the day when air or substratum temperatures reach excessive levels, above or below the range they can tolerate.

While basking or foraging Collared Lizards are able to regulate the intake of solar heat, largely but not exclusively by means of their behavior. Their skins may be light or dark, reflecting or absorbing heat as the melanophores (or black pigment cells in the skin) contract or expand under the control of the autonomic system. At temperatures a few degrees below the threshold of the range that permits them to become active, Collared Lizards in New Mexico are decidedly blackish. This allows them to absorb radiant heat so efficiently that Collared Lizards with body temperatures below 30° are seldom found abroad .

Fitch (1956), who made a prolonged and detailed study of Collared Lizards in Douglas County, Kansas, recorded 513 body temperatures of the reptiles over a period of six years. All but two of the temperatures fell between the extremes of 30.5° and 43.3° C, and the mode for both males and females was approximately 38° C. Fitch notes that 87.1 per cent of the temperatures fell within the six-degree range of 35° to 41° C. Inasmuch as Fitch's data were obtained from a single population comprised of freely breeding individuals inhabiting less than an acre, it is instructive to compare his results with those obtained by recording the body temperatures of Collared Lizards in widely scattered localities. I obtained a total of 58 body temperatures of C. collaris recorded in the field in the following areas: Riverside County, California; Yavapai, Santa Cruz, Pinal and Cochise counties in Arizona; McKinley, Socorro, Otero and Hidalgo counties in New Mexico; and in the Mexican states of Chihuahua and Durango. The mode for males and females is 38° C, or essentially the same as that reported by Fitch. The mean for the composite sample is 37.2°C, slightly below what Fitch reports as "38° to 39° C" for the much larger sample obtained in Kansas. The range in body temperatures for the composite sample is 33.2° to 40.4°C, narrower than the range Fitch reports, but 91.4 per cent of the of the 58 temperatures obtained fall between 35° and 41° C. The somewhat larger percentage of Collared Lizards maintaining body temperatures within the six-degree range is perhaps attributable to the shortcomings of a smaller sample. It seems more probable, however, that the populations of Collared Lizards inhabiting the arid and semi-arid areas in which the data were obtained experienced less difficulty than the population in the more humid climate of Kansas in regulating the intake and dissipation of solar heat.

Fitch discovered that 91 per cent of the records for Collared Lizards in Kansas were obtained while air temperatures were within the eleven-degree range between 23° and 34° C. The over-all range was between 13.5° and 36.0° C, probably not significantly different from the extremes of 21.6° to 36.6°C for the air temperatures I obtained, 94 per cent of which fell within the eleven-degree range of 23° to 34°C used by Fitch. He adds the pertinent observation that when air temperatures rise to levels approaching the mean, from 37° to 38°C, for body temperatures within their normal activity range, Collared Lizards seek shelter underground. Fitch interprets this behavior as evidence of the lizard's preference for lower air temperatures.

It is noteworthy that when a Collard Lizard is abroad with the air temperature approaching 38°C, it becomes advantageous for the reptile to avoid exposure to radiant heat if it is to avoid an accelerated rate of increase in its body temperature. The lizard can most readily dispense with the intake of solar radiation and dissipate the heat from its body by seeking shelter in the cooler depths of the tunnel excavated under an insulating rock. When the lizard's body temperature is below that of the ambient air, however, the lizard can remain alert and active while it regulates in the intake of solar heat. Autonomic control of the melanophores augments the effectiveness of orienting the body to increase or decrease the percentage of the body surface exposed directly to the sun's rays. In arid and semi-arid environments, diurnal lizards absorb radiant heat at rates that more than compensate for the heat lost to the air by conduction, convexion or radiation. At elevations of 4450 m in the <u>altiplano</u> of the Peruvian Andes Pearson (1954) found iguanid lizards foraging with body temperatures as much as 31° above air temperatures of 0°C recorded in the shade.

The preceding discussion may help explain why Collared Lizards in the Pajarito Plateau area appear to be restricted to the warmer, more arid terrain bordering the Rio Grande. These lizards are not abundant, either in the main canyon of the river, or the canyons that drain into it from the Pajarito Plateau. I saw only four individuals during the two years when I was engaged in field investigations during the warmest seasons, although I might have seen more Collared

Lizards had I spent more time in the canyons closer to the Rio Grande. The only lizard of the species seen in the area in 1978 was perhaps three kilometers west of the river in Ancho Canyon at an elevation of 1700 m. It was an adult male basking well over a meter above the ground along the dry stream bed. Slightly more than two kilometers to the north, where a branch of Ancho Canyon dissects the mesa between it and Water Canyon, a Collared Lizard had selected a relatively inconspicuous rock at the very edge of the mesa at an elevation of 1925 m. Where this promontory terminates in vertical basaltic cliffs about a kilometer to the east, the Collared Lizard was not seen, although lizards of the species have gained access to the relatively flat terrain just above the cliffs at elevations a few meters above or below 1950 m. A half-grown Collared Lizard basked on an isolated rock on the mesa immediately to the south of Pajarito Canyon. It is questionable whether Collared Lizards could scale the vertical walls that form most of the west rim of White Rock Canyon, but a trail affords access to the canyon scarcely 50 m from the rock where one of these lizards had been basking. It may have gained access to the mesa top *via* the same route used by man long before the advent of Europeans. If so, Collared Lizards have shown no inclination to extend their distribution westward on the mesas that flank the canyons dissecting the edge of the Pajarito Plateau. Their failure to do so is perhaps attributable to general absence of suitable basking sites in the pinon-juniper forests of the mesa tops.

Mr. Ted Brown observed a Collared Lizard near the mouth of Los Alamos Canyon near Otowi Bridge, and I have seen the species within a few meters of the Rio Grande near the mouth of Sandia Canyon at an elevation of approximately 1660 m. The boulder-strewn wash of Guaje Canyon that extends for at least 10 km above its junction with Los Alamos Canyon closely resembles areas inhabited by Collared Lizards in other parts of their range, although I failed to find any in Guaje on at least five trips through the area in suitably warm weather. Such negative evidence is of little value, however, in view of the general scarcity of Collared Lizards in the foothills of the Jemez Mountains. The species may yet be found in the wash below Guaje Canyon.

The extraordinarily wide distribution of Crotaphytus collaris in the United States is not readily explained. It is exceptional for a lizard supposedly adapted for rocky environments in the arid foothills of the West to have a range extending across the Great Plains almost to the Mississippi River. Specialized basking habits that permit the lizard to maintain its body temperature at a mean level comparable that of human beings understandably restrict the species to environments with sparse vegetation and at least a few rocks. We must assume that these meager requirements can be met, not continuously but at scattered localities where rocky strata have become exposed, all the way, from eastern California through most of Arizona, New Mexico, Texas and Oklahoma to Missouri and Arkansas. Collared Lizards are known from southwestern Oregon southeastward through more than 20 degrees of latitude to the Mexican states of Durango, Zacatecas and San Luis Potosi. They occur at areas near sea-level on the coast of northwestern Mexico to elevations reaching 2200 m on the desert slope of the San Gabriel Mountains in southern California.

Two black bars separated by a light band extend across the nape from shoulder to shoulder, forming the 'collar' that readily distinguishes all Collared Lizards. They vary widely in color as well as pattern, however, with complexities in the distributions of distintive forms that are belatedly becoming evident with the acquisition of more widely representative collections. A Collared Lizard with the pattern and coloration of the populations in the Mojave Desert, for example, inhabits Grand Canyon and ranges into the Painted Desert along the Little Colorado River. Populations both north and south of the Little Colorado are represented by males greenish in color, in contrast to the pinkish yellow that characterizes the males that seem to have been derived from the Mojave-Grand Canyon population. Unfortunately the only systematists who have made any effort to define or distinguish well differentiated populations have employed a piecemeal approach. Until the whole assemblage has been studied we cannot be sure whether we are dealing with an unusually plastic species or with more than one species, with genetically isolated populations.

Short-horned Lizard, Phrynosoma douglassi Beil.

Horned lizards occupy a wide range of habitats, from Canada southward through the United States and across the Isthmus of Tehuantepec in Mexico to southwestern Guatemala. Three of the 13 species inhabit portions of New Mexico, but Phrynosoma douglassi is one of but two species known to range into the southern foothills of the Jemez Mountains, and it is the only one found thus far in LA/NERP.

The patterns and colors of horned lizards are such as to blend into their natural surroundings. Selection permits the color and markings to vary from one area to the next, depending on the color and texture of the substratum. The broad, strongly flattened body that characterizes all horned lizards virtually bliterates any tell-tale shadow. Moreover, the spiny projections on the head, and particularly those that fringe the trunk on most species, help to obscure the body outline. These reptiles, therefore, are fantastically well equipped to bask or forage in the open without being seen by their enemies. Many more horned lizards are undoubtedly present than we can ever detect in any given area, and P. douglassi is surely more widely and abundantly represented in LA/NERP than the few records available would suggest.

The only horned lizard seen in the Park in 1978 was a juvenile obtained at an elevation of 2000 m at the upper end of the Cañada del Buey. It was found on 17 September, after a light rain the previous night. The sky had been overcast, with the air temperature at 14°C at 8:30 a.m. Although the air had barely reached 19.6° C by 3:28 p.m., the lizard had evidently been basking for its body temperature was 34.5 °C. This is well within the range of body temperatures recorded for members of the species while foraging under natural conditions in other parts of their range. Two specimens of the Short-horned Lizard were obtained in 1979, one at 2100 m in Sandia Canyon on 6 June, and one at the confluence of North Mesa and Kwage mesa at an elevation of 2200 m on 28 August. I failed to find horned lizards in the canyons that flank both sides of Kwage Mesa, but on 26 July I found unmistakable evidence of their presence on the ridge that extends westward from Otowi Ruins. The evidence consisted of a large scat composed almost entirely of ants. No other lizard in the United States has a diet so nearly restricted to ants as the horned lizards, whose droppings are unmistakable. The ridge where the scat was found is approximately 1950 m above sea level, and sparsely covered with ponderosa pines, Gambel oak and squaw bush.

It would be misleading to assume that *P. douglassi* is restricted to elevations two or three hundred meters above or below 2000 m, for no other species of horned lizard occurs from the plains of Kansas to areas in the mountains well above the Transition Life Zone. They occur sporadically in thinly forested areas on some of the higher peaks in New Mexico. I found one in an aspen grove on the [illegible] slope of Mount Polvadera at the north end of the Jemez Mountains at 3050 m and Gehlbach (1965) mentions a specimen taken at 3350 m in the alpine-tundra at [illegible] Lookout on Mount Taylor in Valencia County. Even higher elevations were reached in the Sacramento Mountains, where one was obtained near the summit of Sierra Blanca somewhat above 3650 m by Mr. James Lee in 1969.

The species was first known from the Northwest, "the banks of the Columbia River," but it is now known to occupy mountains, hills, canyons and valleys on both slopes of the Continental Divide from the Canadian border southward through portions of Washington, Oregon, and Montana to the Mexican state of Durango. The population in the Jemez Mountains is perhaps less than 150 km from the eastern extremity of the range in New Mexico, for the species is known eastward slightly beyond the Sangre de Cristo Mountains. Off to the northeast, the range extends well into the plains of Kansas. The distribution of *P. douglassi* interdigitates with that of a closely related species, *P. orbiculare* in northern Mexico, from central Chihuahua southward into Durango. Relatively few specimens from the area are available in collections, but in the area of overlap *P. douglassi* occupies the valleys and *P. orbiculare* inhabits the ridges and plateaus at higher elevations.

In view of the similarities of the two species, it is most improbable that they will ever prove to occur sympatrically.

Henderson and Harrington (1914) note that Phrynosoma modestum was recorded at San Ildefonso in 1875. No one has subsequently seen the species in that area, and until recently the nearest records were south of the Jemez Mountains northeast of Cerrillos. On 24 May, 1978, Martha R. Bogert found two P. modestum in the foothills roughly 10 and 11 km southwest of the mouth of Ancho Canyon. The first to be taken was near the trail where it enters Sanchez Canyon at an elevation of 1730 m. The second was found on the mesa between Medio Canyon and Capulin Canyon scarcely 0.3 km south of the boundary of Bandelier National Monument, at an elevation of 1700 m. Degenhardt (1975) listed P. modestum as having a range that perhaps extended into Bandelier and he suggested that it might eventually be found in White Rock Canyon. This remains as a possibility, even though the few specimens known from Sandoval and Santa Fe counties have been taken in relatively flat, sparsely covered terrain, rather than in canyons or washes, which these horned lizards seem to avoid.

Whiptails and Racerunners, Family Teiidae

Chihuahuan Spotted Whiptail, Cnemidophorus exsanguis Lowe.

Approximately 36 species are now recognised in the genus Cnemidophorus (Cole, 19[illegible]), a group of lizards widely distributed in the Western Hemisphere from eastern Oregon in the United States southward through Mexico and Central America to Brazil. At least 12 of the species have distributions that include portions of New Mexico. Three of of these species are represented in LA/NERP, but only one is widely distributed in the area and commonly seen. All three of the species are known to reproduce parthenogenetically. An extensive literature dealing with uniparental populations of whiptail lizards has appeared within the last decade. Cole (supra cit.), who summarizes recent literature notes that a few species of Cnemidophorus include bisexual as well as all-female populations, whereas no males of other species have ever been found. Cole's investigations have pointed to the probability that some parthenogenetic species have arisen as a result of hybridization, and he includes C. exsanguis with the species shown to be triploid and unisexual.

The only specimen of this species obtained in the area covered by this report was obtained not far from the Rio Grande near the mouth of Ancho Canyon at an elevation of 1650 m. Mr. Ted L. Brown informs me that he obtained specimens farther up the river at 1665 m, at the mouth of Los Alamos Canyon near Otowi Bridge. It is noteworthy that Degenhardt (1975) reports C. exsanguis as having the widest distribution of any whiptail in Bandelier National Monument. He managed to obtain specimens between the elevations of 1615 to 1830 m, mainly in grassy, semi-open areas of several canyons, including White Rock. Access to other canyons that drain into the Rio Grande at White Rock Canyon affords a ready avenue for the northern dispersal of C. exsanguis. It may not range much farther north than the mouth of Los Alamos Canyon, and within LA/NERP it would seem to occupy habitats at least 200 m below areas occupied by C. velox. Detailed studies would be required to prove that these two species are as intolerant of each other as the limited data suggest.

C. neomexicanus may not be wholly riparian, but records of its occurrence north of Albuquerque indicate that it is seldom seen more than four or five kilometers from the Rio Grande and its tributaries.

In 1952 when this species was described from specimens obtained in Socorro County, Lowe and Zweifel regarded it as "primarily a bottom land dweller that is to be found either infrequently or not at all in yucca-grass, oak, juniper or piñon dominated habitats at this latitude." At the type locality they found C. neomexicanus occurring sympatrically with four other species, the unisexual C. exsanguis and C. tesselatus and the bisexual C. tigris and C. inornatus. The habitat at the type locality is described as being situated in a transitional area at an elevation of 1463 m, "bordering an Atriplex canescens-Sporobolus airoides playa immediately to the west, and a Yucca elata-Aristida adscensionis-Bouteloua barbata grassland on a sandy, gentle alluvial slope to the east." In this area C. neomexicanus, later shown to be parthenogenetic (Lowe and Wright, 1966), was by far the most abundant of the five species. About 16 km north of the type locality in an area of "Yucca grassland and Larrea-grassland" Lowe and Zweifel found C. tigris "on the playa proper along with C. inornatus and C. neomexicanus," whereas C. tigris and C. inornatus were commonly observed in the surrounding yucca-grassland, where C. neomexicanus did not occur. It was the "commonest lizard in the saltbush-sacaton habitat," however, at this locality.

All five species were also observed on the outskirts of Socorro, "in a sandy, rocky wash in which creosote bush, Larrea divaricata, was the dominant plant." In this area, however, C. tigris was the dominant species, and the others much less abundant. Not far away, "on the Jornada del Muerto, where Russian-thistle (Salsola kali, an early or pioneer successional element) existed in almost pure stands, C. inornatus was very abundant, with all other species far less abundant." Lowe and Zweifel were among the first to note the complexity in the relative abundance of the species, and the shifts in the densities of sympatric species that accompanied changes in the dominant vegetation as one moved from one area to the next.

whiptails of the two species, 69 per cent of which were C. inornatus. In another area occupied by Holbrookia maculata, Uta stansburiana and Phrynosoma douglassi, as well as by the two species of Cnemidophorus, Christiansen assembled 199 whiptails. In this area, described as being "less disturbed," 80 per cent of the sample proved to belong to the bisexual species, C. inornatus, presumably indicating that it was four times as abundant as the unisexual species, C. neomexicanus. Lizards of this species "were all collected along road banks, ditches or near piles of man-made trash," generally in "sparsely vegetated disturbed areas," and likely to be found at the base of "large weeds, shrubs and trees." Unlike the unisexual species, C. inornatus in this area, (within the city limits of Albuquerque) "is found in or around ungrazed areas of dense grass and short herbaceous weeds."

Despite his frequent encounters with both species in the two main study areas, Christiansen reports that closer analysis revealed "well-defined ecological preferences, which largely prevent" the intermingling of the two species. Inasmuch as both study areas were in vacant lots described by Christiansen in his summary as being "nearly metropolitan" it is perhaps debatable whether any truly undisturbed habitats remain under such conditions. Christiansen specifically notes the presence of weeds in the habitats of both species, and their presence would be expected in the habitat of C. neomexicanus as defined by Wright and Lowe. This unisexual species may indeed thrive in areas recently disturbed by man. If the range of C. neomexicanus is actually expanding at the expense of C. inornatus, however, it seems unexpected to say the least to discover that from 69 to 80 per cent of the whiptails in the study areas belong to the bisexual species reputedly being replaced. Cuellar (1977) observes that C. inornatus commonly occurs sympatrically with the parthenogenetic species, and he suggests it is behaving "essentially as a unisexual species" where it occurs in disturbed sites. Taylor's (1965) account of C. inornatus and the unisexual species, C. velox, sharing the same habitat in Santa Fe County can scarcely be interpreted as diagram would suggest that C. tigris is better adapted than the three unisexual species C. exsanguis, C. tesselatus and C. neomexicanus for sandy habitats where creosote bush, Larrea divaricata, is the dominant plant. One might also infer from the diagram, that C. tigris, a bisexual species, is the least competitive of of the five species of whiptail in that part of New Mexico.

Several students of Cnemidophorus, including Zweifel (1965), Christiansen (1971), Maslin (1971) and Cuellar (1977) have discussed or mentioned the higher reproductive potential of parthenogenetic species. "If fecundity, age at maturation, and population age structure are similar in two species," Zweifel observes, a parthenogenetic population could produce twice as many young in a breeding season as a comparable bisexual population. The geometric rate of increase could lead in a few generations to a vast preponderance of the parthenogenetic form." Zweifel reviews data provided by Milstead (1957), who had studied six species of Cnemidophorus in Texas. In the Sierra Vieja Milstead found the same small, bisexual species C. inornatus later studied by Christianson in New Mexico, to be more than 20 times as abundant in plains habitats as the large unisexual species, C. exsanguis. Another unisexual species, C. tesselatus, fared somewhat better in the same habitat, but C. inornatus was nevertheless more than five times as abundant. In the Creosote Bush-Catclaw-Blackbrush association in the plains, however, C. inornatus was only slightly more abundant than the unisexual tesselatus.

In the Stockton Plateau of Texas, Zweifel observes that the unisexual species, C. tesselatus, and the bisexual species, C. tigris, were almost equally abundant. "Where both species were present," Zweifel observes, "one was strongly dominant, outnumbering the other by a minimum of 2.2 to 1." In the La Mota Mountain area where the same two species were ~~the~~ dominant ~~species~~, 104 specimens of C. tigris and all except four of 98 specimens of C. tesselatus came from four plant associations. "In three of these associations tigris dominated by about six to four, whereas in the fourth the ratio was approximately seven to three in favor of tesselatus," according to Zweifel. He concludes that "Milstead's data indicate that parthenogenetic populations are not necessarily denser than those of congeneric bisexual species significant role in its alleged displacement of C. inornatus. He cites only one instance of aggression displayed by C. neomexicanus in its native habitat. In the laboratory, however, he observed many attacks by individuals of the larger, unisexual species. "When many individuals of each species were placed in a single aquarium, as many as half of the C. inornatus lizards were killed." Moreover, "large C. neomexicanus were frequently seen biting smaller adults of C. inornatus on the head." The bisexual species never attacked C. neomexicanus, presumably even when caged with smaller members of the species. Under the conditions of sympatry, C. inornatus could be expected to find the situation disadvantageous.

Christiansen's account contains many pertinent observations and much original data. His comparisons of the two species are instructive, but of necessity his conclusions are based in part on information derived from the literature, as well as from his own estimates and assumptions cautiously identified as such. When he speaks of the "several advantages over C. inornatus" that C. neomexicanus "appears to possess," despite reproductive potentials that are "effectively the same," he fails to explain why C. inornatus is from three to four times more abundant than the larger, more agressive unisexual species in the areas where he conducted his investigations. As noted in the reviews of the information summarized by Zweifel (1965) and Taylor (1965), C. inornatus is reported to occur in almost equal numbers with a unisexual species in only one specific plant association. In all other habitats where the bisexual species shared its habitat with unisexual species, including C. tesselatus and C. exsanguis in Texas, and C. velox in New Mexico, C. inornatus was from five to 20 times as abundant as its competitor.

Wright and Lowe (1968) cite no evidence to substantiate their statement that "the geographical range of C. neomexicanus appears to be expanding...at the expense of C. inornatus." Christiansen quotes the statement, but without mentioning any specific evidence he writes that "the present study supports the hypothesis..." It is more than probable that the activities of man and his animals are disturbing, disrupting, or in many instances destroying natural habitats at accelerof saltgrass and Russian thistle, while _C. tigris_ and _C. neomexicanus_ shared the xeric mesquite and creosote bush. When a wet year followed, however, Medica found _C. inornatus_ extending its range southward into the xeric habitat, while _C. tigris_ moved northward through the salt cedar-saltbush association. Under more humid conditions, Medica reports, _C. neomexicanus_ shifted its activities northeastward through the saltgrass-Russian thistle community, to which _C. inornatus_ had been restricted during the dry year. More detailed information would have been welcome, but Medica adds that during the wet year "all species were intimately associated and ...potentially. competing for a portion of the habitat as well as [for] the food." Even though _C. neomexicanus_ expanded its range into the plant association occupied by the bisexual species during the previous year, Medica does not indicate that _C. inornatus_ was supplanted. The bisexual species, perhaps availing itself of more propitious conditions, had expanded its activities to include the mesquite-creosote association. One can only guess whether the expansion of _C. neomexicanus_ into the the saltgrass-Russian thistle was conditioned by the outward movements of _C. inornatus_. It seems probable, however, that on wet years the differences between mesic and xeric habitats are less sharply defined than they are on dry years, and the lizards are less restricted in their foraging.

Whatever conclusions may be drawn from this incomplete review of the literature dealing with habitat preferences in bisexual and unisexual species of _Cnemidophorus_, it becomes evident that we are seldom dealing with relatively simple, static situations. In view of the changes that occur from place to place or from year to year, or both, scarcely any statement can be made that accurately describes the habitat and behavior of any species beyond a given time and place. No evidence whatever has been reported to substantiate the belief that unisexual species in North America are either more prolific or better qualified for survival in disturbed habitats than bisexual species. A possible exception may nevertheless exist in South America, where bisexual populations of _C. lemniscatus_ appear to have been supplanted by parthenogenetic strains of the same species; the situation will be reviewed in the account that deals primarily with _C. velox_.

Guaje, Bayo, Pueblo, Los Alamos, Sandia, Cañada del Buey, and Pajarito. Although I found fence lizards and skinks on North Mesa and Kwage Mesa at elevations between 2070 and 2100 m, no whiptails were seen. I failed to find any on Barranca and Otowi mesas at comparable elevations, but one whiptail was observed in recently cleared terrain at a disposal site two kilometers west of Tshirege Ruins at the lower end of the Mesita del Buey. The disposal site is surrounded by piñon-juniper woodland at an elevation approaching 2050 m.

Prolonged field work in LA/NERP will perhaps reveal the presence of C. velox in a wider range of altitudes, but its affinity for partially cleared areas in the ecotone at the upper end of the piñon-juniper woodland in the canyons is evident. It is difficult to explain its absence from the mesas covered with "ponderosa pine forest/piñon-juniper woodland" (see Anon., 1977 fig. 18 map) where as many logs and stumps are to be found as there are in the canyons.

Degenhart (1975) reports C. velox from only two canyons, Frijoles and Lummis, in Bandelier National Monument, at elevations between 1800 and 1925 m. This range in elevation is likely to be extended with further investigation. Although Degenhardt notes that the distribution seems spotty, he suggests that populations of the species are awaiting discovery in the southern part of the Monument. Evidently C. velox is neither as abundant nor as widely distributed in Bandelier as it is in LA/NERP, where C. exsanguis is known from but two canyons, not far from the Rio Grande in each. In contrast, C. exsanguis is the one whiptail in Bandelier that is common and widely distributed. Its altitudinal distribution, 1615 to 1830 m in Bandelier, would overlap that of C. velox. Although Degenhardt records both species in Lummis Canyon, he does not indicate whether they occur sympatrically. The information now available for LA/NERP would suggest that the areas occupied by C. velox are widely separated from those along the river, where C. exsanguis and C. neomexicanus occur.

and overlap with other uniparental woodland species is on the order of magnitude of a few meters, where to some extent it appears that the presence of such species determines the geographical limits of _C. velox._" Behavior in areas of overlap in the distributions of unisexual species, it would seem, closely resembles that observed where congeneric bisexual species occur sympatrically. Wright and Lowe, however, emphasize the "disturbed" nature of the habitats occupied by parthenogenetic species of _Cnemidophorus._ They draw attention to the concentration of allopioid parthenogenetic species of _Cnemidophorus_ on both flanks of the Continental Divide at "the broad ecotone between the Rocky Mountains and the Sierra Madre," Eight of the nine uniparental species of whiptail, they point out, "are situated geographically in one of the most complex physiographic and ecological regions in North America." They admit that the uniparental species occupy a moderately wide range of habitats, but they suggest that they share one feature in common. "Each is characterized by such descriptive terms as disclimax, marginal, ecotone, transient, extreme, and perpetually disturbed, all of which define a 'weed habitat.' The presence of such habitats at the time of origin of parthenogenetic individuals from hybridization or between bisexual species looms as the critical factor for the establishment of all-female populations, leading toward their potential perpetuation as successful parthenogenetic species."

"Moreover," they conclude, "as is usual for weeds, the parthenogenetic species are successfully established and widely disbursed within habitats that appear to be little or not all available for bisexual species of the genus." Confirmation of this interpretation is offered by Christiansen (1971), who reports that _C. inornatus_, a biparental inhabitant of undisturbed desert grassland, occurs sympatrically with its uniparental relative, _C. neomexicanus._ This species, however, restricted to "disturbed areas, often those disturbed by man and his animals."

were once far more widely distributed, but became restricted to current levels because they were forced to retreat as the bisexual species invaded "the more stable, widespread habitats" such as the "Thornscrub, Desertscrub and Grassland" that arose? If so, Wright and Lowe seemingly attribute the origins and dispersals of the unisexual species to the disturbed conditions that antedate the arrival of man. The plants referred to as 'weeds', however, are those found growing mainly in areas that human beings have changed in one way or another, commonly by the removal or destruction of the natural vegetation. When ecologists or systematists refer to disturbed environments, therefore, what they commonly have in mind are such modifications as those resulting from fires, overgrazing, timber removal, or even strip-mining. Thus, Christiansen (supra cit.) specifically refers to the areas "disturbed by man and his animals," and Wright and Lowe employ the same phrase.

There are, of course, various degrees of disturbance, and no simple way of specifying how much disturbance has occurred, much less what degree of change is necessary before any given habitat becomes "little or not at all available for bisexual species in the genus," to use the phraseology employed by Wright and Lowe. In the opinion of many biologists the destruction of natural habitats, not only in New Mexico, but throughout most of the Southwest below the elevation of 2400 m, is largely attributable to the introduction of man's domestic animals. Those concerned with game management in New Mexico doubt that any truly natural habitats remain in the state with the possible exceptions of mountains above 2500 m. If the uniparental whiptails had invaded all the habitats supposedly available to them, (and presumably "unavailable" to the bisexual species) they should be far more widespread in the Southwest than is now demonstrable.

This is not to deny that uniparental species, whether they arose from hybridization or from some alternate means, find advantages in some instances in disturbed habitats. In view of the widespread modifications of environments arising from man's invasion of the Southwest, this might be difficult to prove on the basis of circumstantial evidence.

to unisexuality is still in progress and [it seems] to be a fast process."

Zweifel (1965) noted the possibility that "in some circumstances parthenogenesis may be of considerable selective value," and he, as well as Maslin (1971) and Cuellar (1977) call attention to the advantages inherent in the potentially double rates of increase in parthenogenetic species. Perhaps even more important is the "ease of colonization" to which Maslin refers. Theoretically, at least, the possibility that a single individual can establish a colony greatly enhances the chances for the dispersal and establishment of parthenogenetic populations of C. lemniscatus. Beyond that, the information Vanzolini obtained at Óbidos in 1965 and 1968 can most readily be interpreted as evidence that a bisexual population was supplanted by one that is almost certainly parthenogenetic. Although noting the need for additional research, Vanzolini suggests that the pattern of distribution he discovered in the Amazon populations can be construed as evidence that unisexual populations have evolved independently in separate areas, or viewed as the spread of a single original parthenogenetic "strain with superior powers of migration and selective advantages over local bisexual strains."

Despite his citation of Vanzolini's account, Cuellar (1977) apparently ignored its implications and conclusions. Following his discussion of the selective advantages of parthenogenesis, Cuellar is willing to state that "A fundamental premise of this article is that parthenogenesis is rare, not because it cannot arise frequently by mutation, but because it can only evolve successfully in special and limited habitats devoid of the bisexual species." If Cuellar expected additional information for the Amazon populations of C. lemniscata to rule out replacement of bisexual whiptails by unisexual populations, he could not have welcomed the additional information that Vanzolini (1970) provided more recently. As summarized by Vanzolini in his recent account, further investigations have revealed five localities on the Amazon where bisexual populations of C. lemniscatus occur. Nevertheless all-female populations predominate, and Vanzolini can now report that "at least five chromosomal arrangements" have been detected, and "their geographical distribution is complex."

the name Carr adopted for the "true primeval forest," where the upper leaf canopy is continuous and the trunks are mostly buttressed to sustain the huge burden of foliage." Where the trees had been removed grasses and other plants grew to heights of 30 to 70 cm or more, but a network of roads penetrated the area. Whiptails were readily seen on these roads, and far more abundant than any other reptiles in the arboretum. To obtain the cloacal temperatures of these lizards I was shooting them with .22 long rifle shot cartridges in a single shot target pistol with a barrel 25.5 cm in length. Temperatures of the lizard, the air and sometimes the substratum were obtained following the procedures described later the same year (Bogert, 1949). Under favorable conditions at Lancetilla I was sometimes able to record as many as a dozen body temperatures within an hour. It was not difficult to ascertain the sex of the whiptails for the hemipenes of males could easily be everted by applying pressure to the underside of the tail at its base.

Working mainly between the hours of 9 a.m. and 5 p.m. on the 29 and 30 of March, as well as for a quarter of an hour on the afternoon of the 28, and for slightly more than an hour, from 8:58 to 10:03 a.m. in 1 April, I recorded the cloacal temperatures of 78 C. lemniscatus. Males invariably outnumbered females. Even though the proportions varied from day to day, 18 of the 78, or slightly over 31 per cent of the whiptails proved to be females. The preponderance of males in the sample may or may not be attributable to more secretive habits of females of the species, but there can be no doubt that the Lancetilla population was bisexual in 1949.

Cnemidophorus lemniscatus is known in the Atlantic lowlands from Guatemala to Brazil, probably as a series of disjunct populations, with the largest hiatus in Costa Rica. As Vanzolini (supra cit. 1970, 1978) discovered, the species has followed the Amazon River to penetrate the interior of Brazil, at least 1000 km from the coast. In their recent account of the lizards of Honduras Meyer and Wilson (1973) note that this whiptail is "common along the beaches of the Caribbean

Much the same results were obtained by Medica (1967) from his investigations of four species of *Cnemidophorus* in south central New Mexico. Medica's account of *C. exsanguis*, *C. inornatus*, *C. neomexicanus*, and *C. tigris* in a limited area of their sympatric distribution indicates that the means of the cloacal temperatures as recorded for the species all "fell between 39.04 and 38.9°C." Similar studies in other parts of the United States, as well as in Mexico, have produced similar results. The data assembled for whiptails occupying a wide range of habitats show plainly that body temperatures compatible with activity seldom fluctuate more than three or four degrees Celsius above or below mean levels ranging from 38 to 41° C.

Analysis of the data obtained for *C. lemniscatus* at Lancetilla revealed no significant differences between the means for body temperatures of males and females. For the 78 specimens they ranged from 32.6° to 40.4°C, with a mean of 38.4°C. Air temperatures obtained *ca.* 5 cm above the spot where each lizard was killed varied from 25.8° to 33.7° C, with a mean of 30.7°C. In the clearings in the *selva* at Lancetilla, therefore, whiptails were maintaining their bodies at a level that was nearly 8°C above that of the ambient air. This disparity between the means for air and body temperatures in a tropical study area is somewhat greater than the disparity in temperatures Fitch reports for *C. sexlineatus* in Kansas. Air temperatures recorded by Fitch were "concentrated between 33° and 35° C," whereas body temperatures were most often between 39° and 41° C. If *C. lemniscatus* is to maintain its body temperature within the relatively narrow range presumed to be compatible with its foraging activities, therefore, it can do so only by availing itself of radiant heat. This is as readily accomplished in man-made clearings as it is in beaches or the "places of maximum disturbance" along the Amazon to which Vanzolini (1978) refers. Although he admits that we know virtually nothing about the mode of dispersal in *C. lemniscata*, he pointedly observed in 1970 that this lizard's westward expansion "is along the deforested banks of rivers." If "no specimens were seen in natural habitats," as he notes in 1978, and the natural habitats

Skinks, Family Scincidae

Great Plains Skink, Eumeces obsoletus Baird and Girard

This skink, the largest of the 13 species of the genus Eumeces represented in the United States, is regarded by Taylor (1935) as having its closest relatives in China and the Ryukyu Islands. Taylor examined specimens from seven counties in New Mexico, including Valencia and Taos in the northern part of the state. Gehlbach (1965) verified the occurrence of E. obsoletus in Valencia County, which he believes is close to the northwestern limit of its range in New Mexico. There are no recent records to substantiate the occurrence of the species in Taos County and Taylor on his map showing the distribution of the species, inadvertently plots the record for the town of Taos on the headwaters of the Canadian River, in Colfax County.

The first specimen to be obtained north of Sandoval County was a juvenile captured on September 20, 1979 near the mouth of Ancho Canyon at an elevation of 1650 m. It was abroad and foraging near the stream not far from the Rio Grande in an area of juniper, saltbrush, sagebrush, and cholla. This is evidently the first record of the species from Los Alamos County. Although it may occur farther northward along the Rio Grande, this record for E. obsoletus could represent the northern extremity of the range in New Mexico west of the Sangre de Cristo Mountains.

The species has been known from the Canyon de los Frijoles in Bandelier National Monument, where Degenhardt (1975) observed two individuals at elevations between 1[illegible] and 1860 m. This was in an area evidently not far below the headquarters of the National Monument, where immature E. obsoletus have been observed sporadically by members of the Ranger Staff in recent years. No adults were seen. Taylor comments that these skinks are "either rare or very difficult to find and collect" everywhere within their range "with the exception of eastern Kansas." As might be expected of any species widely distributed in the Great Plains,

E. obsoletus is primarily a grassland species. Its distribution may be virtually continuous east of the Pecos River in the southeastern portion of New Mexico. In the Llano Estacado the species is relatively abundant, and large adults are well represented in collections (D. L. Tanner, 1975). From the Guadalupe Mountains westward on both sides of the Mexican Boundary, however, these skinks are known from isolated mountain ranges, most of them surrounded by arid deserts. In such situations these skinks are likely to be encountered along permanent or semi-permanent streams, more often in canyons. At the northern extremity of their range in the foothills of the Jemez Mountains, the few records of these skinks would suggest that the dispersal of the species has been northward along the Rio Grande, where it has gained access to riparian habitats in the deeper canyons that drain into the river.

Degenhardt (supra cit.) and others have observed these skinks only in the vicinity of the Rito de los Frijoles in Bandelier, where the dominant vegetation consisted of such trees as white fir, Abies concolor, Douglas fir, Pseudotsuga menziesii, box elder, Acer negundo, and ponderosa pine, Pinus ponderosa. The capture of a half grown E. obsoletus not far from the Rio Grande near the mouth of Ancho Canyon leaves no doubt that the Great Plains Skink ranges from the Upper Sonoran into the Transition life zone. Degenhardt suggests that the species probably occurs near the lower end of the Canyon de los Frijoles. The habitat of populations near the river was temporarily inundated in the month of August, 1979, however, when Cochiti Lake rose high enough to extend well into the lower end of this canyon.

The distribution of E. obsoletus extends from southern Nebraska southward through eastern Colorado, all of Kansas, most of Oklahoma and Texas well into the Mexican states bordering the Rio Grande. Westward from the edge of the plains in eastern New Mexico, the species is probably represented by disjunct populations as noted above, extending as far as the foothills of the Santa Catalina Mountains north of Tucson (figure 4.7). D. L. Tanner examined specimens obtained east of the Sangre de Cristo

Mountains, on the Canadian River at Sabinosa. Aside from the questionable record for Taos erroneously plotted on the headwaters of the Canadian River by Taylor (1935, fig. 48) on his map showing the distribution of E. obsoletus, no specimens of this skink have been reported from the foothills of the Sangre de Cristo Mountains. The species might have entered the foothills on the Pecos River drainage at the southern end of the range. The nearest record of which I am aware, however, is well off to the southeast near Santa Rosa, in Guadalupe County. The populations in Bandelier and Ancho Canyon cannot be construed as representing an extension of range from the plains to the east. The species has long been known from Albuquerque, and it seems far more probable that the dispersal northward in this part of the state has been along the Rio Grande. Pending more extensive exploration of the terrain bordering this river between LA/HERP and Taos, Ancho Canyon probably can be regarded as the northernmost record of the species in New Mexico west of the Sangre de Cristos.

Henderson and Harrington (1914) provide an early record for this skink in northern New Mexico. They report that "Two fine specimens of this lizard, with the edges of the scales quite dark, were unearthed by the Indians excavating the old pueblo at El Rito de Los Frijoles. One was captured, the other escaped. Old men at San Ildefonso declared that it is poisonous and would not touch it. They have a 'remedy' for its bite." They are mistaken as to its poisonous character. The Mexicans call this kind of lizard escurpion (sic)" The name escorpion is commonly and acceptably used in Mexico for a large, venomous lizard, Heloderma horridum, as well as for its close relative, the Gila monster, Heloderma suspectum, whose range extends into the state of New Mexico in Hidalgo, Grant and Doña Ana counties. The Gila monster was well known, if only because of its sinister reputation, in portions of the Southwest far removed from the arid lowlands to which it is restricted. Thus Dr. H. C. Yarrow (1875) reported that "While camped on the Rio Grande near San Ildefonso, N. Mex., in August, 1874, a large lizard presumably of this species [the Gila Monster] visited the camp, but was not secured, owing to the fact that its sudden appearance frightened the packer, who supposed it to be an alligator." It may have been an exceptionally large E. obsoletus.

Many-lined Skink, _Eumeces multivirgatus_ Hallowell

The Many-lined Skink proved to be a relatively easy to find in LA/NERP although it is infrequently observed on the surface. Only four of these skinks were seen foraging in the open. One was on the sandy bank of the stream bed perhaps 15 m from the stream that flows out of Pueblo Canyon. Two juveniles were observed in the tall grass along the permanent stream in Sandia Canyon at an elevation of almost 2000 m. One managed to escape into the grass, but the other was captured when it attempted to climb the vertical surface of corrugated iron that had been placed along the stream to protect it while the road above was being constructed. The fourth skink seen abroad was climbing the perpendicular side of a large rock at the border of a deep pool. Skinks were never observed in the open in the canyons that lacked streams, although it is virtually certain that these lizards sometimes bask surreptitiously. One found under a log in the north fork of the Cañada del Buey had a body temperature of 31.6° C when the air was 26°C and the underside of the log was 14.5° C. The lizard had undoubtedly been foraging or basking before it sought shelter under the log as I approached to turn it. Most of the skinks were found by overturning logs, although one found on A North Mesa was under a board, and two others were beneath rocks in the same area. Two were under one rock in Sandia Canyon. [illegible] of _E. multivirgatus_ were obtained in the following canyons: Bayo, [illegible], Cedro, and both branches of the Cañada del Buey. Except in Pueblo [illegible] the narrower portions of the canyons, where the ponderosa pine forest is intermixed with Douglas fir, _Pseudotsuga menziezii_, white fir, _Abies concolor_, and larger clumps of Gambel Oaks, _Quercus gambelii_. A permanent stream in Sandia Canyon where skinks occurred mainly near the 2050 m contour is flanked by the same conifers and oaks with such shrubs as _Cornus stolonifera_ and _Jamesia americana_ along the stream. The skinks found at the east end of North Mesa were in piñon-juniper forest, at 2150 m, but in the canyons these lizards were not seen below 1950 m or above 2050 m.

Perhaps <u>E. multivirgatus</u> can be found at lower elevations on years when the summer rainfall is not so far below normal as it was in 1978 and 1979. Moist habitats and an abundance of logs in Los Alamos Canyon near the reservoir at elevations above and below 2300 m. looked promising, but I failed to find any skinks here or at the lower end of the canyon near the 2000 m contour. Efforts to find skinks in Water Canyon by overturning logs and rocks along the intermittent stream proved to be fruitless the one time I visited the area on August 25, 1979.

Many-lined Skinks may occur in Ancho Canyon, although a search for these lizards in the ponderosa pine forest near the elevation of 1950 m, where the floor of canyon is relatively wide and fairly flat may have been too dry for <u>Eumeces</u> to be near the surface. Degenhardt (1975) found <u>E. multivirgatus</u> at elevations ranging from almost 1900 to 2050 m in the canyons of Bandelier National Monument adjacent to the southwestern corner of LA/NERP. Whereas Degenhardt found this species, as well as <u>E. obsoletus</u> in Frijoles Canyon, he notes that the Great Plains Skink was in rocky areas at somewhat lower elevations. Gehlbach (1965) reports that in the Zuñi Mountain area of New Mexico <u>E. multivirgatus</u> is "decidedly less saxicolous than <u>Eumeces obsoletus</u>," and the two apparently do "not occur in ecological sympatry." The larger species will undoubtedly be found at elevations well above the lower end of Ancho Canyon, the only record for the species in LA/NERP at present, but in view of what has been published concerning their distributions elsewhere, we cannot expect to find <u>E. obsoletus</u> and <u>E. multivirgatus</u> sharing the same habitats should their distributions overlap in the Jemez Mountains.

At the time Taylor (1936) published his monograph of the genus <u>Eumeces</u>, the species <u>E. multivirgatus</u> was known from few localities in New Mexico. In recent years it has become apparent that skinks referable to this species are relatively easy to find in a wide range of habitats in New Mexico. Ironically, however, the Many-lined Skink, which Taylor regarded as "one of the most distinct tive" members of the genus in the United States is perhaps more variable than any of its congeners. Mecham (1957) provided convincing evidence that skinks diagnosed as representing species designated as Eumeces gaigei and E. taylori are actually variants of E. multivirgatus. Much of the confusion that existed was attributable to ontogenetic changes in pattern, changes that vary from population to population within the range of the species. A north-to-south trend in the patterns of adults is discernible, from well-defined stripes to variable stripes and finally to unstriped specimens (but see below) in three segments of a cline of sorts that extends from Nebraska and eastern Colorado southward beyond the Guadalupe Mountains in Texas. Patterns once believed to characterize three "distinct species" proved to be present on skinks in some populations. Unicolored skinks, first reported in the Guadalupe Mountains, are encountered in samples from other areas in New Mexico. Mecham, who assembled a sample of 25 specimens from the southern extremity of the range, between the elevations of 975 and 2500 m in the Guadalupe Mountain region, found that fewer than half of the skinks retained the striped pattern; 52 per cent of the skinks in the sample were unicolored, and most of them were from sites at elevations below 1700 m.

Moreover, Mecham obtained evidence that skinks more or less uniformly olive brown in color and devoid of stripes represented an allelomorphic pattern phase of the more widely distributed skinks with stripes that had long borne the name E. multivirgatus. While searching for skinks in a forested area at an elevation of 2250 m in the Guadalupe Mountains on 28 April 1954, Mecham found a unicolored, gravid female under a rock with a striped male. The female was isolated in a laboratory terrarium, where it laid five eggs on 30 May that hatched nearly a month later on 28 June. Two of the hatchlings, Mecham reports, closely resembled the striped young characteristic of E. multivirgatus. The other three differed markedly, however, for they lacked longitudinal stripes or lines. Hence they resembled the unstriped mother that earlier investigators would have erroneously regarded as a distinct species, "Eumeces taylori." Plainly this view is no longer tenable now that Mecham has shown conclusively that an unstriped female can produce both striped and unstriped progeny in the same litter.

With a bare majority of 52 per cent of the skinks in the Guadalupe Mountain region conforming to the "taylori phase," Mecham made no effort to recognize the name at the subspecific level. Nevertheless, he suggested recognition of a nominate subspecies, E. m. multivirgatus, applying this name to the populations largely restricted to the sandhill and prairie region of southeastern Wyoming, eastern Colorado, and much of Nebraska, where skinks of the species were subject to relatively little variation. The skinks inhabiting the areas to the south, mainly New Mexico, Arizona and western Texas, where they occupied a wide range of habitats, were admittedly "much more variable." Nevertheless, Mecham suggested that such populations be grouped under the name Eumeces multivirgatus gaigei (preoccupied by E. m. epipleurotus of Cope).

Unfortunately, the skinks of the species since reported in southwestern Utah, and adjacent portions of Colorado, as well as from Arizona, New Mexico and Texas, have revealed a far more extensive range in variations than Mecham had forseen. Maslin (1957), for example, illustrated the patterns of two juveniles and three adults representing populations in two counties in Colorado and one county in Utah. Even without the complications arising from ontogenetic changes in pattern, Maslin's figure reveals that adults of E. multivirgatus are represented in southern Colorado and southeastern Utah by three distinguishable modes of striping. W. W. Tanner (1957) depicts patterns that he regarded as representing three subspecies even though all of the specimens were from Coconino County, Arizona. The pattern that Tanner identifies as that of "E. multivirgatus taylori," is shown with vestiges of the upper lateral stripe. Fainter vestiges are mentioned for specimens taken as far north as Nebraska, and they are discernible on an adult female from LA/NERP. Mecham describes vestiges of these stripes only on hatchlings of "taylori" from the Guadalupe Mountains.

Gehlbach (1965) plotted snout-vent lengths against pattern peculiarities to show the ontogenetic change from the pattern of E. m. multivirgatus to that of E. m. epipleurotus

In a sample consisting of five juveniles and 25 adults from the Zuñi Mountain region, Gehlbach states that a "complete pattern reduction can be observed in this variable sample comparable to Tanner's diagrams B through D," which, as noted above, Tanner assigned to three subspecies. It may be inferred from Gehlbach's statement that nearly patternless specimens were included in his sample; although he considered the sample intermediate between E. m. multivirgatus and E. m. epipleurotus, he declined to recognize E. m. taylori as a "nongeographic subspecies." Specimens later reported by Mecham (1967) from the Texas High Plains, some 135 to 175 km east of one reported earlier as E. m. multivirgatus from Lea County, New Mexico, revealed peculiarities that prompted him to modify views expressed earlier. Though Mecham notes that he is fully cognizant of his earlier restriction of the name E. m. multivirgatus to populations in northwestern Nebraska and the adjacent areas, after discussing the divergence as well as possible adaptive convergence in the High Plains and Lea County specimens he decided to call them "intergrades between E. m. multivirgatus and E. m. gaigeae [=E. m. epipleurotus]."

Mecham describes specimens among those he called intergrades as belonging to the patternless or "taylori" phase. One of these was "paler in color than the same phase from the Guadalupe Mountain region." Mecham adds that "a light line only slightly paler than the ground color is faintly indicated on the third scale row." In this respect it evidently resembles an essentially unicolored specimen from Nebraska, described by Heyl and Smith (1957) as having faint vestiges of stripes. The individual that Mecham obtained in Texas deposited four eggs on 23 May, 1966 that hatched on 24 or 25 June. All four of the offspring were "of the taylori phase," but were much darker than the unstriped young of the form that Mecham had previously described from the Guadalupe Mountain region. Further evidence of divergence in the population from the High Plains is suggested by Mecham's comparison of the hatchlings with those produced by the female from the Guadalupe Mountains. The mean overall length of the latter was more than 21 per cent greater than the mean for the High Plains litter of four.

The discovery of E. multivirgatus at three localities clustered around Lubbock in the High Plains of Texas led Mecham to suggest that the species "was once common over much of the Texas Panhandle before most of the native grassland was destroyed by agriculture." Within relatively recent times, he believes, annectant populations might have permitted gene exchange between the populations in eastern Colorado and the High Plains of Texas. In view of W. L. Tanner's report (1975) of Multi-lined Skinks in Chaves, DeBaca and Roosevelt Counties, as well as additional specimens from four more localities in Lea County, it seems probable that skinks of the species were recently more or less continuously distributed throughout southeastern New Mexico and on into Texas south of the Canadian River. Gene exchange was perhaps maintained with populations in the Guadalupe Mountains even after annectant populations were no longer extant to the northwest of the High Plains. It is not unusual to find evidence of differentiation in disjunct populations beyond the periphery of a more or less continuous range, presumably because such populations are among the first to become isolated with the advent of more xeric climatic conditions. The similarity of the habitats in eastern Colorado and the High Plains of Texas, as Mecham notes, might account for the retention of the same or similar peculiarities as a result of adaptive convergence. In a species as variable as E. multivirgatus, comparisons of adequate samples representing any two local populations would inevitably reveal differences. In fact, the distribution of these skinks in much of New Mexico is now probably discontinuous.

Applegarth (1979) who has plotted records of E. multivirgatus for nine localities in Eddy County, believes that as a result of the semiarid climate now prevailing in the Carlsbad area, "this species may be restricted to a few mesic refugia" near springs or spring-fed streams. In Applegarth's opinion, Multi-lined Skinks at the southern extremity of their range, in southern New Mexico, western Texas, and northern Mexico are found as isolated populations that "live in mountains and relatively mesic locations in valleys." In view of the occurrence of these skinks in the grasslands of the Texas High Plains and the sandhills of eastern Colorado and western Nebraska, it seems odd that Gehlbach (1965) failed to find the species in the Plains Life Belt of the Zuñi Mountain area. This belt includes extensive areas that earlier authors had mapped as "mixed grasslands," or "short-grass plains" according to Gehlbach. He attributes the absence of E. multivirgatus in such areas to their avoidance of E. obsoletus, which reaches its maximum abundance in the Plains Life Belt. In New Mexico sporadic droughts as well as grazing pressures have probably eliminated grassland in many areas. Within the last century the impact of such human activities as logging and ranching, particularly where overgrazing was involved, may well have fragmented the former distribution of E. multivirgatus.

At the time Mecham (1957) published his map showing the distribution of pattern types in E. multivirgatus, the patternless "taylori phase" was known from but three of a dozen localities in New Mexico. The northernmost record for the unstriped form was in Bernalillo County. The only samples Mecham had examined that contained striped as well as unicolored individuals were from the Guadalupe Mountains in Culberson County, Texas, where 13 specimens had been taken in the Transition Zone, and two had been obtained "near a spring" in the Upper Sonoran Zone. The preponderance of the taylori phase in populations below 1675 m in elevation prompted Mecham's observation that the absence of stripes might be selectively advantageous in "the lower and more xeric habitats." Conant (1975) suggests the unicolored form "blends better with the rocks and soils in the open, arid landscape." Now that both striped and unstriped individuals have been reported from such widely separated areas as western Nebraska, the High Plains of Texas, the Zuñi Mountain region of northwestern New Mexico, and Coconino County, Arizona, it is not unexpected to find the patternless form in LA/NERP.

The 30 specimens in the sample from the Zuni Mountain region that Gehibach (1965) discusses were from 10 collecting sites distributed over an area that extends from Fort Wingate across the Continental Divide to a locality almost 100 km to the southeast. Gehibach reports that in this region multi-lined skinks occur "in a wide variety of Roughlands situations, but most often they are taken in heavy cover such as the oak-mahogany and riparian associations where broadleaf litter was abundant. A few were found under rocks and logs in the dryer pinyon-juniper and ponderosa pine associations." The sample could include specimens from several disjunct populations from an array of habitats perhaps somewhat more varied than the riparian, piñon-juniper and mixed conifer associations where skinks were found in LA/NERP. In contrast to Gehibach's sample, however, the 16 specimens from the Jemez Mountains were all obtained within five kilometers of the collecting site in Sandia Canyon. The sample, therefore, probably represents a single population of interbreeding individuals.

The specimens from LA/NERP range in snout-to-vent lengths of 28 to 34 mm for three juveniles, through 38 to 47 mm, for four half-grown individuals, to a range of 54 to 70 mm for nine adults. The largest adult is a male from the Cañada del Buey, but a female from Sandia Canyon is nearly as large, with snout-to-vent measurements of 67 mm.

As might be expected, the patterns represented on skinks in the sample vary extensively. The markings on juveniles consist of five light stripes: a median stripe that bifurcates at the back of the head (Pl. , fig 1); paravertebral stripes on the third scale rows (counting from the middle of the back); and lateral stripes on the sixth scale rows. The paravertebral stripes are more sharply defined than the median and lateral stripes, but variations are discernible in the three specimens.

The bifurcation of the median stripe is missing on the half-grown individuals, but all five stripes are retained on three of them. The fourth retains the light stripes on the third scale rows, and vestiges of the light stripes on the sixth scale rows. These remnants of stripes extend from the ear openings posteriorly and gradually disappear behind the insertion of the forelimbs. The scales below the sixth row are grayish, but between the sixth row and the third row they are brown, slightly darker than the area between the paravertebral stripes (Pl. fig. 2). It seems relatively certain that this half-grown individual without any trace of the median stripe, but with somewhat reduced paravertebral stripes and faint vestiges of the lateral stripes, represents an intermediate stage in the ontogenetic trend that leads to the nearly unicolored condition. The only essentially patternless adult in the series is a gravid female from Sandia Canyon, the one mentioned above as the largest female in the sample. Faint remnants of the paravertebral stripes are barely discernible on this specimen (Pl. fig. 3). Without additional specimens from the area, however, it is uncertain whether the half-grown individual ever resembled the patterned juveniles in the sample that have sharply defined median stripes. The "*taylori*-like" hatchlings of the unicolored female from the Guadalupe Mountains that Mecham (1965) describes lacked stripes, but he mentions a pale brown streak that extends over the eye, "back over the shoulder, and dwindles away on the anterior portion of the body." In this respect the hatchlings Mecham describes more closely resemble the adult female than the half-grown female, one with snout-to-vent dimensions of 56 mm that was captured in the Cañada del Buey. These two females are the only skinks in the LA/NERP sample that lack the middorsal stripe, and they may not be identical with the similar allelomorphic pattern phase found in the Guadalupe Mountains. At least five other lizards identifiable as striped examples of *E. multivirgatus* escaped capture in the Los Alamos area. If the immature female lacking the median stripe is legitimately grouped with the virtually patternless adult, therefore skinks with the normal complement of stripes are roughly ten times as numerous in the LA/NERP population as the "*taylori* phase." Mecham's sample from the Transition Zone of the Guadalupe Mountains of Texas consisted of 11 striped individuals and two of the "*taylori* phase." Neither sample is sufficiently representative to afford a reliable index, but the limited evidence available suggests that patternless skinks of the species occur with decreasing frequency from south to north, as well as from lowland to montane habitats.

The stripes on the eight patterned adults from LA/NERP vary so extensively in width and intensity that no two individuals have the same pattern. The light median stripe may encompass the two median scale rows, or it may be restricted to their inner margins. The stripe may be as nearly white as the paravertebral stripes, or it may be light brown. Each paravertebral stripe is bordered above by a narrow dark stripe. ~~that may~~ have serrated margins. These light stripes on the third scale row on each side of the dorsum are the most conspicuous features of the pattern. In contrast are examples of the nominate subspecies, E. m. multivirgatus from Colorado, where the median stripe, is margined with black lines. It is commonly more conspicuous than the paravertebral stripes, which may be bordered by rows of dark scale margins rather than sharp lines. Some individuals in the LA/NERP sample more closely resemble those of the nominate subspecies than others. However, the overall appearance of skinks from plains habitats in Colorado and Nebraska suggests that they have smaller percentages of dark (brown or black) pigments in their patterns than skinks taken farther south that are currently recognized as Eumeces multivirgatus epipleurotus.

While the preceding account was being prepared, Mecham's (1980) detailed summary of virtually everything ever published that concerns Eumeces multivirgatus brings our knowledge of the species up to date. Although Mecham continues to recognize two subspecies, he now regards the skinks inhabiting the plains of southeastern New Mexico and the High Plains of Texas to the east as representing a population of "uncertain subspecific status." The range of the nominate subspecies, E. m. multivirgatus, is mapped as extending from southeastern Wyoming eastward over much of Nebraska and southward along the eastern flank of the Rocky Mountains in Colorado. Specimens from southern Colorado, southeastern Utah and central Arizona, along with those from the mountains of New Mexico as far to the southwest as Grant County west of the Rio Grande, and to the Guadalupe Mountains of New Mexico and Texas north-east of the river, are referred to E. m. epipleurotis. Mecham's map shows three disjunct populations to the south, one in northern Chihuahua and two in Texas, like those in the plains of southeastern New Mexico and the adjacent plains of Texas, regarded as being of uncertain specific status. Although Mecham plots one locality in southwestern South Dakota, and another in southern Chihuahua, he regards both of these as questionable. Whereas Mecham (1957) listed seven specimens from San Miguel County in New Mexico, D. L. Tanner (1975) omits them from his lists as well as his map. These skinks remain unrecorded north of San Miguel County east of the Sangre de Cristo Mountains, although Tanner lists another species, E. obsoletus, from three localities on the Canadian River in San Miguel County. There appears to be an interdigitation of the distributions in Roosevelt, Lea and Eddy counties, where Tanner plots localities for both species. Tanner lists a specimen of E. multivirgatus from 1.6 km SW of Eastern New Mexico University, 0.8 km. N of Highway 70, apparently only 0.4 km south of the source of a specimen of E. obsoletus listed on the preceding page. The occurrence of both species within 400 m of each other cannot be construed as evidence of ecological sympatry, although both species have seemingly become adapted to plains habitats in this portion of New Mexico.

As far as published records for E. multivirgatus are concerned, the population in [illegible] is at the eastern periphery of the range, but probably not isolated from skinks of the species inhabiting Bandelier National Monument. Little effort seems to have been made to find this species in the foothills along the western slope of the Sangre de Cristo Mountains. (Whereas Taylor (1935) listed the two specimens he had taken near Taos (the types of his Eumeces gaigei) and one from Pecos in San Miguel County, he inadvertantly plotted two of these on the Canadian River when he mapped [illegible] distributions of New Mexican specimens he referred to two species.) There are undoubtedly populations to be discovered in the foothills between Taos and Santa Fe, probably with annectant populations in Apache Pass that will extend the distribution to the Pecos River where it emerges from the Sangre de Cristo Mountains. At present there are no records for Santa Fe County although during the spring of 1977 I found a striped skink that escaped capture when I turned over a board inside the city limits of Santa Fe.

Snakes, Suborder Serpentes

Typical Harmless Snakes, Family Colubridae

Striped Whipsnake, Masticophis taeniatus Hallowell

It is difficult, if not impossible to account for the distribution of the striped whipsnake. It occupies an extensive area from the Gulf Coast of Texas northwest through most of New Mexico, and much of the Great Basin to inland portions of Oregon and Washington. On the whole the whipsnake seems to be more at home in piñon-juniper woodland, but it inhabits a wide range of environments, particularly rocky areas, between sea-level and 2850 m. Relatively minor variations in the pattern and color of this whipsnake are detectable, but specimens from southern New Mexico closely resemble those obtained in the state of Washington. It is exceptional to find a snake occupying such an array of habitats without having adaptive modifications readily apparent in its pattern or coloration. In spite of the stability in pattern characters in the populations distributed over some 2500 km to the northwest, those to the southeast have become differentiated into three additional subspecies. Between El Paso and the Gulf Coast of Texas four populations, each with a distinctive pattern, have evolved.

Whipsnakes, the slender, fast-moving, diurnal snakes grouped in the genus Masticophis, are represented in the United States by four species. Three of these species occur in the extreme southwestern corner of New Mexico. In addition to the striped whipsnake, M. taeniatus, the coachwhip, M. flagellum, and the Sonoran whipsnake, M. bilineatus, have been found in Hidalgo County. The coachwhip is largely restricted to open valleys, and the other two are more often seen in the foothills. The Sonoran whipsnake is more commonly observed in trees or shrubs, and apparently it preys on young birds as well as on lizards. The extent of the differences in the feeding habits of the three species has not been ascertained. So few specimens have been available from Hidalgo County that it cannot be said with certainty whether their distributions actually overlap or interdigitate, but all three species are known to prey on lizards, perhaps more often than on other vertebrates. It seems probable, therefore, that some means of avoiding competition has evolved in the relatively limited area where the ranges of the three species ostensibly overlap. Actual sympatry of any two of the three species remains to be demonstrated, and without more detailed information it cannot be completely ruled out as a possibility.

The population of M. taeniatus in LA/NERP may well be confined to the relatively open areas toward the lower sections of the canyons. The only specimen I observed during the two summers that I worked in the area was found dead on the road in Pueblo Canyon at an elevation of ca. 1900 m. This is in an area where there is a strong influx of ponderosa pine in the pinon-juniper woodland, not far from the stream that drains Pueblo Canyon. Mr. Ted Brown obtained a specimen near the mouth of Los Alamos Canyon not far west of Otowi Bridge at an elevation of 1675 m. The species may prove to be more or less continuously distributed along the Rio Grande, for Degenhardt (1975) notes that this whipsnake was observed during June and July in White Rock Canyon in Bandelier National Monument, where the dominant vegetation is juniper, sagebrush, Artemisia tridentata, sand dropseed, Sporobolus cryptandrus, and blue grama grass, Bouteloua gracilis.

Degenhardt regards the striped whipsnake as being "quite abundant within its limited distribution in the Monument", whereas Gehlbach (1965) reports only three specimens from the Zuni Mountain area, in Valencia and McKinley counties. He adds, however, that " 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." Gehlbach defines the Roughlands Life Belt as extending from 2075 m to at least 2440 m above sea-level in the rocky uplands. "The 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 belt includes the upper part of Bailey's (1913, pp. 25-46) Upper Sonoran Zone and lower limits of his Transitional Zone --- and pinyon-juniper and lower ponderosa pine zones of Pearson (1931).

Coachwhip Snake, Masticophis flagellum Shaw

Many of the 122 species of snakes currently recognized as inhabitants of the United States occupy extensive portions of the country. Owing to specializations of one sort or another, however, others are restricted to peninsular Florida, portions of the Southwestern deserts, isolated mountains, or perhaps with distributions that barely extend across the international border from Mexico. Only six of the 122 species are distributed from coast to coast, and the ranges of all but two of these are to some extent fragmented. The only two that can be regarded as being fairly continuously distributed across the lower half of the United States are the common kingsnake, Lampropeltis getulus, and the coachwhip.

Although M. flagellum shuns the higher mountains as well as the swamps and heavily wooded areas, it is sufficiently adaptable to occupy habitats ranging from dry flatwoods, rosemary scrub, and high pine habitats in Florida, grassland and the wooded, sandy flood plains of streams in the Middlewest, to creosote bush and mesquite grassland in the southwestern deserts, and thorn forest and short-tree forest in northwestern Mexico. In New Mexico the coachwhip is widely distributed in the Lower Sonoran deserts characterized by creosote bush and mesquite, extending into the Upper Sonoran Zone on both sides of the Sangre de Cristo Mountains. Its dispersal in the lowlands has permitted it to penetrate the central portion of the state, following the Río Puerco and the Río San José to reach Laguna and the vicinity of Grants (Gehlbach, 1965) in Valencia County. The coachwhip turns up sporadically around Santa Fe, where it must approach the upper limit of its range slightly above 2100 m in the piñon-juniper woodland. Ted Brown has obtained specimens in the vicinity of Poajoaque and San Ildefonso, but the species seems to be less frequently seen west of the Rio Grande. The only individual I obtained was found dead on the highway that crosses the wide, relatively flat terrain in Mortandad Canyon at an elevation of 1600 m. The habitat here is characterized by piñon-juniper woodland, with a few small Gambel oak.

Vision plays a prominent role in the foraging activities of whipsnakes. Kingsnakes, bullsnakes and rattlesnakes, among others that evidently make more extensive use of their sense of smell, are less dependent on their sight. They avoid the surface during warm summer days and hunt for their prey at night. The whipsnake is strictly diurnal, however, and in the warm desert lowlands of the Southwest it is the only snake likely to be seen abroad during the hours of daylight. The coachwhip's ability to tolerate such conditions reflects its ability to move swiftly enough to seek shelter at frequent intervals. The most productive deserts are honeycombed with the burrows of rodents and lizards and the coachwhip can readily dissipate the heat it has absorbed on the surface by retreating a few centimeters below it.

The rapidity of its movements, therefore, permits the coachwhip to be active when other snakes have been forced to retreat. This stream-lined serpent is probably the fastest snake in the United States, but it is swift only in comparison with other snakes. On rough terrain a frightened coachwhip can often glide through shrubs, around rocks or other objects at speeds much faster than those of a man in pursuit. Actually it is questionable whether the snake can travel faster than eight to ten km/h, even for a short burst of speed. In relatively open terrain but with a surface sufficiently rough to permit the snake to gain traction, the coachwhip is readily overtaken by a man proceeding at a fast walk. Nevertheless, this snake with a large percentage of its body in contact with the substratum while crawling absorbs heat at a relatively rapid rate. Heat is received by conduction from the ground, as well as from the sun's radiation. In an effort to ascertain how rapidly a coachwhip might absorb heat under such conditions, as well as to obtain a rough idea of the maximum body temperature the snake could tolerate, a simple experiment was carried out.

The snake tested was obtained 6.7 km west of Boulder City, Nevada. The place selected was a dry lake 9.9 km south of the site of the snake's capture. The dried mud bottom of the dry lake was sufficiently rough to permit the snake to crawl without difficulty. The coachwhip was liberated on the lake-bed at 1430, on 5 August, when the temperature of the air one meter above the ground closely approximated 41° C. The temperature of the hard, cracked surface of the lake bed, although measured with questionable accuracy by applying the bulb of a mercury thermometer to the surface, closely approximated 50°C when the instrument was shaded to exclude solar radiation. The cloacal temperature of the snake at the time of its release was 35.3°C. The cloacal temperatures of four other coachwhips, obtained at the time of their capture earlier in the summer, varied from 27.5°, 29.8°, 35.2° to a maximum of 38.9°C. This is probably little more than an approximation of the range in cloacal temperatures for the coachwhip while prowling during the summer.

Perhaps prompted by the heat from the substratum the snake set out at a moderately fast speed, following a relatively straight course for 36.5 m. Then, for no apparent reason, the snake turned to the left at a 90° angle and travelled 5.5 m before it again turned in much the same fashion so that it followed a course that brought it back to within a few meters of the liberation site. The time required for the snake to travel 78.5 m proved to be slightly less than 3 min. The average speed of the coachwhip while travelling on the dry lake bed, therefore, was little more than 1.5 km/h, although it began to move more slowly toward the end of the three-minute period. Before four minutes had elapsed the snake behaved as though the posterior two thirds of its trunk had become paralyzed although the snake was moving the anterior third of its body in an erratic, uncoordinated fashion. This movement gradually subsided, and six minutes after its release on the hot surface no movement was detectable. A thermometer thrust into the snake's mouth revealed that its body temperature immediately behind the head had risen to 45.9°C. The snake remained motionless, with the body rigid, although the heart continued to beat for approximately ten minutes after the onset of paralysis at the posterior of the trunk.

Until more extensive experiments have been carried out with coachwhips and other snakes, uncertainties remain, but the few other snakes thus far tested seem to reach their upper limits of tolerance at levels somewhat below 45°C. The snakes with distributions wholly restricted to the warmest arid deserts are either nocturnal or readily shift to nocturnal activities during the warmest part of the year. Consequently they readily avoid the hot surface temperatures that the coachwhip tolerates. Even though a snake prowling on the surface at temperatures comparable to those on the dry lake where the individual was tested might reach potentially lethal thermal levels within two or three minutes, coachwhips can ordinarily gain access to subsurface shelters in much less time. Nevertheless an abundance of burrows large enough to accommodate the relatively slender body of the coachwhip may well be the sine qua non for its survival in the hotter desert environments.

As might be expected in a species that occupies extensive portions of North America, from Florida to northern California, and from southwestern Nebraska in the United States southward through nearly all of northern Mexico to eastern San Luis Potosi and extreme northern Veracruz, some characters vary extensively. This is particularly true of the color and markings, with ontogenetic changes in the pattern, and the widespread occurrence of melanism further complicating efforts to define subspecies. The individuals in some populations, particularly those to some extent isolated at the periphery of the range of the species, tend to vary less than those inhabiting environmentally diversified areas near the middle of the range. Seven subspecies of Masticophis flagellum are recognized in a recent review (Wilson, 1970), that attempts to define them on the basis of pattern. The futility of this procedure becomes evident, however, when the author lists no fewer than seven "pattern classes" for the subspecies, M. f. cingulum inhabiting the area that extends from southeastern Arizona through Sonora to northern Sinaloa in Mexico. The subspecies inhabiting New Mexico is designated as M. f. testaceus, although Wilson evidently considers all specimens from the valley of the Rio Grande from Albuquerque southward to Mexico and westward Arizona as "intergrades between lineatulus and testaceus." It is difficult to reconcile this statement with the distribution he shows for lineatulus in his map (fig. 3) as being largely restricted to the Chihuahuan Desert. A large percentage of the specimens examined are evi-

Mountain Patchnosed Snake, Salvadora grahamiae Baird and Girard

The patchnosed snake inhabiting the foothills of the Jemez Mountains is one of seven species grouped in the genus Salvadora. It was also the first patchnosed snake to receive a scientific name. It became the type species of the genus when the name first appeared in print in 1853, based on a specimen that Colonel James D. Graham had obtained while he was with the Mexican Boundary Commission from 1850 to 1852. Graham indicated that the specimen had been taken in "Sonora," but his travels south and east of Tucson were largely restricted to terrain that became part of the United States after the Gadsden Purchase of 1853. Graham ventured only as far as the village of Santa Cruz, a few kilometers south of the present international boundary. Studies of patchnosed snakes in this part of their range leave little doubt that the holotype of Salvadora grahamiae came from the vicinity of the Huachuca Mountains, in what is now the southwestern corner of Cochise County, Arizona.

Owing to the relative scarcity of patchnosed snakes they had been accumulating in scientific collections for more than a hundred years before systematists could ascertain the relationships and distributions of the six additional species that eventually were to be grouped with Salvadora grahamiae. Investigations were hampered by inadequate samples as well as imprecise type localities, and at least three other species were confused with S. grahamiae before the complexity of its distribution could be demonstrated. It can now be shown that snakes of the species occupy habitats ranging from near sea-level on the Gulf Coast of Texas westward to the Baboquivari Mountains southwest of Tucson, Arizona. Specimens had been available from Sandoval County, including one from Bandelier National Monument, before the species became known from five localities in Santa Fe County. The species proved to occur as far north as southern Rio Arriba County in 1977, when Ted Brown found a specimen dead on the road to Puye Cliff Dwellings, roughly eight kilometers west of the Rio Grande. It has since been found as far north as Embudo Canyon At the southern extremity of its range S. grahamiae is known from specimens obtained in the states of Hidalgo, Queretaro, Zacatecas, and Durango. In each of these states, as well as in the state of Chihuahua at the northwestern extremity of its distribution in Mexico, S. grahamiae is replaced in more humid habitats of the Volcanic Cordillera and the Sierra Madre Occidental by a closely related species, Salvadora bairdi. This species so closely resembles the Gulf Coast populations of S. grahamiae that investigators around the turn of the century regarded them as representing the same species. With larger, more representative samples, consistent differences could be found, with no evidence of interbreeding in the area in Mexico where they occupy contiguous ranges. Evidence recently assembled suggests that the superficial similarity of S. grahamiae populations inhabiting the humid portions of Texas and northeastern Mexico, mainly east of the 100th meridian, and the populations of S. bairdi inhabiting the Central Plateau, qualifies these two forms as sibling species.

Mountain patchnosed snakes in New Mexico closely resemble those from Arizona, as well as those inhabiting isolated mountain ranges in and around the Chihuahuan Desert, from western Texas southward to Zacatecas and Durango. Now that many gaps in our knowledge of the distribution of S. grahamiae have been filled, it can be shown that the darkest specimens come from humid environments, particularly in the lowlands bordering the Gulf Coast of Texas and Mexico. The pattern on snakes from this region consists of two brown stripes on each side of a light vertebral stripe. The paravertebral stripes are almost three times as wide as the narrow lateral stripes from which they are separated by equally narrow light stripes. The climate becomes progressively drier toward western Texas, with concomitant changes in the pattern of the patchnosed snakes. The general trend is toward a reduction in the width of the brown stripes, with the light vertebral stripe, as well as the pale stripe separating the brown stripes, becoming increasingly wider. Although snakes from the more xeric habitats have essentially the same pattern as those farther east, they are appreciably lighter in their over-all color.

The trend toward a reduction in the width of the brown stripes reaches its limits with the loss of the lateral stripe. Snakes with readily discernible lateral stripes occur as far west in Texas as Devils River in eastern Val Verde County. Farther west in the same county, at almost precisely the level where the annual precipitation drops below 500 mm, snakes with lateral stripes are replaced by others that have either lost all trace of the lateral stripe or retain only vestiges. In other words, patchnosed snakes with four stripes range across Texas almost to the Pecos River, but from this stream westward to south-central Arizona *S. grahamiae* is represented by snakes with only two stripes. Like the holotype that Graham probably obtained in the Huachuca Mountains, these snakes are bluish grey, with markings reduced to a broad, virtually white vertebral stripe flanked by brown stripes nearly as wide.

Whereas Schmidt (1940) regarded patchnosed snakes from southeastern Texas and the adjacent portions of Mexico as a distinct species, specimens more recently available leave no doubt that this population is incompletely differentiated from *S. grahamiae*. The presence of a readily discernible lateral stripe is the only character that easily distinguishes the form described by Schmidt, but it can be retained as a subspecies, *S. g. lineata*. Populations containing snakes on which the lateral stripe has been greatly reduced but not completely lost occur mainly around the periphery of the Chihuahuan Desert, as mapped by Miller (1977:366). Isolated mountains in this desert, however, are occupied by patchnosed snakes assignable to the nominate subspecies, *S. g. grahamiae*. In essence the distribution of *S. g. lineata* is roughly J-shaped, for it extends southward around the Chihuahuan Desert through parts of Queretaro, San Luis Potosi, Zacatecas and Durango, and thence northwestward through eastern Durango to southwestern Chihuahua. The range of *S. g. grahamiae*, though contained on three sides at the south, extends off to the north and west, with disjunct populations in the isolated mountains from the Chisos in the Big Bend of Texas, westward to the Baboquivari Mountains in southern Arizona.

The distance between the Pecos River in Texas, the eastern extremity of the range of *S. g. grahamiae*, and the westernmost outpost of the subspecies in the Baboquivari Mountains in southern Arizona, is roughly 900 km. The latitudinal distribution of the Mountain Patchnosed Snake, however, is far more extensive, for it extends through 12° of latitude, almost to the Tropic of Cancer. The evidence that has been accumulating for well over a century suggests that the distribution of this form is discontinuous from southern New Mexico to Zacatecas. Owing to the restriction to mesic refugia, it is largely restricted to foothill habitats, from 1000 to 2000 m above mean sea-level. The mountains it occupies are commonly surrounded by creosote bush-saltbush desert, an environment shunned by *S. g. grahamiae* except in those portions of the deserts traversed by streams.

Whether the nominate subspecies is continuously distributed along the rivers in New Mexico, or represented by disjunct populations bordering truly riparian habitats along the Pecos, Rio Grande and the headwaters of the Gila River, remains uncertain at present. Additional collecting will undoubtedly fill many of the gaps between the sites where the snake is now know to occur. The Mountain Patchnosed snake is more often found in rocky areas, in canyons or open terrain, usually near springs, creeks or rivers. Nevertheless it spurns the relatively dense shade characteristic of truly riparian habitats.

The only patchnosed snake found in or near LA/NERP while the area was being surveyed was obtained near the mouth of Sandia Canyon on 28 September 1979. The snake was foraging in a rocky area scarcely 200 m from the Rio Grande, at an elevation of 1660 m. Like other patchnosed snakes, *S. g. grahamiae* is known to prey on small lizards, particularly whiptails of various species. Few were seen in the immediate area although at least two species occur near the mouth of Sandia Canyon, which is scarcely 12 km from the northernmost record for the species. It has been observed on both sides of the Rio Grande near Otowi Bridge, and it seems probable that the patchnosed snakes thus far found in the canyons draining into this portion of the river from Bandelier National Monument northward to the road leading to Puye Cliff Dwellings all represent a single interbreeding population.

Smooth Green Snake, Opheodrys vernalis Harlan

Two species of green snakes occupy extensive portions of the United States, but the nearest relative of O. vernalis is probably O. major, an inhabitant of southeastern Asia. These two species are so similar in color as well as in scutellation that Schmidt and Necker (1936) had no hesitancy in regarding them as being congeneric. Both species are diurnal, largely insectivorous, and terrestrial, even though O. vernalis is sporadically seen in bushes. Like its American relative, O. major finds suitable habitats from near sea-level to elevations somewhat above 1800 m, although it is reported to be more abundant in mountain forests. O. vernalis is one of the few reptiles known to occupy habitats in the spruce-fir forests, particularly where there are green meadows in the vicinity of lakes or streams. The species may occur elsewhere in the vicinity of LA/NERP but thus far the only specimens known from the immediate area were two found in Los Alamos Canyon near the reservoir at 2300 m by Douglas Duerre in 197 and 197 . The smooth green snake manifests such a strong preference for meadows that it is likely to be restricted to canyons with permanent streams in the Jemez Mountains.

The range of the smooth green snake extends from Nova Scotia westward through glaciated areas both north and south of the Great Lakes to southwestern Manitoba and southeastern Saskatchewan in Canada, and thence southward through portions of the Dakotas and eastern Nebraska to northeastern Kansas. From New England the range extends southward in the Appalachian Highlands to North Carolina. In New England the smooth green snake is regarded as an upland species, but it occupies the plains and prairies of North Dakota, eastern Nebraska and Kansas. To the west and south the range of the smooth green snake is fragmented, although the species is represented in much of

Colorado from mountainous areas, and beyond, in northeastern Utah. The Colorado population is more or less continuous southward in the mountains of New Mexico on both sides of the Rio Grande. Specimens have been reported from Abiquiu and [illegible] Creek, 10 miles east of Tierra Amarilla in Rio Arriba County, and from Santa Fe Canyon in Santa Fe County, as well as from San Miguel County. South of the Sangre de Cristo and the Jemez Mountains the species reappears near Ruidoso in the Sacramento Mountains. An old record for Mesilla Valley in Lincoln County may be questionable, but a snake of the species has recently been found in western Chihuahua near the Continental Divide in Mexico. An isolated population on the Gulf Coast of Texas near the Louisiana border is slightly farther south than the one in Chihuahua.

The population represented in Los Alamos Canyon is close to the southwestern periphery of the Colorado-New Mexico population. Gehlbach (1965) failed to find smooth green snakes in that part of New Mexico covered in his herpetolggical survey of the Zuni Mountain Region, where the ringneck snake, Diadophis punctatus, proves to occur in riparian habitats in at least two localities. Both ringnecks and smooth green snakes were undoubtedly continuously distributed over all but the most elevated (above 2500 m) portions of New Mexico when more humid climates prevailed at least as late as Pleistocene times. Other snakes ill-adapted for survival in xeric environments are largely restricted to isolated mesic refugia in New Mexico.

Great Plains Rat Snake, Elaphe guttata Linnaeus

Improbable though it would seem to me, the rat snake in the Jemez Mountains is the same species that lives in the Pine Barrens of southern New Jersey. The snake that Linnaeus described in 1766 proves to be widely distributed over much of the United States east of the Mississippi. The pattern and color vary extensively, but red and orange pigments are prominent on snakes in many areas. In fact the vernacular name, 'red rat snake ' was sometimes used, even though the snakes from upland areas tend to be blotched with brown. 'Corn snake' is the name most commonly used for the rat snake that became the nominate subspecies, Elaphe guttata guttata. When it became evident that the predominately grey snakes west of the Mississippi belong to the same species, the form we now recognize as the Great Plains rat snake became known as Elaphe guttata emoryi.

Rat snakes from southwestern Illinois westward through most of the Great Plains to southeastern Colorado and the eastern half of New Mexico closely resemble rat snakes in Texas, and the adjacent states in Mexico, where snakes regarded as E. g. emoryi occupy portions of the Chihuahuan Desert, as well as the relatively mesic lowlands of San Luis Potosi. A comparable adaptability of the subspecies is reflected in the northern part of its range, where this rat snake occupies gullies or ravines in the plains, but reaches elevations of nearly 2000 m in the mountains. Evidently the species was once even more widely distributed, for a disjunct population was discovered some years ago on the Pacific side of the Continental Divide, in eastern Utah and the contiguous parts of Colorado. This population inhabits the relatively arid lowlands known as the Moab Desert where it is traversed by the Colorado River. In arid and semi-arid environments these rat snakes often occur near streams or springs.

The first E. guttata known to have been found in the Jemez Mountains was obtained under a log within 50 m of the Rito de los Frijoles, in Bandelier National Monument during the summer of 1933 (Woodbury and Woodbury, 1942).

As far as I have been able to determine, no rat snake has been seen or reported in Bandelier National Monument since 1933. Specimens have become available from the general area, however. On 11 July, 1974 Mr. Ted Brown found one 1.1 km north of Jemez Springs at an elevation of 1900 m in Sandoval County. Another specimen in the collection of the University of New Mexico was obtained near the Rio Grande at Pilar, in Taos County. In view of these records more or less on three sides of LA/NERP, it was virtually certain that this rat snake inhabited the Research Park. The species is not regarded as being abundant in any part of its range, although its seeming scarcity in such canyons as the Rito de los Frijoles can probably be attributed to the relatively dense ground cover on the floor of the canyon and the secretive habits of the snake. Moreover, it is known to forage at night during the warmer months in the arid portions of Texas and the Mexican state of Coahuila, even after the onset of the summer rains.

Until more extensive collecting has been done at night in LA/NERP it is uncertain whether E. guttata becomes nocturnal in the foothills as it does in the lowlands. The only collector known to have found this species is Mr. Douglas Duerre, who often searched for reptiles in the area around White Rock, where he lived until the summer of 1979. During the summer of 1978 Mr. Duerre found a specimen under a rock at an elevation of nearly 2000 m in Pajarito Canyon. The site was north of the stream, where a small ravine dissects the edge of the Mesita del Buey. Roughly a month after finding the first specimen Mr. Duerre went back to the site and found another snake of the species under the identical rock. This specimen was obtained by Mr. Michael Williams, who presented it to the Museum of Southwestern Biology at the University of New Mexico. Through the kindness of Dr. William Degenhardt and with the assistance of Mr. Williams, I was able to obtain a photograph of this specimen. The species can scarcely be so uncommon in the foothills of the Jemez Mountains as our meager knowledge would suggest. Rat snakes may eventually be found in virtually every canyon with a more or less permanent stream. Unless our knowledge of the distribution of E. guttata increases at an accelerated rate, however, another fifty years may be required before its distribution in LA/NERP can be satisfactorily mapped.

Ringneck Snake, Diadophis punctatus Linnaeus

Of the 44 species of snakes now recorded in New Mexico, only five, including the ringneck snake, are known from coast to coast. In much of the humid portion of the United States, where the average annual precipitation is at least 750 mm, ringneck snakes are fairly continuously distributed. West of the 100th meridian, however, where the topography becomes more varied and the precipitation diminishes in the lowlands, mesic environments are largely restricted to elevated areas, either mountains or plateaus. Because D. punctatus is ill-adapted to cope with dry environments, in the Southwest it is more often found in the vicinity of streams or springs in canyons or ravines. It follows that disjunct populations are the rule in the Southwest, where the distribution of Diadophis is among the most fragmented of any snake's.

Populations of ringneck snakes may be expected in almost any isolated mountain high enough to capture enough moisture to support conifers and oaks. Ringneck snakes prove to be represented in such elevated areas as the Providence Mountains of eastern California, even though this range is in the Mojave Desert. The Providence Mountains are surrounded by areas of xeric vegetation, creosote bush, Larrea divaricata, and Joshua trees, Yucca brevifolia, plants able to tolerate environmental conditions exploited only by reptiles adapted for survival in warm, dry deserts. The survival of ringnecks in such isolated mesic refugia in arid portions of the United States and Mexico has resulted in the divergence of several populations. At least 14 subspecies are currently recognized in the United States and Mexico, although Gehlbach (1965) showed that the variations in some populations precluded their recognition as valid races.

Unfortunately the only comprehensive monograph of the genus Diadophis was that of Blanchard, published in 1942. At that stage in our knowledge of ringneck snakes Blanchard assigned the subspecies to four "groups," each of which he regarded as a separate species. As viewed by Blanchard, *Diadophis* consisted of: (1) Populations distributed west of the deserts, from Baja California Norte, through California and Oregon to southern Washington, with seven subspecies referred to *Diadophis amabilis*; (2) Disjunct populations on both flanks of the Continental Divide, from southern Idaho southward through mountainous areas in Utah, Arizona and Mexico to Chihuahua and western Texas, assigned to *D. regalis*, with two subspecies; (3) Ringneck snakes widely distributed in the United States from the Great Plains to the Atlantic, including portions of Canada adjacent to the Great Lakes, with five subspecies representing *D. punctatus*; and (4) A geographically isolated species, *D. dugesi*, inhabiting the Transverse Volcanic Province of Mexico, from Veracruz to Nayarit and Jalisco.

Far more intensive collecting in the years that followed the publication of Blanchard's monograph revealed the existence of annectant populations in areas between the ranges of the four "species" as mapped in 1942. Gehlbach (*supra cit.*) summarized much of the literature, as well as a great deal of information derived from specimens unavailable to Blanchard 23 years earlier. Although he was concerned primarily with the status of ringneck snakes in the Zuñi Mountain region in northwestern New Mexico, Gehlbach's investigations lent additional support to the belief that the genus *Diadophis* contained but one species. Herpetologists now regard — the ringneck snakes of Canada, the United States and Mexico as incompletely differentiated representatives of the species *punctatus* described by Linnaeus in 1766 when he applied the name to a snake from South Carolina.

Gehlbach (1974) greatly enhanced our knowledge of ringneck snakes in New Mexico and the contiguous states, an area of particular interest inasmuch as the prairie ringneck snake, *D. p. arnyi*, intergrades with the regal ringneck, *D. p. regalis* in western Texas. As re-defined by Gehlbach, ringneck snakes west of the Sangre de Cristo Mountains in New Mexico are referred to *D. p. regalis* whereas the few spcimens obtained east or south of this range are assigned to *D. p. arnyi*. The prairie ringneck does not attain the lengths reached by the regal ringneck, although Gehlbach found that populations in western Texas were intermediate in several characters and he regarded them as intergrades between the two subspecies. Despite this evidence of gene exchange in western Texas, Gehlbach found the larger and otherwise distinctive form, *D. p. regalis*, occurring sympatrically with *D. p. arnyi* in the Guadalupe Mountains of New Mexico and Texas, with no evidence of interbreeding. For reasons not readily apparent, therefore, the two forms behave as though they represented distinct species in this isolated mesic refugium. To explain this somewhat anomalous situation Gehlbach suggests that "southwestern ringnecks have a common ancestry, and that gene flow was interrupted long enough for the two morphotypes to evolve. Then secondary intergradation occurred, followed by the isolation of some populations, and finally recontact without interbreeding in the Guadalupes."

Except for this isolated population in southeastern New Mexico, ringnecks have gone unrecorded in this portion of the state. Prairie ringneck snakes are known from but three localities north of the Guadalupes in New Mexico, although Conant (1975) maps the distribution of the subspecies as extending northward through the southeastern corner of Colorado. The larger race, *D. p. regalis*, is far more widely distributed in the mountainous portions of the state. Gehlbach (1974) plots 11 localities for the subspecies in New Mexico, in addition to its sympatric occurrence in the Guadalupe Mountains. At an earlier date Gehlbach (1965) had reported this ringneck as far to the northeast as the vicinity of Thoreau in McKinley County. The northernmost record for the state, however, seems to be that of Degenhardt (1975), who obtained a single specimen in Bandelier National Monument. It was found in White Rock Canyon, *ca.* 1.6 km south of the confluence of the Rito de los Frijoles, at an elevation of 1630 m.

Degenhardt suggests that ringnecks are "probably confined to areas along the Rio Grande in White Rock Canyon." Where suitably moist conditions prevail at higher elevations, however, it now becomes evident that Diadophis can survive farther from the Rio Grande. Douglas Duerre, who lived in Los Alamos for many years, informs me that in 1964 he found a ringneck snake near Mountain School, which is situated on Diamond Drive. The school lies at an elevation of approximately 2300 m in an area that was largely ponderosa pine forest before it became part of the city of Los Alamos. Unfortunately no specimen is still extant to document this slight extension of the known range of D. p. regalis. Not all members of this subspecies have the broad, light-colored band behind the head, which Gehlbach (1965) found to be dominant in some parts of New Mexico but variable in others. The neck ring occurs in specimens from Sandoval County, but others lack it. Few other snakes are quite so readily identified when the light band is present, as it was on the specimen that Duerre found in Los Alamos. Because ringneck snakes are so difficult to find in the Jemez Mountains decades may elapse before another one is found in the LA/NERP area. It seems preferable to me to list the species, which Duerre, a competent amateur herpetologist, could scarcely have confused with any other snake in the area.

Gehlbach (1965:305) notes that a regal ringneck in the Zuni Mountains was obtained in "pinyon-juniper-ponderosa ecotone at 7200 feet [ca. 2200 m]" at a locality that had been worked intensely in preceding summers without any ringnecks having been discovered. It was "crawling over sandstone rubble near a small stream at 9:45 a.m." Ringnecks are more commonly found in moist situations, under rocks, logs or other debris. During the rainy season in some parts of its range D. p. regalis is active during the day, and occasionally turns up on paved highways. Diadophis punctatus is an extraordinarily adaptable species, despite its restriction to mesic environments. Inasmuch as it occurs in all but three of the lower 48 states it has been reported from a wide range of habitats, including relatively dry sphagnum bogs in Florida (Carr, 1940) and grassland habitats in Arizona (Lowe, 1964). Carr mentions ringnecks in Florida as one of the few snakes that are "gregarious hibernators. Three or four are frequently called together under a log or in sphagnum" and he found several in the water among water-hyacinth roots, along with a mud snake, Farancia, and an aquatic salamander, Pseudobranchus.

Blanchard (1942) reported a wide range of morphological modifications in ringneck snakes, many of which can presumably be construed as adaptive. When he compared samples representing populations from nearly all regions known to be inhabited by ringnecks, Blanchard found extensive variations, not only in size and proportions, but in color, markings, scutellation and dentition. The number of teeth on the maxilla varies within relatively narrow limits in most other colubrids, but Blanchard found as few as nine in some ringnecks from the western states, whereas more than twice this number could be found in snakes representing populations near the Atlantic Coast. Moreover, there were regional differences in the size of the two posterior maxillary teeth. These were greatly enlarged in some populations but not in others, and not always separated from the anterior teeth by a diastema.

Gehlbach (1974) noted differences in the behavior of ringnecks obtained in different areas. He observed that snakes referred to the subspecies D. p. arnyi and D. p. regalis, when attacking smaller snakes, usually held onto their prey at the site of the original bite, sometimes chewing in the same place. They did not shift their jaws to begin swallowing until their prey was immobilized. These observations led Gehlbach to suggest that southwestern ringnecks might perhaps be mildly venomous. In view of the more extensive observations on the predatory behavior of the night snake, Hypsiglena ochrorhyncha, a colubrid that also lacks grooves in the two enlarged posterior teeth in the upper jaw, it seems possible that ringnecks may be using venom to subdue their prey. There are regional differences in the diets of ringneck snakes. In the eastern states the most often devour earthworms or amphibians, but they are believed to prey on other snakes or on lizards in the Southwest. Much depends upon the relative abundance of suitable prey, however, for the slender salamander, Batrachoseps, comprises a large percentage of the ringneck's diet in coastal southern California.

It is pertinent to note that such amphibians are usually seized by the head and swallowed almost immediately. When a ringneck was offered a night lizard, Xantusia vigilis, however, the snake seized it by the neck and promptly coiled around the lizard, which it killed by constriction. Small salamanders make no effort to defend themselves by biting, whereas most lizards do. Ringnecks evidently distinguish lizards from salamanders, which need not be subdued before they are swallowed. In areas where ringnecks depend largely on salamanders, small frogs, earthworms and other invertebrates, the acquisition of a toxic saliva would confer few advantages. In such areas as Arizona and New Mexico, lizards are far more abundant than either earthworms or amphibians throughout most of the warmer months. Under such conditions snakes able to subdue their prey by using venom might well stand a better chance of surviving than they would were they forced to depend solely on constriction. This interpretation would lend support to Gehlbach's belief that ringnecks in the Southwest might be mildly venomous.

Ringneck snakes are comparatively small in other parts of their range, usually between 30 or 40 cm, but they are known to reach lengths of three quarters of a meter in Arizona, and snakes of comparable dimensions are reported for Utah. Even such ringnecks would find it difficult to subdue, much less swallow, an adult tiger salamander, Ambystoma tigrinum, the only salamander in Arizona. New Mexico has this species, as well as two others, the Sacramento Mountain salamander, Aneides hardyi, and the Jemez Mountain salamander, Plethodon neomexicanus, both of which occur in areas inhabited by ringneck snakes. Nevertheless it is uncertain whether any of these three salamanders are included in the diet of Diadophis punctatus. Small snakes and lizards are readily accepted by captive ringnecks, however, and they probably prey on these reptiles in their native habitats.

Gopher Snake, *Pituophis melanoleucus* Daudin

A large snake, rarely more than two meters in length, that inhabits the Pine Barrens of New Jersey and extensive areas to the south, was widely known as the "pine snake" long before Daudin provided a scientific name for the species in 1803. Decades later Holbrook realized that the pine snake had characters that readily distinguished it from rat snakes and other serpents with which it had been grouped. Accordingly, when Holbrook, in 1842, published the second edition of his well known treatise on North American herpetology, he assigned the pine snake to a new genus, for which he coined the name *Pituophis*. This was derived from the Greek words *pitys* (=pine) and *ophis* (snake), presumably reflecting Holbrook's approval of the vernacular name that had been used so extensively for snake well known as an inhabitant of pine forests from New Jersey to Florida.

The generic name provided by Holbrook had been in use for more than a century before enough evidence became available to show that *P. melanoleucus* was a species represented from coast to coast by annectant populations. Disjunctions occur in the vicinity of the Mississippi River, but the distribution of the species is fairly continuous from the Great Plains to the Pacific. Snakes known as gopher snakes in southwestern Canada, California, and other western states are generally acknowledged being conspecific with the bull snakes of the Middlewest, the pine snakes of the East, as well as the *cincuate*, the name most often used for *P. melanoleucus* in Mexico where the species is known as far south as the state of Zacateoas.

Pine forests over much of the United States, as well as northern Mexico, afford suitable habitats for the species. As may be inferred from its extraordinarily wide distribution, however *P. melanoleucus* exploits a vast range of environments. In parts of the United States and Mexico it frequents irrigated or cultivated fields, even those below sea-level in Imperial County, California. Gopher snakes are likely to thrive in grassland, woodland, prairies or plains, wherever pocket gophers, chipmunks, squirrells or other rodents are present, although lizards, birds and rabbits are included in the diet. Even the barren deserts support a few gopher snakes, however, and they are seen sporadically in mountains above the 2800 m contour in portions of their range. They may reach such altitudes in New Mexico, but they are more frequently seen in the Lower Sonoran areas in the southern part of the state than they are in the Upper Sonoran piñon-juniper. Their range undoubtedly extends into the Transition Life Zone, and they may occur along the lower edge of the Canadian, but if they penetrate spruce-fir woodland, they are surely uncommon in dense forests.

Degenhardt (1975) mentions only two specimens obtained in Bandelier National Monument. One was taken at an elevation of 2011 m near the main entrance, and the second was found in White Rock Canyon at an elevation of 1625 m. In both areas Degenhardt reports that juniper and blue grama grass, Bouteloua gracilis, were important components of the vegetation. The only gopher snake observed in the LA/NERP area during the two summers encompassed by my survey was found at an elevation of nearly 2000 m in an open, relatively grassy area in Mortandad Canyon, where the ponderosa and piñon pines were the most abundant trees, although the Gambel oak, Quercus gambeli, was present in moderate abundance. Mr. William Watkins, who lives in White Rock, informs me that he has often found gopher snakes basking on the paved highway that traverses the Pajarito Plateau on the western outskirts of Los Alamos. This area is covered mainly by ponderosa pine, replaced to some extent in the canyons by white fir, Douglas fir, and Engelmann spruce, with quaking aspen farther west on the steep slopes of the Sierra de los Valles. As noted above, however, it is questionable whether gopher snakes occur in the dense mixed conifer forests although they may tolerate the more open stands of quaking aspen.

Differences in the pattern and color of pine snakes from New Jersey readily distinguish them from the bull snakes of Texas or the gopher snakes of California. Detailed studies of the variations in P. melanoleuca, not only of the pattern and color of individuals, but variations in the scutellation, have permitted students of the species to recognize 15 subspecies, two of which are restricted to peninsular Baja California, with an additional three occurring as endemics on islands off the coast. Of the ten subspecies inhabiting the United States, two have distributions extending well into Mexico. The same subspecies, P. m. sayi and P. m. affinis, occupy all but the northwestern corner of New Mexico, where the Great Basin race, P. m. deserticola, replaces P. m. affinis. The Bull snake, P. m. sayi, is restricted in New Mexico to the eastern plains, with a wide distribution to the east. The Sonoran gopher snake, P.m. affinis, has a range that extends from the Sangre de Cristo Mountains southward through the mountains west of the Pecos River and onto the Mexican Pleateau as far as the state of Zacatecas. Toward the west P. m. affinis occupies nearly all of Arizona, with its distribution extending through the Sonoran Desert across Imperial Valley into the foothills of San Diego County, California and the contiguous portion of Baja California.

Where the range of P. c. affinis extends into Mexico east of the Sierra Madre Occidental it occurs sympatrically with another species, P. deppei, which occupies much of the Mexican Plateau from southern Chihuahua to the state of Puebla. The range of P. deppei in turn overlaps that of P. lineaticollis along the southern portion of the Plateau, with P. lineaticollis occupying the elevated areas inland from the Pacific in the states of Michoacán, Guerrero and Oaxaca. The distribution of P. lineaticollis may continue eastward along the Continental Divide at the Isthmus of Tehuantepec, for the species frequents pine forests in elevated portions of the state of Chiapas, as well as Guatemala. The genus Pituophis, therefore, is now regarded as comprised of three well differentiated species, distributed from southwestern Canada to southern Guatemala. Throughout much of the extensive area occupied by these three species, they are among the most ubiquitious and conspicuous of the snakes to be found. Few other snakes play a more important role in the control of rodent populations.

Common Garter Snake, Thamnophis sirtalis Linnaeus

There are nine species of garter snake with distributions extending into New Mexico, but only three of these occur in the LA/NERP area. The species, T. sirtalis, was the first [garter snake] ~~one~~ to be described (by Linnaeus, in 1758) [probably] ~~many~~ because it is the abundant, widely distributed form in eastern Canada and the whole eastern potion of the United States. The specimen upon which Linnaeus based the name is believed to have come from the vicinity of Quebec. Since 1758, but mainly during the last century, representatives of the species have been discovered from coast to coast. Some populations have become ecologically specialized, and in some instances isolated geographically by increasingly arid climates in parts of the Southwest. As a result [some] populations [are] restricted to mesic refugia, such as swamps surrounded by inhospitably ~~dry~~ environments, [A few of th.] have evolved their own peculiarities. Gene flow has been interrupted sporadically in the ecologically diversified portions of the United States and Canada, from the plains westward to the Pacific. [Populations of T. sirtalis] ~~Certain snakes of the species~~ have evolved their own morphological peculiarities in several areas, sometimes to a degree that has warranted the recognition of subspecies, no fewer than 12 of which are currently recognized.

The subspecies inhabiting New Mexico, T. s. dorsalis, occupies the swamps along the Rio Grande from southern Colorado southward to the vicinity of El Paso, Texas. The same subspecies has recently been discovered at four localities at the northeastern edge of the Chihuahuan Desert in Mexico. The subspecies known as the New Mexico Garter Snake is a relatively handsome form, with a light vertebral stripe flanked by darker areas usually with red bars above an indistinct yellowish lateral stripe. In contrast, the nominate subspecies, T. s. sirtalis, is a rather drab, extremely variable snake that may be slate-colored, brown or even greenish, with black spots that often extend onto the stripes, completely obscuring them in some individuals. The New Mexico Garter Snake more closely resembles the red-sided subspecies, T. s. parietalis, which occupies areas at the western edge of the range of T. s. sirtalis, with an isolated population of the Texas garter snake,

T. s. annectens, surviving in the intervening portion of the Texas Panhandle. This hiatus in the distribution of the species extends northwestward into Colorado. West of the Rio Grande, however, there is a much greater gap in the distribution. No garter snakes of the species occur in the wide area between coastal southern California and the range of T. s. dorsalis in New Mexico. Populations of T. sirtalis occupy restricted portions of Colorado, Utah and Nevada, but if the species ever penetrated Arizona there are no records of any surviving populations in the state. It is the only one of of the 48 states south of Canada that lacks this member of the genus.

The New Mexico Garter snake is not scarce in areas where the Rio Grande sporadically overflows its banks to form swamps in the depressions. Because the river flows through White Rock Canyon where it borders Bandelier National Monument, habitats suitable for T. sirtalis may not be available in the area. Degenhardt (1975) lists the species among the snakes known from the vicinity that may be found in the Monument, and Fleisher (1978) lists T. sirtalis as being "uncommon along the Rio Grande." No specimens have been cited, however, to document the presence of this garter snake in Bandelier National Monument. On 8 July 1979, while exploring the swampy area around Riverside Lake on the outskirts of Española, Mr. William Atkins obtained two adult T. s. dorsalis deposited in the collection of the University of New Mexico. The land along the river is relatively flat between Española and Otowi Bridge, and probably affords suitable habitats for this garter snake in several areas. Insofar as can be demonstrated at present, however, the species barely reaches the LA/NERP area; where Ted Brown obtained a specimen at Otowi Bridge on 15 July 1978. Cottonwood and tamarix grow along the river in this area, at an elevation approximately 1675 m.

Black-necked Garter Snake, Thamnophis cyrtopsis Kennicott

The range of the black-necked garter snake extends through 24 degrees of latitude. It is known from southeastern Utah and southern Colorado southward through the eastern half of Arizona, much of New Mexico, parts of Texas, and nearly all of Mexico except the Atlantic coastal plain. Eastward across the Isthmus of Tehuantepec the species is known from both Guatemala and Honduras. Currently five subspecies are recognized, two of which are known from the United States, but only the nominate subspecies, T. c. cyrtopsis, occurs in New Mexico.

Although the species is more or less continuously distributed across northern New Mexico, it evidently shuns areas of dry creosote bush desert, bordering the Rio Grande southward from the vicinity of Belen, and much of the Chihuahuan Desert in Mexico. Off to the west, however, the species reappears from Hidalgo County northward through the headwaters of the Gila River and on beyond, where streams from the mountains afford suitable habitats for this garter snake. Temporary pools in intermittent streams, as well as springs and cattle tanks commonly support small populations, whether in deserts or forested areas. The species is most often seen in rocky areas although this garter snake is not restricted to foothills.

Fleisher (1978), who made the latest study of the amphibians and reptiles in Bandelier National Monument, reports that T. cyrtopsis is fairly common along the Rio Grande, as well as in the vicinity of creeks below the elevation of 1800 m. The only specimen I obtained in the area covered by my survey during the abnormally dry summers of 1978 and 1979 was found near the Rio Grande at the mouth of Sandia Canyon at an elevation of 1658 m. The snake was found early in the morning of 27 September 1979 crawling in a rocky area where the dominant vegetation consisted of cottonwood, Populus wislizenii, tamarisk, Tamarix pentandra, piñon, Pinus edulus, and the one-seed juniper, Juniperus monosperma. It is noteworthy that a juvenile T. cyrtopsis was found the same morning 2.2 km east of the Rio Grande. This is outside the study area, not far from Buckman in Cañada Ancha. Two black-necked garter snakes were found swimming in the river less than 50 m south of Otowi Bridge during the month of August, 1929. The species has been known from this area for more than a century, for Dr. H. C. Yarrow in 1875 reported six specimens obtained the previous year at San Ildefonso.

Western Terrestrial Garter Snake, Thamnophis elegans Baird and Girard

The third species of Thamnophis known to inhabit the Jemez Mountains is far more abundant and widely distributed in the LA/NERP area than any other snake. The species was described in 1853, based on a specimen from El Dorado County, California. The subspecies in New Mexico, T. elegans vagrans, long known as the wandering garter snake, was described in the same publication as T. vagrans, which seemed to represent a different species until far more extensive studies could be undertaken almost a hundred years later. Eventually it could be shown that annectant populations of an extremely variable species ranged all the way from the northwestern half of New Mexico well beyond the United States into the southern part of British Columbia. The same subspecies occupies portions of all the states from the eastern foothills of the Rocky Mountains almost to the Pacific, with parts of the Canadian provinces of Alberta and Saskatchewan, as well as British Columbia included in the known range. Thamnophis e. vagrans is replaced by other subspecies, including the nominate subspecies, in California, and disjunct populations occur on mountains in southern Nevada, the San Bernardino Mountains in southern California, with one population isolated in the San Pedro Martir Mountains in northern Baja California. This is the only locality where the species is known to occur in Mexico, although closely related populations of uncertain status have been discovered in the Sierra

Madre Occidental of northwestern Mexico.

Contrary to the implications of the vernacular name, *T. e. vagrans* is not strictly terrestrial. Those found in the LA/NERP area were most often either in water or within two or three meters of streams or pools. Some were under logs, rocks, and even tar paper, or in one instance, a cardboard box. One was in a small stream that flowed through an area of tall grass as it approached the main stream in Los Alamos Canyon. This garter snake is most often seen near the streams in the canyons, but it occurs on the mesas without much doubt even though I failed to obtain specimens in such areas. It was not found in the mixed conifer-quaking aspen forest where others assisted me in my search for *Plethodon neomexicanus*, which must surely be eaten by *T. e. vagrans* on occasion. A snake of the species was obtained at an elevation of 2250 m below the reservoir in Los Alamos Canyon, where it was in an open, grass-covered area, bordered by a forest of Douglas fir, *Pseudotsuga menziesii*, white fir, *Abies concolor*, Engelmann spruce, *Picea engelmanni*, with aspen, *Populus tremuloides*, near the stream. The stream was bordered in some areas by the redosier dogwood, *Cornus stolonifera* and cliff bush, *Jamesia americana*. These same two shrubs were found at a somewhat lower elevation, *ca.* 2150 m, in Sandia Canyon, where a permanent stream flows through a steep-sided canyon, but the *T. e. vagrans* found here were in a thicket of New Mexico locust, *Robinia neomexicana*. In Guaje Canyon, at an elevation of 1980 m, a wandering garter snake was crawling in the piñon-juniper forest near the edge of the small stream bordered by tall grass, and willow, *Salix* sp., ~~where it flowed through the piñon-juniper forest~~.

In the area covered by my survey, *T. e. vagrans* was taken in the following canyons, Guaje, Pueblo, Los Alamos, Sandia, and Pajarito, as well as at Otowi Ruins, which is on a promontory between Bayo and Pueblo canyons. It is questionable whether any other snake in northwestern New Mexico is so nearly ubiquitious, for the species ranges from the piñon-juniper well into the mountains, where it occurs in meadows at elevations of at least 3000 m. Like other widely distributed snakes, the wandering garter snake consumes such invertebrates as slugs, earthworms and leeches, as well as fishes, salamanders, frogs and their tadpoles, lizards and occasionally even small mammals. One that Dr. Philip Shultz captured in a mountain meadow a little below 3000 m in the Sangre de Cristo mountains contained a vole, Microtus. A garter snake of the species found in piñon-juniper woodland near Edgemont in southern Santa Fe County contained a juvenile horned lizard, Phrynosoma douglassi. The wandering garter snake is the only serpent often seen inside the city limits of Santa Fe, more often in areas where lawns are maintained, or artificial fish ponds.

Night Snake, *Hypsiglena torquata* Gunther

All pit vipers, including the rattlesnakes, have eyes with vertically elliptical pupils. Such eyes characterize a relatively small percentage of the harmless snakes, most of which have round pupils. All but two of the 37 species of harmless snakes represented in New Mexico have round pupils. The only exceptions are the night snake and the lyre snake, *Trimorphodon biscutatus*, both of which seem to have extended their distributions northward from the tropics, where a larger percentage of the snakes are adaptively specialized for nocturnal activity. The lyre snake has a distribution that extends from Central America northward to southern Nevada, but its range extends through only the southwestern portion of New Mexico. It follows, therefore, that any harmless snake found north of Sierra County in New Mexico is readily identifiable as *Hypsiglena torquata* if it has vertically elliptical pupils.

In the Southwest both night snakes and lyre snakes commonly prey on lizards, which they subdue with venom. Both lyre snakes and night snakes have enlarged teeth at the rear end of the upper jaw that are brought into play by a chewing action. These teeth at the rear of each maxilla are deeply grooved in the lyre snake, and long enough to penetrate the skin of lizards ordinarily eaten. Venom expelled from a modified salivary gland presumably reaches the lizard's blood stream through the groove. Cowles and Bogert (1935:82) watched a captive lyre snake seize a night lizard, *Xantusia vigilis*, near the middle of its body. "There followed a rhythmic chewing movement of the jaws, apparently made in an attempt to bring the small rear fangs into action. Each jaw was alternately loosened and then brought down tightly, the procedure continuing for fully two minutes until the movements became slower." The snake remained motionless for the next five minutes, tenaciously holding its prey after it was completely immobilized. The snake abruptly dropped the lizard, now paralyzed and possibly dead. A few seconds later the snake seized the head of its seemingly lifeless prey and proceeded to engulf it.

Night snakes subdue their prey in much the same fashion, and chew vigorously to imbed their rear teeth, which are enlarged but not grooved. Tubular or grooved teeth are readily recognized as fangs and their function is obvious. The enlarged teeth of the night snakes may not be aptly described as fangs, but these ungrooved teeth of Hypsiglena evidently enable such snakes to introduce enough toxic saliva into their prey to subdue it. The venom apparatus of the night snake, perhaps less efficient than that of the lyre snake, seems nevertheless to be effective. Cowles (1941), who first reported the venomous nature of Hypsiglena, noted that a night lizard died approximately 45 minutes after being seized by a night snake. Inasmuch as a night lizard died about seven minutes after being seized by a lyre snake, as noted above, one might suspect that either it had a stronger venom or that more of the lyre snake's venom had reached the lizard's blood stream.

Cowles's observations in the laboratory were corroborated in the field some years lager by Goodman (1953), who watched the struggle between a night snake scarcely 185 mm in length and a juvenile sagebrush lizard, Sceloporus graciosus, with an over-all length of 33 mm. Goodman, who came upon the scene shortly before sunset, when night snakes are seldom seen, found that the snake had seized the lizard at the base of its tail. The snake chewed vigorously at intervals that lasted several minutes, even after the lizard appeared to be paralyzed. It looked as though it were dead approximately 45 minutes after the snake seized it. A few minutes earlier Goodman found it necessary to capture the snake when it became evident that it was dragging its prey into a hole beneath a large boulder. The snake released the lizard at this time, and Goodman, believing the lizard to be dead had placed it in the refrigerator. Seven minutes later when Goodman opened the refrigerator he found the lizard "vigorously wriggling within its jar." Roughly two hours after the night snake had presumably imbedded its enlarged rear teeth in the lizard, it became almost completely paralyzed before it finally died.

Even though the venom apparatus of the night snake seems to be relatively primitive and much less efficient than that of the lyre snake, few doubts exist that even without grooved teeth, H. torquata manages to reach the blood stream of its prey with enough venom to subdue it. Other snakes lacking fangs have been reported to produce painful bites on occasion, with symptoms closely resembling those arising from small amounts of venom in the blood. Venom glands of snakes are regarded as specialized salivary glands, and it is reasonable to suppose that some snakes had evolved toxic salivas as the first step in the evolution of a complex venom apparatus that eventually included fangs. Such specialized teeth are not readily used for defense when they are situated at the back of the upper jaw. However, two of the rear-fanged snakes are regarded as dangerous to human beings. Only the boomslang and a close relative, both of which are restricted to Africa, are known to inflict bites resulting in human fatalities. Lyre snakes, like most other rear-fanged snakes, rarely make any effort to defend themselves by biting a captor. Thus far no one has reported being bitten by a night snake, and it can safely be considered harmless, if only because it would be unable to engage its enlarged teeth unless it had an opportunity to chew.

Night snakes have from eight to ten anterior maxillary teeth that are separated by a gap from two larger, sharply recurved teeth at the posterior end of the jaw. Night snakes attain somewhat larger dimensions in some parts of their range than in others, although adults found in New Mexico are commonly between [illegible] in over-all length. The teeth in front of the gap on the maxilla of a snake of these dimensions are roughly one mm in length, whereas those behind the gap are twice this size. Teeth only two mm in length, however, readily penetrate the skin of the small lizards that fall prey to night snakes.

By restricting their activities almost exclusively to the hours of darkness night snakes escape diurnal predators as well as the intolerably hot surface temperatures that characterize arid deserts in summer. Few residents of New Mexico ever see night snakes, which can, on rare occasions, be found by overturning rocks, logs or other debris, or in crevices where they seek shelter during the day.

The night snake is perhaps more abundant in the warmer, lowland deserts, but even in such areas it is among the least commonly seen of all the snakes in the Southwest. Collectors have found it more productive to search for Hypsiglena in the deserts by scanning the highways at night while driving motor vehicles. In California Klauber (1939:48) found night snakes on the road between 7:40 p.m. and 12:45 a.m., more often in rocky deserts or boulder-strewn areas than in barren or sandy deserts. His investigations also revealed that night snakes shunned cultivated fields, grassy areas, as well as riparian habitats, although they were found occasionally in desert brush or the chaparral-covered foothills on the coastal as well as the desert slopes of the mountains. In southern California and southwestern Arizona, night snakes were among the least frequently seen of the 18 species that occurred on the roads. Among the 1945 snakes recorded by Klauber in the areas on both sides of the Colorado River, there were only 15 night snakes. They comprised less than 0.8% of the total.

No comparable study has been made in the deserts of southern New Mexico. Pough, (1966:676), however, carried out investigations during the course of three summers in two areas immediately west of New Mexico in Cochise County, Arizona. Pough's data provide a reliable index to the relative abundance of the species known from the west side of the Peloncillo Mountains in New Mexico. He made 123 round trips on the road between the New Mexico boundary and the Southwestern Research Station maintained by the American Museum of Natural History in Cave Creek Canyon in the Chiricahua Mountains. Of 116 snakes found on this road while he drove a total of 4474 km, only one H. torquata was included. The species proved to be slightly more abundant in the San Simon and San Bernardino valleys farther south in the same county. In this area Pough recorded a total of 168 snakes while traversing 5816 km of pavement. The snakes found on the road, a sample containing just 12 species, including H. torquata, which was represented by two specimens. At this rate, one might expect to find one night snake for every 2909 km travelled at night in this part of Arizona.

Night snakes are at least as difficult to find in northwestern New Mexico as they are in the Jemez Mountains. Gehlbach (1965), who spent portions of seven summers assembling collections of amphibians and reptiles in a study area that included most of McKinley and Valencia counties obtained only one *H. torquata*. It was found under a sandstone slab "near the lower end of the pinyon-juniper association" 4.8 km northeast of Thoreau. Gehlbach saw a second individual 3.2 km south of Thoreau, but it escaped into a deep crevice. One specimen mentioned by Gehlbach was obtined in Chaco Canyon, beyond his study area. Neither Degenhardt (1975) nor Fleisner (1978) were aware of any night snakes obtained or reported from Bandelier National Monument. This species might be expected to occur in White Rock Canyon, as Degenhardt suggests, but now that it is known from areas several km away from the river at elevations above 2100 m, the species may be found in any dry, rocky area at least to the upper limits of the juniper-piñon woodland.

During the summer of 1978 I learned from Mr. Billy Atkins that Mr. Douglas Dunaya had obtained a night snake on the [Los Alamos] golf course, which lies south of North Mesa. It was found during the day, but I was unable to ascertain whether it had been discovered under something or whether it was crawling on the surface. It may have been flushed from concealment when the grass was watered. I failed to discover *Hypsiglena* even though I found incontrovertible proof of itsppresence a few kilometers north of the golf course while I was overturning logs and rocks on Kwage Mesa while searching for skinks. Beneath a rock within 50 m of the confluence of North Mesa and the narrow extension of it known as Kwage, I found the recently shed skin of a night snake. Faint traces of the pattern were discernible on the transparent outer layer that had been left ~~buried~~ [intact] by a snake *ca* 40 cm in length. There was no doubt concerning the identity of the snake that had chosen this place to shed. The rock was at the very edge of the mesa, at an elevation of 2135 m in an area where the dominant plants were piñon and juniper. Adults and hatchlings of the many-lined skink, *Eumeces multivirgatus* had been taken in the area a few weeks before the exuvia from the snake was found on 25 September, 1979. Skinks probably were the night snake's main source of food in the area, for they are readily eaten by captives. Fence lizards, Sceloporus undulatus, were more commonly seen on Kwage Mesa, but not necessarily more abundant than the secretive skinks. Both species are probably included in the diet of H. torquata in this area, and there is one record of a night snake's having consumed lizard eggs.

Like several other species in the Jemez Mountains, the range of H. torquata extends southward well beyond the international boundary. In the United States night snakes are known from southwestern Kansas, western Oklahoma and Texas and throughout nearly all of the Southwest, including the deserts, and the foothills on beyond them to coastal California. Northward the range extends through the Great Basin Desert to eastern Oregon and south-central Washington. Night snakes have been found from coast to coast in northern Mexico, including virtually all of Baja California, and all but the most humid portions of the Mexican Plateau, as far south as the semi-arid northern part of the state of Querétaro. The southern extremity of the night snake's distribution has not been ascertained but there are records from Guerrero, and a related form, probably conspecific with H. torquata, is known from Jalisco and Zacatecas. When more detailed information becomes available for the distributions, as well as the extent of the variations in the populations now poorly represented in collections, it seems probable that Hypsiglena will prove to be monotypic. Several ill-defined subspecies have been recognized in northern Mexico and the United States, and perhaps some of these can profitably be retained. Others currently recognized as species are likely to be relegated to subspecific status.

Until recently old records from Nicaragua, Costa Rica, and South America were often listed, but the record for Costa Rica proved to be based on a specimen of Leptodeira septentrionalis (Duellman, 1958:75) and South American records have been rejected. The type specimen of Hypsiglena torquata allegedly came from "Laguna Island, Nicaragua," but in view of the absence of any records for Oaxaca, or Chiapas in southern Mexico, and none for either Guatemala or El Salvador, it would be difficult to account for the hiatus in the range of H. torquata if it actually occurs in Nicaragua. If the type specimen [redacted] is conspecific with the snakes found on the Pacific slope of Mexico, it must surely have been accompanied by erroneous locality data when it was catalogued.

Snakes identified as H. torquata have a dark nuchal blotch preceded by a white band, which is lacking in specimens long referred to H. ochrorhyncha, originally applied to a snake from Cabo San Lucas, Baja California. These two forms were undoubtedly derived from a common ancestor, the range of which may have been split when the night snakes were forced to shift their distribution southward while cooler climates prevailed in the Southwest. Under such conditions populations would have been isolated on both sides of the Gulf of California. It must be assumed that the two populations diverged during a relatively prolonged period of isolation before a trend toward warmer climatic conditions permitted them to expand their respective distributions northward.

If this is a valid assumption, it seems probable that the population in Baja California had become much better adapted for xeric environments than the population on the opposite side of the Gulf. With the onset of warmer climates, the night snakes once restricted to the peninsula spread northward, followed by an eastward dispersal through the deserts north of the Gulf. Once they had gained access to the area that is now Sonora their southward dispersal eventually permitted them to regain contact with the descendants of the night snake population on the mainland. Despite the divergence in pattern, the night snakes with the white nape band seemingly interbreed freely with those lacking the nape band.

As a result of this interbreeding, night snakes with a wide range of patterns have been found inhabiting an area that extends from southern Sonora southeastward in the lowlands of Sinaloa on beyond the Tropic of Cancer, a distance of at least 200 km. Within this extensive area, therefore, we find snakes lacking the white nuchal band and hence resembling those in the deserts of Sonora and Arizona to the north, living side by side with night snakes much like the type specimen of _H. t. torquata_ in having a white nuchal band. Except for the differences in the pattern on the nape, no other character has been found that will distinguish the tropical form from night snakes north of Mexico. Such differences in the nuchal pattern are attributable to pattern dimorphism in a single species. As noted above, differences in pattern presumably evolved while populations of the ancestral _Hypsiglena_ were geographically isolated. When they eventually regained contact, however, differences in pattern did not discourage interbreeding. Breeding experiments with night snakes remain to be carried out, but since both patterns were reported in small sample of night snakes from southern Sonora in 1945, much larger samples from the state of Sinaloa corroborate the belief of Bogert and Oliver (1945:83) that night snakes on both sides of the Gulf of California are conspecific, despite superficial differences.

Pit Vipers, Family Crotalidae

Western Diamondback Rattlesnake, Crotalus atrox Baird and Girard

Rattlesnakes are widely distributed in the Americas, through 86 degrees of latitude, from southern Canada southward to Uruguay and most of northern Argentina. Three of the species are placed in the genus Sistrurus, and 28 other species are grouped in the genus Crotalus, which is more widely distributed than any other group of snakes in the Western Hemisphere. Mexico, however, has been the center of diversification, for 26 of the 31 species now recognized are either restricted to Mexico or have distributions that extend into this portion of North America. Of the 15 species that inhabit the United States only two have distributions that fail to reach Mexico. Seven of the 15 species are known from New Mexico, but two of these, the Mojave rattlesnake, Crotalus scutulatus, and the ridge-nosed rattlesnake, C. willardi, have ranges that barely extend into the extreme southwestern corner of the state.

Whereas all seven species are known from Hidalgo County, only two are known to occur as far north as the Jemez Mountains. Both of these, the prairie rattlesnake, Crotalus viridis, and the western diamondback, C. atrox, are occasionally found in LA/NERP. The prairie rattlesnake will be discussed in the ensuing account wherein it may be noted that it is widely distributed on all sides of the Jemez Mountains, in contrast to C. atrox, which closely approaches the northern extremity of its range in the area covered by this report. Western diamondbacks appear to have penetrated northern New Mexico mainly along the Rio Grande and Pecos rivers in their postglacial dispersal. They were known as far north as Otowi as early as 1929, but in 1978 Mr. Ted Brown found one roughly 10 km west of the Rio Grande at an elevation of 1800 m on the road leading to Puye Cliff Dwellings. This extends the known distribution into Rio Arriba County approximately 4.5 km north of the boundary of Santa Fe County.

The western diamondback is one of the four most widely distributed and relatively abundant rattlers. Although its range is restricted to the United States and Mexico it occurs throughout the Chihuahuan and Sonoran deserts, as well as the southeastern portion of the Mojave Desert, where the species inhabits the lowlands as far north as the southern tip of Nevada. The distribution of *C. atrox* extends well beyond the deserts, however, for it is known from Arkansas and Oklahoma westward to the foothills of the San Jacinto and Santa Rosa mountains at the western edge of the Sonoran Desert in southern California. In northern Mexico *C. atrox* is known from coast to coast, and southward to the states of Zacatecas, San Luis Potosí and the northern extremity of Veracruz. Isolated populations have been discovered in central Veracruz as well as farther southward around Tehuántepec on the Pacific coast of the state of Oaxaca.

The altitudinal range of *C. atrox* extends from below sea-level in the Salton Sink of southeastern California, to areas in the Mexican states of Durango and San Luis Potosí at least 2400 m above mean sea-level. Much of the terrain inhabited by the diamondback is desert or mesquite-grassland. The widespread vegetational matrix is the microphyllous desert scrub, dominated in many areas by the creosote bush, *Larrea tridentata*. In Coachella Valley near the edge of the Sonoran Desert in Riverside County, California, diamondbacks are largely restricted to mesquite thickets, and mesquite, *Prosopis juliflora*, as well as the screwbean, *P. pubescens*, are commonly among the conspicuous trees in areas frequented by *C. atrox* in the deserts of California, Arizona and New Mexico. Along the coast of Sonora, where diamondbacks occur near the seashore, giant cacti, the *sahuaro* as well as the *cardón*, are conspicuous elements of the flora, along with the more shrub-like elephant tree, *Bursera microphylla*, and ocotillo, *Fouquéria splendens*. The Joshua tree, *Yucca brevifolia*, occurs in areas inhabited by diamondbacks in northwestern Arizona, and a similar yucca, *Y. filifera*, characterizes portions of the desert inhabited by *C. atrox* in the state of San Luis Potosí.

Southward beyond the mesquite-grasslands along both coasts of northern Mexico diamondbacks inhabit the thorn forests as well as the tropical deciduous forests as mapped by Leopold (1950). Although Leopold indicates the presence of tropical deciduous forest from southern Sonora southeastward along all of the Pacific Coast, the range of C. atrox terminates abruptly in northern Sinaloa. The isolated colony at the Isthmus of Tehuantepec inhabits the tropical deciduous forest nearly ten degrees to the south. Unless C. atrox at some time in the past was continuously distributed along the Pacific Coast, it is difficult to explain the occurrence of the species in southeastern Oaxaca. Along the western edge of the Chihuahuan Desert, probably in Durango and Chihuahua, as well as in southern New Mexico, C. atrox occurs in pine-oak woodland at elevations approximating 1600 m. In the Chiricahua Mountains of Arizona and the Animas Mountains of New Mexico C. atrox is relatively abundant in the mesquite-grassland that surrounds these isolated ranges, and the sporadic occurrence of the species in woodland is perhaps attributable to a few individuals that stray above the mesquite, which reaches altitudes of 1800 m.

Climatic conditions at LA/NERP evidently permit C. atrox to reach higher elevations than those attained in the Animas Mountains. Diamondbacks may be more often seen in the immediate vicinity of the Rio Grande, where the vegetation consists of juniper, saltbush, rabbitbrush, cholla cactus, usually with a few tamarisk, cottonwood and even an occasional ponderosa pine. These large rattlesnakes inhabit piñon-juniper woodland on both sides of the river, however. I failed to find or otherwise obtain any C. atrox in the study area in 1978, and the two obtained in 1979 were both found near the Rio Grande. Dr. John Applegarth and Mr. Ted Brown found one crawling near the stream in Ancho Canyon near its confluence with the Rio Grande at an elevation of 1650 m on 20 September. I found one a week later in the talus below the Buckman Road at the mouth of Sandia Canyon at an elevation of 1670 m.

While camping near Otowi Bridge during the month of August, 1929 I obtained four *C. atrox* in the immediate vicinity. A half-grown individual was discovered at our campsite near the river, and two days later I captured two juveniles as I climbed the talus slope of the mesa that lies west of the bridge. Later in the morning a large adult was found in the ruins of an archaeological site on the summit of the mesa at an elevation of 1870 m, approximately 200 m above the Rio Grande. Diamondbacks undoubtedly occur in all of the canyons, as well as on some of the mesas in the LA/ERP area at elevations between 1640 and 1870 m. With the limited information now available it is difficult to guess how far diamondbacks may have penetrated the canyons that empty into the Rio Grande. Moreover, it remains to be ascertained whether *C. atrox* inhabits any of the areas occupied by *C. viridis*, even though rattlesnakes of the two species occur sympatrically in other parts of New Mexico. As noted earlier in this account, *C. atrox* occurs at least 10 km west of the Rio Grande in the relatively open alluvial plain traversed by the road to Puye Cliff Dwellings.

Degenhardt (1975) was unaware of authentic records for *C. viridis* in Bandelier National Monument, although he reports *C. atrox* at elevations between 1920 and 2010 m in Lummis and Capulin canyons, at the Pueblo of the Stone Lions, and on Frijoles Mesa. Near the southern boundary of the Monument Miss B. B. Fuller and Mr. Kenneth D. Adam may well have discovered a denning site at an elevation of 1860 m approximately six km from the Rio Grande in Medio Canyon. They were examining pictographs on the the wall of the canyon immediately below the ruins of San Miguel when they found three *C. atrox* within a few meters of one another in the talus along the foot of the cliff. The species was readily identified in a photograph obtained by Miss Fuller.

Diamondbacks are the largest rattlers to be found in New Mexico although it is questionable whether any exceeding 1.7 m in length can be authenticated. Individuals 1.5 m in length (excluding the rattle) are not exceptional, however, but records of diamondbacks exceeding 1.6 m in length are not necessarily based on acceptable measurements; they seem to be seldom preserved and deposited in museums where the dimensions reported can be verified. There is little doubt that C. atrox attains a larger size in eastern Texas and northeastern Mexico than elsewhere. Klauber (1972) summarized information obtained from informants as well as published sources, but noted that few reports of extraordinarly large diamondbacks could be considered reliable. He concludes his discussion of maximum records for C. atrox with the statement that "Altogether, the evidence indicates that/the western diamond in the eastern part of its range may, in rare instances, attain a length a few inches over 7 feet (2,134 mm.), But I cannot claim to have measured one of this size."

Detailed summaries of what has been learned about C. atrox, or any other species of rattlesnake, will be found in Klauber's comprehensive work cited above. This well organized compendium was issued in two well-indexed volumes that appeared in 1956, and a revised edition was published in 1972. Relatively little of importance concerning rattlesnakes has appeared in print since that year. For sound reasons Klauber emphasized the impact that rattlesnakes have had on human thought and activities. Any rattlesnake is potentially dangerous to/the human beings who share or usurp the habitats of any of the 31 species. Large rattlesnakes more often inflict fatal bites than other rattlers, and in most areas occupied by C. atrox the largest rattlesnakes to be seen will be adults of the species. Only one other rattlesnake, the eastern diamondback, C. adamanteus, is known to reach a larger size, and the average fully adult male measures 1.524 mm according to Klauber (supra cit.). Because C. atrox occupies a much larger area than C. adamanteus, it is probably responsible for more fatal bites than any other venomous snake in the United States.

Wholly reliable figures concerning the incidence of snakebite are difficult if not virtually impossible to obtain, even though most victims/now receive medical attention. Most of the problems concerned with snakebite and its treatment have been discussed recently by Russell (1980), who has summarized and evaluated much of the information directly or indirectly concerned with snake venom poisoning in the United States. Evidence cited by Russell suggests that *C. atrox* may cause more bites than any other venomous snake in this portion of North America. This is reflected in the results of a nationwide survey that revealed more bites from venomous snakes in Texas than in any other state.

¶ As noted by Russell, however, when the incidence of snakebite is expressed in terms of the number of bites per 100,000 population, the rate was highest in North Carolina, followed by Arkansas and Texas. The yearly average for the number of bites per 100,000 was 18.79 in North Carolina, 14.70 in Texas, but appreciably lower in New Mexico, where the rate reported is 7.47. The incidence varies from year to year within states, but the figures supplied by Russell point to the probability that New Mexico, with a population now well over a million, might have an annual average of more than 80 persons bitten by rattlesnakes.

The figures published by Russell are probably as reliable as any obtainable. It is of interest to note, however, that an estimate based on the number of fatalities recorded in New Mexico over a 42-year period suggests that many fewer persons are bitten in the state than Russell's data would indicate. Campbell (1975), who notes that "only a rough estimate of the average annual number of rattlesnake bites in New Mexico is possible," analyzed data obtained from the State Health Agency of the New Mexico Social Services Department. During the years 1931 to 1972 the State Health Agency had recorded only 19 fatalities from snakebite. Because fatalities on Indian reservations were not reported by the agency during part of this period Campbell suggests that perhaps 25 deaths in the state might have been attributable to snakebite during the 42-year period. On this basis the number of deaths resulting from snakebite in New Mexico would approximate a yearly average of 0.6. Assuming that the mortality rate for those bitten by rattlesnakes in recent decades is roughly 3% in the United States, a figure supplied by Klauber (*supra cit.*), Campbell's . .

calculations lead him to conclude that the number of rattlesnake bites occuring annually in New Mexico would approximate a mean of 20.

Without detailed knowledge of the methods employed by those who assembled the data, the figures supplied by Russell for the incidence of snakebite in New Mexico cannot be reconciled with the estimate obtained by Campbell. The average number of of bites by rattlesnakes in the state perhaps falls between the extremes of 20 and 50, and may, in fact, be affected by the influx of people. The data that Campbell obtained from the State Health Agency indicate that snakebite fatalities were reported from only 15 of the 32 counties in New Mexico from 1931 to 1972. Over this 42-year period no deaths attributable to rattlesnake bite were reported in the seven counties, including Santa Fe and Taos, that lie west of Colfax and San Miguel counties. In contrast, at least one fatality was reported for each of the six states situated along the eastern boundary of New Mexico in the plains. The sample of 19 fatalities leaves doubt concerning the reliability of inferences drawn from the survey. It may be significant, however, that San Miguel was the only county where as many as three deaths from snakebite were recorded in the state.

Even with these limited data, it seems evident that the incidence of snakebite in Santa Fe and Los Alamos counties is relatively low despite the fact that the two species of rattlesnakes inhabiting the LA/NERP area are among the six believed to cause most of the bites in the United States. Snakes of the same species vary in their reactions, depending in part on the place as well as the conditions under which they are confronted by human beings. To judge from the few rattlesnakes I have seen in the vicinity of the Jemez Mountains, as well as by the reports of others, the rattlesnakes of the two species in the area are not inclined to be agressive. They either tend to remain motionless, thus enhancing the probability of their remaining undetected, or they attempt to flee when crevices or burrows afford shelter in the immediate vicinity. Despite the potential danger of rattlesnakes, therefore, they cannot be regarded as a serious hazard if the persons invading their habitats are alert and take the precautions necessary to avoid either stepping on rattlesnakes or coming within striking distance.

Western Rattlesnake, Crotalus viridis Rafinesque

The western rattlesnake is represented in New Mexico by three subspecies. These are: (1) The Hopi rattlesnake, C. v. nuntius, an inhabitant of the Coconino Plateau and the Painted Desert in Arizona that intergrades with C. v. viridis west of Gallup; (2) the Arizona black rattlesnake, C. v. cerberus, which abruptly replaces the Hopi rattlesnake in the mountains south of the Painted Desert in Arizona and barely ranges into New Mexico near the state line; and (3) the prairie rattlesnake, C. v. viridis, now known almost throughout the entire state with the exception of areas adjoining Arizona. The prairie rattlesnake seems to be adapted primarily for grassland, particularly the plains and prairies. Nevertheless, it has penetrated the foothills of the mountains in the state, although it is absent from the higher mountains. It is questionable whether C. v. viridis occurs in New Mexico above 2900 m. Hence it cannot be regarded as ubiquitous even though it is the most widely distributed of the seven rattlesnakes in New Mexico.

Crotalus viridis is perhaps the most adaptable of the 15 species of rattlesnake in the United States. One or another of the nine subspecies occupies much of North America west of the 100th meridian, from southwestern Canada to northwestern Mexico. From extreme western Iowa to the Pacific Coast the various subspecies have become adapted to a wide range of habitats, including islands near the coast of California and Baja California. The only insular population that has become sufficiently well differentiated to warrant recognition, however, is C. v. caliginis on South Coronado Island off the northwest coast of Baja California. The other subspecies are either restricted to parts of the Unites States, or they have distributions that extend into Canada or a short distance into Mexico. The species is absent from the warmest lowland deserts, as well as from the higher parts of the Rocky Mountains. Despite this avoidance of elevated areas farther inland, the most widely distributed of three subspecies in California, the northern Pacific rattlesnake, C. v. oreganus, has a distribution that extends from the coastal lowlands eastward through mountains and valleys and into the Sierra Nevada, where it reaches elevations of 3400 m in some places near timberline. Inasmuch as C. v. oreganus is found at sea level along the Pacific Coast, it seems certain that this rattler has a greater vertical range than any other. The Mexican dusky rattlesnake, C. t. triseriatus, has been reported from Mt. Orizaba at elevations that may exceed 4400 m, but it seems to be adaptively specialized for montane environments; it has not been reported below 1400 m.

As a rule, the rattlesnakes adapted to montane environments are dark, commonly black or slate gray. The Arizona black rattlesnake, C. v. cerberus, varies extensively but nevertheless conforms to the rule. The prairie rattler is an exception, however, for the greens, olive-greens, and olive-browns of the populations inhabiting the plains are largely retained by members of the same subspecies found in montane environments. The pattern and coloration of C. v. viridis, which probably evolved in a progenitor adapted for grassland habitats, cannot have been particularly disadvantageous when members of this subspecies extended their range into mountainous areas. In the relatively barren terrain of the Painted Desert, however, where red is the predominant color of the landscape in many areas, greenish pigments have been largely eliminated as the result of natural selection's having favored the retention of pigments that enhanced the chances of the snakes' survival on red soils. If this assumption is correct, therefore, the Hopi rattlesnake, C. v. nuntius, has evolved in situ, where its pink, red or red-brown coloration can readily be interpreted as being procryptic.

As noted earlier in this account, C. v. viridis gradually merges with C. v. nuntius, with intergrades occurring over a broad zone from Gallup westward. Gehlbach (1965) has discussed some of the difficulties encountered in assigning specimens from northwestern New Mexico to the subspecies as mapped by Klauber (1935: 76). Until more reprepresentative samples become available from the Four Corners area no completely satisfactory interpretation can be attained, but Gehlbach suggests that intergrades between the prairie and Hopi rattlesnakes may also merge with the midget faded rattlesnake, C. v. concolor, in the San Juan Basin.

Unlike nuntius, which is surely a relatively recent derivative of the prairie rattlesnake that extended its range westward across New Mexico from the Great Plains, cerberus appears to have been derived from ancestors that evolved to the west of the Colorado River. The Arizona black rattlesnake so closely resembles C. v. helleri, which is now restricted to northern Baja California and southern California west of the deserts, that both of them were grouped with C. v. oreganus, the "black" rattlesnake that occupies much of the area between southern California and British Columbia. Detailed analysis awaited the assemblage of suitably representative samples of the rattlesnakes inhabiting the Pacific states and the mountains of Arizona. The thorough investigations of Klauber (1949) left no doubt concerning the affinities of rattlesnakes on opposite sides of the deserts. He decided to recognize the disjunct population in Arizona mainly because of "its dark color and a marked subdivision of the scales on the snout." In even the most diagnostic characters, however, Klauber noted that "some overlapping" occurred. The differences between helleri and cerberus "are somewhat less consistent" than those employed by Klauber in diagnosing other races of C. viridis. He might not have recognized cerberus, however, had it not been for the "added weight of complete territorial separation."

So we have poorly differentiated subspecies in California and Arizona, the nearest populations of which are separated by approximately 320 km of desert that appears to be uninhabitable by subspecies of C. viridis. The isolation of cerberus in Arizona is presumably the result of a trend toward increasingly arid climates and the expansion of the deserts. Regardless of how long ago the ancestors of cerberus became territorially isolated from their western progenitor, the morphological similarities of helleri and cerberus suggest that they are potentially capable of interbreeding. It seems probable that the ancestors of cerberus had penetrated much of the rugged terrain on both sides of the Colorado River before they reached areas invaded from the east by the prairie rattlesnake and its derivative, *nuntius*.

There is perhaps no way to find out how long the progenitors of *cerberus* and *viridis* had been territorially isolated or when their respective dispersals eventually led to their occupation of contiguous areas. In the absence of either hybrids or intergrades in the zone where interbreeding might occur, however, it seems reasonable to infer that the extent of their divergence precludes, or at least discourages, gene exchange between *cercerus* and the nominate subspecies or its closely related subspecies, *nuntius*.

The nature of the isolation mechanism that inhibits interbreeding between *cerberus* and *nuntius* remains to be ascertained. Klauber (1949:168) suggested that there might be an overlap in the distributions of these two subspecies without intergradation. Although more than three decades have elapsed since this statement appeared, we still lack evidence that *cerberus* actually occurs sympatrically with either *nuntius* or the nominate subspecies. If representatives of readily distinguishable subspecies never occur together, we can scarcely expect to find evidence of their interbreeding. The evidence available would favor this explanation, at the same time raising a more difficult question: How can rattlesnakes of separate lines of descent continue to occupy adjacent areas and maintain mutually exclusive distributions for long periods of time?

Whereas *C. v. viridis* exploits a wide range of habitats in New Mexico, including mountains, why is it excluded from the mountains in Arizona inhabited by *cerberus*? Is it because neither of the two forms can tolerate the competition that would accompany the presence of the other? This may be a valid assumption, but it fails to explain why these snakes, as well as others to be cited below, behave as though some impregnable physical barrier prevented their invasion of areas occupied by near relatives. Klauber (1972: fig. 2-6) indicates that the distribution of the prairie rattlesnake extends as far west as Steeple Rock, the easternmost outpost for *cerberus* near the Arizona boundary in Grant County, New Mexico. It is of interest to note that somewhat farther south in the same region *C. v. viridis* is abruptly replaced by the Mojave rattlesnake, *C. scutulatus*, which occupies areas west of the Peloncillo

Mountains in Hidalgo County. The Mojave rattlesnake is widely distributed to the west as well as to the south of New Mexico. Its range may interdigitate with that of the subspecies of C. viridis occupying areas adjacent to the Mojave Desert, but there are no substantiated reports of viridis and scutulatus occurring side by side. In Hidalgo County both species can be found on New Mexico Highway 9 where it crosses the Peloncillo Mountains through Antelope Pass at an elevation of 1370 m a few kilometers northeast of Rodeo. The road is in relatively flat terrain so that it is difficult to detect the divide that separates San Simon Valley on the west from Animas Valley to the east. Whenever collectors have kept accurate records to document specimens found on this road they discover that scutulatus is restricted to the area west of the divide. Whereas viridis seems to be somewhat more frequently encountered farther east near Animas specimens have been taken within a kilometer or so of the divide.

Much the same situation prevails at the edge of the Mojave Desert in Los Angeles County, California. Crotalus viridis helleri is the only rattlesnake inhabiting the San Gabriel Mountains, where it is relatively abundant as far north as the foothills along the edge of the desert. The Mojave rattlesnake begins to be found in the relatively flat desert, often in areas inhabited by the much smaller sidewinder, C. cerastes, but never in terrain occupied by C. v. helleri. In the absence of scutulatus in San Joaquin Valley, not far north of the western extremity of the Mojave Desert known as Antelope Valley, helleri is relatively common in open, flat terrain. A similar situation exists where the range of the western diamondback, C. atrox, extends across the Sonoran Desert and northward into the Coachella Valley. Whereas atrox occurs in a wide range of habitats in the plateaus, mountains and valleys lying to the east, in the Coachella Valley it is largely restricted to the mesquite thickets along the edge of sand dunes. In the foothills of the San Jacinto Mountains immediately to the west of the dunes occupied by atrox, a closely related species, the red diamond rattlesnake, C. ruber, makes its appearance. The red diamond barely ranges into the flat desert but in no instance is it known to occur in the areas occupied by *atrox* (see Klauber, 1972:fig. 2:1). The vegetation in the rocky ridges and alluvial cones of the foothills on the desert slope of the San Jacintos differs little from that in the foothills of lesser mountains to the east. As may be inferred from what is known of the distribution of *atrox* in Bandelier National Monument and LA/NERP, this rattlesnake occurs well beyond the upper limits of the Lower Sonoran Zone in many areas. Moreover, *atrox* occurs sympatrically with several other rattlesnakes, including *mitchelli*, *molossus*, *scutulatus*, *tigris* and *viridis*, as well as some of the smaller species, notably *lepidus*. Where *atrox* might have invaded the foothills of the San Jacintos and intermingled or perhaps even have interbred with *ruber*, however, the two species have effectively maintained mutually exclusive distributions.

Such distributions have been largely ignored by herpetologists, who have made little if any effort to account for the maintenance of allopatry by closely related species whose dispersals have seemingly resulted in their occupancy of contiguous areas. This neglect is perhaps attributable to the difficulties entailed in assembling the requisite data to conclusively demonstrate the phenomenon. This is particularly true of animals as secretive as snakes, which can seldom be found in adequate numbers when attempts are made to delineate ranges in precise detail. Mutually exclusive distributions of related species are not confined to rattlesnakes, and they may prove to be more widespread among other serpents as they become better represented in collections. Part of the problem arises from the necessary dependence upon negative evidence. When hybrids or intergrades occur in zones of contact they offer relatively convincing evidence of gene interchange. When evidence of interbreeding is lacking, however, decades of field work may be required in critical areas before an investigator can convince himself, much less his colleagues, that two readily distinguishable forms live in adjacent areas but meticulously avoid each other.

So the phenomenon remains unexplained. The maintenance of territories by individual members of some species has been reported for a wide variety of vertebrates, including reptiles. Among crocodilians and lizards males actively defend territories against the intrusions of conspecific males, but trespassers of other species are ignored. Owing to their secretive habits relatively little has been learned about territorial behavior in snakes. Klauber (1972:603), who reviewed the literature dealing with rattlesnakes suggests that they probably have home ranges, or at least "a restriction of wandering or prowling to a relatively small area." Klauber found no evidence, however, that any rattlesnake has "a defended territory, from which other rattlesnakes are driven away."

What little is known about territorial behavior in snakes, therefore, sheds no light on the maintenance of mutually exclusive ranges by potentially competing species whose dispersals have led to their occupation of contiguous areas. It is noteworthy that this situation ordinarily involves distinct species, ruber and and atrox in California, and scutulatus and viridis (including the subspecies helleri, oreganus, lutosus and cerberus) in California, Nevada, Arizona and southwestern New Mexico. The abrupt replacement of the nominate subspecies, C. v. viridis, by the distantly related subspecies, C. v. cerberus, near the Arizona-New Mexico state boundary, and the replacement of this black subspecies by C. v. nuntius northeast of Flagstaff, Arizona, suggest that the interreactions between the subspecies in these instances closely resemble those between closely related species. As noted above, cerberus might well be regarded as a distinct species were it not for the lack of any dichotomous chareracter that serves to distinguish it from helleri perhaps because the two became isolated in relatively recent times. Any of several mechanisms might discourage interbreeding between populations of fairly closely related rattlesnakes where their ranges are proximate.

If it is largely a matter of individuals of distinctive species or subspecies avoiding each other where contacts might occur, however, the behavior involved can only be described as mysterious. We on 19 July 1975 and 9 July 1976, respectively.

Degenhardt (1975) failed to find C. v. viridis in Bandelier National Monument, although he reports finding a specimen on "New Mexico Highway 4 approximately two miles north of the monument boundary in Pinyon-Juniper habitat." This provides an additional record for LA/NERP, but no definite records have yet been published for Bandelier National Monument. Fleisher (1978), however, indicates that viridis is "uncommon in pinyon-juniper at lower elevation mesas," in his list of the species presumably known to occur in the monument.