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A Biogeographic Analysis of the Herpetofauna of the San Luis Valley, Colorado

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A BIOGEOGRAPHIC ANALYSIS OF THE HERPETOFAUNA OF THE SAN LUIS VALLEY, COLORADO

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by
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MANUSCRIPT THESES

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ABSTRACT

During the period January, 1960, to September, 1965, herpetological collections were made throughout the isolated San Luis Valley in south-central Colorado. Over 800 specimens representing 15 species were examined and compared taxonomically with populations outside the Valley. Brief notes are included on natural history and ecology of the species in the area. Data are also presented on geography, geology, climate, vegetation, and zoogeographic position of the Valley. Thamnophis sirtalis dorsalis is eliminated from the fauna of Colorado upon re-examination of the specimen upon which this record was based. Data on Phrynosoma douglassi from the Valley support Gehlbach's (1965) conclusion that the race ornatissimum is only a high altitude variant of P. d. hernandesi. The first known intergrades of Eumeces multivirgatus are described from the Valley, proving E. m. multivirgatus and E. m. epipleurotus to be conspecific. A previously unknown ontogenetic pattern change is also described for this species. The relictual Valley population of Bufo cognatus is considered to represent a distinct race, but is not named due to a lack of information on geographic variation of the species in other areas. It is recommended that the name of the New Mexico-Arizona population of Pseudacris t. triseriata, currently considered a western relictual colony of the eastern population of P. t. triseriata, be changed to P. t. maculata. Specimens from the supposed areas of intergradation show a smooth north-south cline in taxonomic characters rather than an abrupt change.

INTRODUCTION

From a herpetological point of view, many isolated areas in the western United States are still very poorly known. The San Luis Valley in south-central Colorado is an outstanding example of such an area, being well separated by high mountains from the adjacent country.

Most of the faunal surveys of the past half-century have been delimited by geo-political rather than natural units. This type of survey makes for a very artificial situation zoogeographically but is often dictated by necessity. Several herpetological studies of natural areas, however, have been attempted in recent years. Martin's (1958) study of the Gomez Farias region of Tamaulipas and Gehlbach's (1965) report on the herpetofauna of the Zuni Mountain area of New Mexico are two outstanding examples of herpetological zoogeography dealing with natural areas. Both works have greatly influenced me in the writing of this thesis.

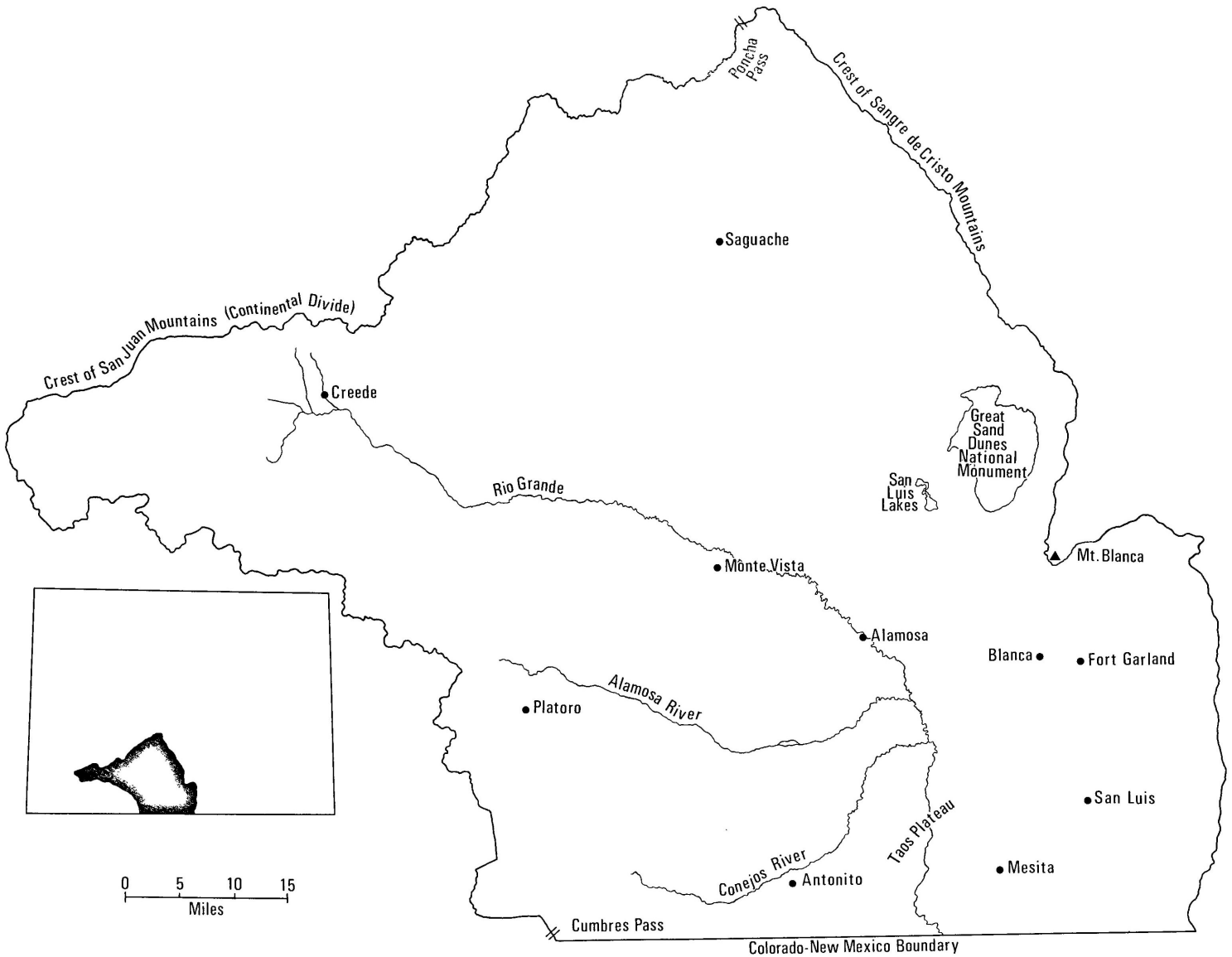
I first became interested in the herpetofauna of the San Luis Valley in early 1960. Sections of the entire area were extensively collected until September, 1965, when I moved from the Valley. All major museums were checked for material from the study area. A total of over 800 specimens from the San Luis Valley area were examined during the course of this study, most of them collected personally and deposited in the Louisiana State University Museum of Zoology.

The chief objectives of this study are (1) to find out what species of reptiles and amphibians have been successful in establishing themselves in the harsh environment of the San Luis Valley, (2) to plot the geographic

distribution of these forms within the Valley, (3) to find probable limiting factors to dispersal within the Valley, thus possibly explaining curious local distribution patterns, (4) to determine the effect of relative isolation on the variability of characters in the Valley populations, (5) to determine the taxonomic status of these populations and their relationships with populations outside the Valley, (6) to postulate on past and present dispersal routes into the Valley, and (7) to consider the probable effects of geological-historical events on herpetofauna of the area.

To gain an understanding of the animal habitats occurring in the Valley a discussion of the geography, geology, climate, and vegetation of the area is essential. All of these, as well as more subtle factors and their interactions, directly or indirectly limit the distribution and success of any species.

Figure 1. Map of the San Luis Valley. Insert map shows position of the Valley in Colorado.


Poncha Pass
Crest of Sangre de Cristo Mountains
Saguache
Crest of San Juan Mountains (Continental Divide)
Creede
Great Sand Dunes National Monument
San Luis Lakes
Rio Grande
Mt. Blanca
Monte Vista
Alamosa
Blanca
Fort Garland
Alamosa River
Platoro
San Luis
Taos Plateau
Mesita
Conejos River
Antonito
Cumbres Pass
Colorado-New Mexico Boundary
0 5 10 15
Miles

GEOGRAPHY AND GEOLOGY

The San Luis Valley is a mitten-shaped intermontane basin lying in south-central Colorado (long. 105° 10' to 107° 35' W, lat. 36° 56' to 38° 27' N). It has a north-south distance of slightly over 150 miles and extends nearly 100 miles east-west. The total area encompassed is slightly more than 8,200 square miles, which is larger than the combined areas of Rhode Island, Connecticut, and Delaware. In this paper the San Luis Valley is considered to include the mountains forming the boundaries of the area as well as the foothills and Valley floor.

The Valley area includes five entire county units (Alamosa, Conejos, Costilla, Mineral, and Rio Grande) and portions of two counties (Saguache and Hinsdale).

The Valley is bounded by the Sangre de Cristo-Culebra mountain range to the east, the San Juan, Sawatch, and Conejos Ranges to the west, and the Taos Plateau on the south. The Valley floor ranges in elevation from 7,500 to nearly 8,000 feet and has a very flat surface. The lowest areas lie along an axis running parallel and adjacent to the eastern margin of the Valley floor. The extreme elevations in the Valley area are 7,500 feet at the San Luis Lakes and 14,317 feet at Blanca Peak in the Sangre de Cristos, a vertical range of nearly 7,000 feet. The Sawatch and Sangre de Cristo Ranges merge on the north with the relatively low (9,010 feet) Poncha Pass lying between. The eastern, western, and northern boundaries of the Valley contain some of the highest peaks in Colorado, nine rising to more than 14,000 feet, eighteen others having elevations in excess of 13,000 feet. The Continental Divide follows the ridge of the San Juan group.

The Taos Plateau forms a line of basalt-capped, flat-topped hills across the southern boundary of the San Luis Valley and rises to about 8,700 feet in elevation. This line runs roughly from Antonito to San Luis, which is quite close to the state boundary between Colorado and New Mexico. Two low volcanic peaks, San Antone Mountain and Ute Peak, are also included in this plateau. The only major break in the Taos Plateau is the Rio Grande Canyon, which cuts a relatively deep, narrow channel, draining the Valley.

The Sangre de Cristo Range extends from the Arkansas River on the north, southward to the vicinity of Las Vegas, New Mexico, a distance of some 200 miles. These mountains are more recent in origin (Miocene) than the San Juan complex, which was formed mainly by Tertiary volcanic activity (Burford, 1961). The Sangre de Cristos, being younger mountains, have much more exposed bare rock areas, and much less soil, vegetation, and water than the more weathered San Juans. The geological features of the Sangre de Cristos are better known and especially well exposed due to the dry climate and limited soil cover (see Bolyard, 1960; Litsey, 1960).

The Mississippi River System drains most of the mountains and plains east of the Continental Divide, but most of the streams of the San Luis Valley and its flanks form the headwaters of the Rio Grande drainage. A closed drainage system occurs in the north end of the San Luis Valley, with streams from both the Sawatch and northern Sangre de Cristo Ranges collecting in the San Luis Lakes which lack a natural outlet. In recent years much of this water has been channeled off for irrigation purposes, occasionally causing the lakes to dry up during the spring and early summer.

Glaciation was widespread throughout the San Juan and Sangre de Cristo Ranges during the Pleistocene and small remnants of these glaciers still survive in both ranges. All present major water courses were heavily glaciated, forming prominent moraines and extensive alluvial fans on the Valley floor margins (Ramaley, 1942).

Ramaley (1942), Hanson (1929), and others believe that prior to the late Pleistocene the entire Valley was an extensive lake, formed from the drainage of both the San Juan and Sangre de Cristo Ranges and naturally dammed by the volcanic Taos Plateau. When the flood waters eroded an outlet through the plateau, forming the Rio Grande Canyon, the lake was slowly drained leaving the flat lake bed as the Valley floor.

Dry lakes, occasionally wet during some seasons, are found in many lower portions of the Valley floor. Creeks in the northeastern portion of the Valley sink and disappear, reappearing nearer the center of the Valley as springs and Artesian wells.

The soils of the Valley floor consist mainly of fine sand and clays. Larger material occurs primarily in the alluvial fans along the margins of the Valley. The uppermost geological stratum on the Valley floor, the Alamosa formation of the post-Miocene to pre-glacial period, consists of alternating layers of fine sand and blue clays and provides ideal conditions for an artesian basin. Thousands of wells have been bored, primarily in the period from 1890 to 1910. The water table of the Valley floor is high, usually lying between three and eight feet from the surface (Ramaley, 1942). Underlying the Alamosa formation, which is hundreds of feet

in depth, rests the Santa Fe formation of Miocene age. This formation consists primarily of many thin layers of alluvium separated by interstratified lavas and tuffs (Siebenthal, 1910).

The Great Sand Dunes occupy approximately 40 square miles along the northeastern corner of the Valley, adjacent to Medano, Music, and Mosca Passes, and parallel to the Sangre de Cristo Range for approximately 10 miles. Strong spring and early summer southwestern winds striking the mountains, causing the winds to drop their accumulation of sand, probably formed the Great Sand Dunes (Merk, 1960).

The Valley basin was formed late in the history of the Rocky Mountains by being downdropped along a moving fault near the eastern boundary of the Valley floor. Formations of all ages, except Silurian, are found within the San Luis Valley area (Curtis, 1960).

CLIMATE

The only U. S. Weather Bureau station currently operating in the San Luis Valley is located near Alamosa on the central portion of the Valley floor. In past years a number of small supplementary co-operative stations were located in other areas of the Valley. Some mean comparative weather data from these stations are presented in Table 1. Weather data in the following account are taken from Ramaley (1942) and the Alamosa U. S. Weather Bureau (1963).

As seen in Table 1, precipitation is lowest in the central portions of the Valley and increases toward the periphery. With most localities averaging less than ten inches of total precipitation annually, cold desert conditions are common in areas not extensively irrigated. Most of the Valley and the relatively dry Sangre de Cristo Range lies in a rain shadow produced by the San Juan Range. Uplift and cooling of the moist west winds as they cross the San Juans results in relatively heavy precipitation. The amount of precipitation is roughly proportional to the elevation to which the air mass is forced, with much local variation resulting from such factors as the shape of valleys, exposure of slope, storm path, and size of individual mountains. Maximum precipitation usually occurs in the Douglas Fir Zone.

About 80 percent of the total annual precipitation on the Valley floor occurs as light scattered afternoon showers from April until October. Highest amounts of rainfall occur during July and August. Hail is frequent during summer thunderstorms, occasionally causing great crop

Table 1

Valley Climatological Data

	Elevation	Mean annual temperature	Average length of growing season	Annual precipitation
Blanca	7,980 ft.	42.0°F.	105 days	9.2 in.
Del Norte	7,880	42.3°	121	8.1
Garnett	7,610	41.4°	97	6.8
Manassa	7,670	41.7°	99	6.9
Saguache	7,740	43.9°	119	8.9
San Luis	7,800	42.2°	108	11.2
Wagon Wheel Gap	8,434	34.8°	26	--
Alamosa	7,546	41.9°	90	6.3

damage. In most years, June, July, and August are the only snow-free months on the Valley floor. Most snowfalls are light and the total amount averages less than 28 inches a year at Alamosa. But snow remains on the ground for several weeks during cold weather. Snow packs of more than 30 feet in depth are common at Wolf Creek Pass and Cumbres Pass in the San Juan Mountains.

Mean annual temperatures for several localities are listed in Table 1. At Alamosa, summer temperatures during June, July, and August range from a maximum of 91°F to a minimum of 26°F, and an average normal maximum of 80.3°F to an average normal minimum of 45.7°F. Mean lengths of growing seasons (period from last killing frost of season to first killing frost) and elevations for several towns are given in Table 1. Usually, the months of June, July, and August comprise the only frost-free period on the Valley floor. Above 9,000 feet, frost is apt to occur occasionally every month in the year. At elevations between 13,000 and 14,000 feet, frost is apt to occur nightly throughout the year. The coldest temperature ever recorded at Alamosa was -50°F; -40°F is usually reached at least once very winter. Data obtained at the Alamosa weather station are probably fairly typical for the entire Valley floor.

During the day there is normally about a 3°F difference in temperature for each 1,000-foot increase in elevation. At night there is a tendency for the denser masses of cold air to drain down valleys and to slide under the lighter layer of warm air, causing an inversion of the normal vertical gradient. The daily range of temperature fluctuations are therefore usually of a much greater extent than at other

localities at the same altitude but not in a valley situation. Each 1,000-foot rise in elevation in this area delays spring and speeds up the coming of autumn by about two weeks.

With the increase in altitude there is a decrease in the atmospheric pressure. This decrease has several climatic effects including: (1) allowing more intense insulation during the day, due to the thinness of the atmosphere; (2) surface heat is more rapidly lost at night; (3) the evaporative power of air is greatly increased; (4) the partial pressure of oxygen is lowered; and (5) the partial pressure of carbon dioxide is also lowered. Cloud cover averages less than 5 percent daily, with completely overcast days being rare. The evaporative power of the air is controlled by temperature, relative humidity, wind velocity, and atmospheric pressure. In the Valley area the evaporative rate is lowest in the coniferous forest belts (spruce-fir and Douglas Fir associations) and steadily increases both up-slope and down. The evaporation rate greatly exceeds the amount of precipitation on the Valley floor. Garnett, in the center of the Valley, had an average of 49.9 inches evaporation per annum, the highest rate recorded from any station in Colorado.

There seems to be no constant relationship between relative humidity and altitude. On the Valley floor relative humidity ranges from an average of 76 percent in the early morning to about 40 percent during the afternoon.

Winds are light during the coldest months, but become strong during spring and early summer, occasionally blowing great quantities of dust and sand. These winds are usually from the southwest.

Winter extremes, short growing seasons (hence, periods of animal activity), and widespread areas of high aridity have made a great portion of the Valley an unsuitable habitat for most species of Colorado reptiles and amphibians. All terrestrial ectotherms occurring in the Valley, with the exception of Phrynosoma douglassi, are confined to the vicinity of perennial streams, marshes, ponds, lakes, and irrigation drainages. In addition, most of the reptiles are further limited in local distribution to rocky areas with suitable deep crevices for hibernating through the long, severe winters. Many other factors besides climate interact to preclude the occurrence of many species of reptiles and amphibians. Thus, of the 62 species known to occur in the state, only 14 are known with certainty to have been able to extend their ranges into the San Luis Valley and adapt to its harsh environment.

VEGETATION OF THE SAN LUIS VALLEY

An extensive study of the vegetation of the San Luis Valley was published by Ramaley in 1942. Another major paper on this subject dealt with the economic value of the local vegetation and ecological conditions to agriculture and grazing (Hanson, 1929). Cary's (1911) report on the biology of the state also had many observations on the flora of the San Luis Valey and included a detailed map of the Life Zones of the state.

The Life Zone concept with its characteristic plant indicators is very useful, at least in the western United States with the considerable variation in topography present. Each Life Zone reflects a degree of uniformity in environmental conditions. Plant indicators of the different Life Zones may be regarded as portraying the character of the habitat. These indicator species are based on a cause-effect relationship, with the total environment acting as the cause on a few plants sufficiently restricted by growth conditions to be useful in recognizing similar animal habitats, including microclimate, similar paths of energy transfer, and shelter types. (Sampson, 1939). Two widely separated areas in the same Life Zone having the same indicator species should therefore show the same basic ecological conditions which also affect the animals living in the Life Zone.

The Upper Sonoran Life Zone extends up the narrow Rio Grande Valley in New Mexico into the San Luis Valley. Here the zone widens and occupies much of the flat Valley floor, foothills, and lower mountain sides. Elements of the Transition Zone extend down onto the Valley floor along all major permanent water courses, cutting narrow pathways into the

Upper Sonoran vegetation. The Upper Sonoran Life Zone ranges in elevation from 7,500 to 8,500 feet, sometimes as high as 9,000 feet on the warm western slopes of the Sangre de Cristo range. The characteristic plants occurring in the Life Zone form two major and many minor plant associations in the Valley area.

The Rabbitbrush-Greasewood Association occurs in the central portion of the Valley floor in areas with a high water table. The chief limiting factors for vegetation in this association appear to be the excess alkali in the soil and the lack of soil aeration. Plant cover is sparse in most areas, with much bare soil exposed. This association has doubled its original limits with the rise in the water table due to extensive irrigation by canals and artesian wells. Presently the Rabbitbrush-Greasewood Association ranges in an ellipse from Manassa on the south to Saguache on the north. Monte Vista forms the western boundary, and the town of Blanca the eastern limit. Commonest species of plants characteristic of this association include the following: Sarcobatus vermiculatus, Chrysothamnus sp., Distichlis stricta, Sporobolus airoides, and Muhlenbergia asperifolia (Ramaley, 1942).

The Pinyon-Juniper Association forms a band of varying width about the rim of the Valley floor below the true coniferous forest. Dominants in this association are Pinus edulis and Sabina scopulorum. This association nearly always occurs in rocky areas. Other more minor plant associations in this Life Zone include Grassland and Sedgeland, River-bottom Forest, Aquatic Vegetation, Abandoned Field, Sand Dune, and Sagebrush Scrub (Ramaley, 1942).

Fourteen of the fifteen species of reptiles and amphibians found in the San Luis Valley occur in the Upper Sonoran Life Zone, the single exception being Bufo boreas.

Immediately above the Pinyon-Juniper Association lies the Transition Life Zone. This zone usually ranges in altitude from 8,200 to 8,800 feet but, depending on the slope facing, may extend higher or lower. The Transition Zone varies greatly in the Valley area in both vertical width and plant characterization, being sometimes strongly marked and in other areas dilute and ill defined. These variations appear to be due mainly to differences in the angle of include of the slope and the exposure facing. On warm south or southwestern slopes this zone is almost entirely lost, being crowded out by the upward extension of the Upper Sonoran elements (Cary, 1911). The Transition Zone connects the San Luis Valley to the Arkansas River Valley via the low (9,010 feet) Poncha Pass in the extreme northern portion of the Valley. This connection has probably served as an important route for animal dispersal into the Valley.

The yellow or Ponderosa pine, Pinus scopulorum, is the dominant Transition Zone tree in this area. Other typical indicators include Quercus gambeli, Q. fendleri, Prunus melanocarpa, Populus angustifolia (along streams), Amelanchier alnifolia, A. bakeri, Ceanothus velutinus, Kunzia tridentata, and Cercocarpus parvifolius (Cary, 1911).

Elements of both Upper Sonoran and Canadian enter about equally into the composition of this zone, but many species of plants, birds, and mammals are wholly or mainly restricted to the Transition Life Zone,

Cary (1911) listed the species restricted to each Life Zone in Colorado. Reptiles taken in this zone in the Valley include Eumeces multivirgatus, Sceloporus undulatus, and Crotalus viridis. Other species such as Pituophis melanoleucus and Phrynosoma douglassi undoubtedly occur in this zone also. No amphibians were found in the Transition Zone. This probably can be accounted for by the lack of suitable habitat, especially breeding sites. All streams in this zone are extremely swift and descend in altitude at a rapid rate. No ponds or other standing water was found in this Zone.

The extensive Canadian Life Zone lies immediately above the Transition, and includes the largest portion of the coniferous forests in this area. This zone ranges in elevation from 8,300 to nearly 10,000 feet in the San Luis Valley area. Large expanses of moist, open meadow often occur in the vicinity of streams. Aspen groves (Populus trimuloides) also are common in areas which have been either burned over or lumbered. Climax vegetation includes lodgepole pines (Pinus murrayana), white fir (Abies concolor), limber pine (Pinus flexilis), and Pseudotsuga taxifolia (Cary, 1911). Very little undergrowth occurs in these forests.

Reptiles and amphibians collected in this Life Zone in the Valley include Ambystoma tigrinum, Pseudacris triseriata, Bufo boreas, Rana pipiens, and Thamnophis elegans.

In the Valley area the Hudsonian Life Zone consists of a prominent dark-colored forest belt bordering the upper boundary of the Canadian Life Zone. Dominants in this upper forest include Engelmann spruce (Picea engelmanni), balsam fir (Abies lasiocarpa) and foxtail pine (Pinus aristata). Like the Transition Life Zone, the Hudsonian shares many elements

with the Life Zones above and below it and has very few species characteristic of the zone. The Hudsonian Zone occurs only in mountains high enough to support an Arctic-Alpine Life Zone above it. The upper boundary of the Hudsonian is timberline. This Life Zone ranges in elevation from 10,200 to 11,500 feet, again depending primarily upon slope facing. The mossy floor of this zone is usually saturated with water from melting snow above in the Arctic-Alpine Zone. Cold bogs and ponds are numerous in this Life Zone in the San Juan Range (Cary, 1911).

I have found Ambystoma tigrinum, Pseudacris triseriata, and Bufo boreas in the lowest portion of this zone at about 10,200 feet elevation near Cumbres Pass.

Timberline occurs from 11,000 to 12,000 feet elevation in the San Luis Valley area. Above this boundary lies the Arctic-Alpine Life Zone, limited to only the highest peaks of the San Juan and Sangre de Cristo ranges. This zone is snow covered most of the year, with much of it remaining through the entire summer. The only shrubs able to withstand the harsh climate are a few species of alpine willows (Salix petrophila, S. glaucops, and S. chlorophylla). These willows form dense thickets a few inches to three feet in height, and occur from timberline to about 13,000 feet in elevation. Above 13,000 feet the vegetation consists primarily of mosses and lichens. Small flowering plants are common below 13,000 feet, but few species are represented (Cary, 1911). No reptiles or amphibians were encountered in this Life Zone. Very little effort was made in collecting this area, however.

HISTORY OF HERPETOLOGICAL INVESTIGATIONS IN THE SAN LUIS VALLEY

The first reptiles and amphibians from the San Luis Valley to be recorded in the literature were collected during 1873-74 by members of the Geographic and Geologic Exploring Survey and were reported by Yarrow in 1875. The species involved were Ambystoma tigrinum, Bufo cognatus, Pseudacris triseriata, Rana pipiens, Thamnophis elegans, T. sirtalis, and Phrynosoma douglassi. In nearly all cases the only locality data presented were either "San Luis Valley," "Rio Grande River, Colorado," or "Fort Garland, Colorado," the latter being the shipping point but not necessarily the site of collection, a common source of confusion and error to later workers. All of the species listed by Yarrow (1875), with the exception of Thamnophis sirtalis, can be found today within a few miles of Fort Garland. The current status and range of T. sirtalis in the Valley area will be discussed in the species accounts.

The first state herpetological checklist for Colorado was published in two parts by Ellis and Henderson in 1913 and 1915. Very few new records for the San Luis Valley were included.

From 1925 to the present the University of Michigan, University of Kansas, and especially the University of Colorado have made several collecting trips into the San Luis Valley. I have been able to examine the majority of these specimens.

Maslin (1959) brought the distributional knowledge of Colorado herpetofauna up-to-date by listing the specimens contained in the University of Colorado Museum as well as the literature records for the state.

Many Valley specimens are included in this work. With the rapid accumulation of more material from throughout the state and the checking of Colorado material in other major museums, a supplement to Maslin's (1959) work was published in 1965 by Smith, Maslin, and Brown.

Many papers of a general nature, or monographs on various species of reptiles and amphibians that range into the area mention Valley specimens. These are referred to in the species accounts.

SPECIES ACCOUNTS

CLASS AMPHIBIA

ORDER CAUDATA

FAMILY AMBYSTOMATIDAE

Ambystoma tigrinum (Green)

Species examined: Alamosa Co., Alamosa, LSUMZ 13843-44; Great Sand Dunes National Monument, UMMZ 122930-32; near Mosca, LSUMZ 13845; 5-15 mi. E Mosca, UCM 19769-70, 20395-401; Conejos Co., Spectacles Lake Camp Ground, 8,700 feet, UCM 5955, LSUMZ 13940 (lot of 10 larvae); Platoro, LSUMZ 13941 (lot of 18 larvae); Summit Cumbres Pass, LSUMZ 13868; Summit La Manga Pass, LSUMZ 13869-70; Rio Grande Co., 6 mi. W Del Norte, LSUMZ 13841-42; 7 mi. W Del Norte, UCM 25644.

Literature records: Alamosa Co., S shore, San Luis Lake, 20 mi. NE Alamosa (Gehlbach, 1956); State Hwy. 150, 5-15 mi. E Mosca (Smith et al., 1965); Conejos Co., Spectacles Lake Camp ground (Maslin, 1959); Costilla Co., Eastdale Reservoir, 3 mi. SW Mesita (Smith et al., 1965); Mineral Co., Creede (Osborn, 1901); San Luis Valley (Dunn, 1940).

There have been differing opinions on the subspecific status of Ambystoma tigrinum in the San Luis Valley. Dunn (1940), in a review of the species, indicated that the entire Valley population was assignable to the subspecies nebulosum, with the Front Range serving as the boundary between the races mavortium and nebulosum. Lowe (1955) described

a new subspecies utahense, which included western Colorado in its range. Gehlbach (1965) showed, however, that A. t. utahense is but an ontogenetic variant of A. t. nebulosum. Gehlbach (1956) recorded two adults and several large larvae from the San Luis Lake as A. t. nebulosum. Maslin (1959), with but a single specimen available from the Valley, listed it as A. t. utahense (=nebulosum). Smith et al. (1965), with a larger series available, considered the specimens from the eastern counties of the Valley (Alamosa and Costilla) as belonging to A. t. mavortium, and those from Saguache, Rio Grande, Conejos, Mineral and Hinsdale Counties as A. t. utahense (=nebulosum).

Mr. Robert Reese, University of Colorado, is currently doing his dissertation on the taxonomic status and variation found in Colorado Ambystoma tigrinum. For this reason many Valley specimens are unavailable for examination. My conclusions concerning the subspecific status of Valley A. tigrinum are therefore only tentative, awaiting the completion of his dissertation.

Dunn (1940) stated, "Larvae and recently transformed young are usually useless in racial discrimination." He also found structural characters to be inconsistent within and among various races of Ambystoma tigrinum, and for these reasons based all definitions of subspecies primarily on adult color pattern. Dunn (1940), Gehlbach (1965), and others have commented on the dangers of allocating single specimens and subadults to subspecies due to the amount of variation usually present both within a population and ontogenetically.

Gehlbach (in litt.) gives the following definitions for typical adult coloration patterns of mavortium as, "6-28 (17) cream to olive vertical bars or large blotches," for nebulosum, "11-50 (32) yellow to dark olive spots, or indistinct blotches." Of the Valley specimens I have been able to examine, those from Conejos and Rio Grande Counties definitely fit the adult utahense phase of the subspecies nebulosum, having a uniform gray to dark brown body coloration and indistinct olive tail blotching. The status of specimens from Alamosa County is somewhat confusing. Two specimens, UCM 19770 from 5-15 mi. E Mosca and LSUMZ 13845 from near Mosca, have a typical A. t. mavortium adult pattern of few large dorsal blotches and vertical lateral bars. Eight other specimens from 5-15 miles E Mosca have a pattern similar to that of A. t. nebulosum from Arizona and western New Mexico with numerous small yellow spots. At present I am uncertain as to whether the Alamosa County specimens represent intergrades between nebulosum and mavortium, or if both races are present in the area and not interbreeding, or if the 2 specimens I consider mavortium are actually aberrant specimens of nebulosum. No specimens examined appear to be intermediate in pattern between the two subspecies. The Saguache County specimen listed by Smith et al. (1965) as A. t. utahense (=nebulosum) comes from a site directly north of the Mosca locality (specimen not examined). It is evident that a much larger sample from throughout the Valley will be necessary to correctly evaluate the subspecific status and the local ranges of Ambystoma tigrinum.

Most Valley specimens were taken from breeding ponds. Specimens were collected throughout the summer, which leads me to believe that in

the Valley adults of this species remain in the breeding ponds at least until the August rains, when transformation of the larvae occurs. The advantages for the cannibalistic adults are obvious, but probably greatly reduces the number of larvae to reach transformation. I am unaware of any other record of this phenomenon from elsewhere in the range of A. tigrinum.

Specimens were taken at elevations ranging from 7,600 feet on the Valley floor to 11,400 feet near the timberline in the vicinity of Platoro. Undoubtedly this species occurs much higher.

Much of the water in the Valley appears to be unsuitable for the breeding of this species. Seining yielded no specimens in any water with a pH above 7.0, which contained fish, or which had any current. This eliminates many otherwise suitable ponds on the Valley floor due to the high alkalinity of the soil and widespread stocking of game fish in cattle and irrigation reservoirs.

Two neotenic individuals of this species measuring about 10 and 11 inches total length were examined in an Alamosa pet shop. Both were said to have been taken in a high mountain lake in the Sangre de Cristos east of the town of San Luis. A forest ranger also told me of neotenic individuals being taken in an irrigation reservoir in the Carmel District southwest of Alamosa.

Two lots of larvae were taken on 9 July 1965 in the vicinity of Platora, 11,400 feet, and at Spectacles Lake, 8,700 feet, both localities in Conejos County. The sample from the lower locality ranged from 43 to 52.5 mm (47.7) snout-vent length and that from the higher elevation 29

to 37 mm (32.6). The size difference is probably due to earlier breeding at lower elevations.

Metamorphosis on the Valley floor occurred on or about the 8th of August. A single individual taken on a road on this date measured 52 mm snout-vent length and traces of gills remained. The largest non-neotenic Valley specimen examined measured 114 mm snout-vent and 252 mm total length.

ORDER ANURA

FAMILY BUFONIDAE

Bufo cognatus Say

Specimens examined: Alamosa Co., San Luis Lakes, LSUMZ 11171-214; 5 mi. W Mosca, LSUMZ 11215; 7 mi. W Mosca, LSUMZ 11216-217; SW corner Great Sand Dunes Nat'l. Mon. LSUMZ 11218.

Literature records: Alamosa Co., San Luis Lake (Maslin, 1959); 1 mi. S San Luis Lake (Maslin, 1959); Costilla Co., Medano Ranch (Cockerell, 1910; Ellis and Henderson, 1913, 1915; Maslin, 1959); Fort Garland (Yarrow, 1875, 1882; Cope, 1889); "Costilla Co." (Kellog, 1932). Medano Ranch is now in Alamosa County.

Bufo cognatus seems restricted to the sandy, eastern portion of the San Luis Valley as a disjunct relictal population, occurring at least 1,500 feet in elevation above any other known population of this species. Maslin (1964, p. 75) noted this peculiar distribution and stated, "Such amphibians such as the Great Plains Toad [B. cognatus] occur east of here [Boulder, Colorado] and also to a less sharply marked degree the Plains Spadefoot Toad [Scaphiopus bombifrons]. Interestingly enough, both of

these species occur in a topographically similar area, the San Luis Valley, which, however, is some 3,000 feet higher." The over-all range of this species has been shown by Stebbins (1966, map 36). The nearest record to the east of the San Luis Valley is the Wet Mountain area of Fremont and Custer Counteis, Colorado (Banta, unpublished), about 50 air miles northeast of the San Luis Valley population across the Sangre de Cristo Mountains. To the south in relatively poorly known (in a herpetological sense) New Mexico, Stebbins (1966, map 36) showed the Great Plains Toad to extend up the Rio Grande River to an area midway between Sante Fe and Albuquerque, a distance of some 170 air miles south of the San Luis Valley population across the Taos Hills.

San Luis Valley B. cognatus were compared with small samples of specimens from southern Arizona, southeastern New Mexico, and the Mexican states of Sonora and San Luis Potosí. Data for all specimens of this comparison group were lumped, although a great deal of variation was noted in this group and will be commented on later. Two major differences were clearly evident between the Valley population and the comparative sample (See Tables 2 and 6). The San Luis Valley specimens reached sexual maturity at a much smaller size than any individuals in the lumped sample from other portions of the range, and, in fact, none was as large as even the smallest sexually mature individual of the comparative series. The largest individual from the Valley, a female, measures 57.2 mm snout-vent length; the smallest sexually mature individual from the comparison series measures 58.5 mm. The two samples also vary greatly in relative length and width of the parotoid gland.

Table 2

A Comparison of Taxonomic Characters of Populations of *Bufo cognatus*

	Valley Population	Comparative Sample
Tibia Length / Snout-Vent	37.3 34.0-40.4	35.5 32.1-39.2
Head Length / Head Width	77.4 68.6-83.2	71.0 67.0-74.3
Head Length / Snout-Vent Length	31.0 28.5-34.1	27.0 24.4-29.3
Parotoid Width / Parotoid Height	66.0 50.5-86.6	49.2 40.6-56.4
Snout-Vent Length in mm (Sexually Mature Adults)	49.7 41.4-59.6	74.2 59.6-102.0

As shown in Table 2, the Valley population has a much shorter, more rounded parotoid, and there is only a small amount of overlap in this character with the values for the comparative sample. Minor amounts of variation between the two samples were found in the ratios of tibia length to snout-vent length, head length to head width, and head length to snout-vent length.

As is the case with several other San Luis Valley reptiles and amphibians, nearly all characters examined have a greater range of variability than in comparative samples from other warmer portions of the species' range. Casual inspection of dorsal patterns of the B. cognatus at hand seems to indicate that there is a darkening of the entire dorsum in San Luis Potosí, while specimens from Sonora and south-central Arizona are much lighter than normal, showing a tendency toward losing posterior blotches and lateral markings. The anterior dorsal blotches showed much less contrast with the ground color than is normal in other portions of the range. The parotoid glands of the Arizona-Sonora population show a tendency toward shortening and rounding, as in the Valley toads. Bufo cognatus, as well as most other western anurans, needs a comprehensive study of geographic variation. While I feel the San Luis Valley population probably deserves subspecific recognition, naming it would be unwise until a more definitive study can be carried out over the entire range of the species.

Nearly all specimens of B. cognatus collected in the San Luis Valley were taken after a moderate rain on 7 to 9 July 1965 while breeding in a shallow, flooded depression, just south of San Luis Lake. The great

majority of specimens were found sitting in very shallow water among emergent clumps of grass. Pseudacris triseriata and Scaphiopus bombifrons were also found breeding at the same site during this three-day period. Transformed young were collected on 24 July 1965, a period of, at most, 17 days from fertilization to metamorphosis. Bragg (1940) stated that metamorphosis begins about 1½ months after the eggs are laid, at a length of 26 to 29 mm. Newly transformed Valley specimens measure 18.9 to 20.6 mm, which corresponds well with the smaller size of sexually mature Valley B. cognatus. The greater range of variability and decrease in size of amny of the reptiles and amphibians of the Valley will be discussed further in connection with Pituophis melanoleucus and Phrynosoma douglassi.

Bufo boreas (Baird and Girard)

Specimens examined: Conejos Co., Summit of Cumbress Pass, LSUMZ 13833; Jct. of North and South Fork Conejos River, UCM 1965-69; Hinsdale Co., Regan's Lake, 25 mi. W Creede, UCM 25685; Saguache Co., 4.8 mi. SE Doyleville, USL 1022.

Literature records: Conejos Co., Cumbres Pass (Ellis and Henderson, 1913); Jct. of North and South Fork Conejos River (Maslin, 1959); 1 mi. NE Cumbres Pass, 10,000 feet (Gehlbach, 1956); Hinsdale Co., Regan's Lake, 25 mi. W Creede (Smith et al., 1965).

The San Juan Mountains bordering the San Luis Valley form the southernmost portion of the range of this species in the Rocky Mountain area. As Burger and Bragg (1947) pointed out, the subspecific status

of Bufo boreas in Colorado is uncertain, and an examination of many more specimens from the entire Rocky Mountain area is needed to clarify the status of the southern Colorado population. Such a project is beyond the scope of this report. Data obtained from the available Valley material agree well with Burger and Bragg's (1947) descriptions of their specimens from Gothic in Gunnison County, just to the north of the San Luis Valley. Karlstrom (1962) in a review of this species examined no specimens from southern or central Colorado, although his range map (p. 65) is essentially correct for this area.

The largest specimen measures 78.6 mm snout to vent. Various body, leg, and head proportions are given in Table 6. There seems to be some degree of proportional narrowing of the head and elongation of the body from the transforming individual to the adult, but these observations are based on only seven specimens.

This species seems to be restricted to elevations between 9,000 and 11,000 feet in elevation (and perhaps higher) in the San Luis Valley area, and are present only in the San Juan Mountains bordering the western edge of the Valley. Specimens were recorded from glacial kettles, bogs, beaver ponds, large reservoirs, and rivers. Transforming individuals were noted at Regan's Lake, Hinsdale Co., on the 2nd of August, 1964. Mr. Robert Reese of the University of Colorado (in correspondence) has also taken B. boreas in Mineral Co. at Wetherill's Ranch.

Bufo woodhousei woodhousei Girard

Specimens examined: Alamosa Co., Alamosa, LSUMZ 13942; Great Sand Dunes National Monument, UCM 3856-91, 7527; Rio Grande Co., Monte Vista, UMMZ 62207-18.

Literature records: Alamosa Co.,Great Sand Dunes National Monument (Maslin, 1959); Costilla Co., Fort Garland (Yarrow, 1882); Rio Grande Co., Monte Vista (Smith et al., 1965).

The above locality records indicate a widespread distribution of Bufo w. woodhousei over the central San Luis Valley floor. Stebbins (1966, range map 34) showed the Valley population as being connected to the main portion of the population via the Rio Grande Valley to the south. I am not aware, however, of any specimens of this species from the southern half of the San Luis Valley or from the Rio Grande Valley of northern New Mexico. Bufo w. woodhousei probably has a disjunct distribution similar to that of Bufo cognatus in this area.

The Valley population of Bufo w. woodhousei is extremely variable in several characters that usually are used to distinguish species, and a number of aberrant individuals will key out to Bufo terrestris, Bufo americanus, or Bufo hemiophrys, depending in part upon which key is used. The specimens from Monte Vista, which is located near the western edge of the Valley floor, are the most typical of B. w. woodhousei. The single specimen from Alamosa, in the center of the Valley, closely resembles B. terrestris and B. americanus in having concave parotoids, knobs on the posterior ends of the supraorbital crests, which extend beyond the junction of the postocular crests, and dark ventral mottling. More minor

differences noted in this specimen when compared with a series of typical B. w. woodhousei include the presence of a much deeper depression between the supraorbital crests; the postocular crests being disjunct from the supraorbital crests, the eyelids, and the parotoid gland; the vertebral stripe, while present, is obscure (due to the poorly defined edges and blending effect with the rest of the dorsal ground color); the dorsal and lateral warts and tubercules are much reduced in number and size, with relatively smooth surfaces between; the large warts are more or less paired along the vertebral stripe and are not ringed by a lighter color; and the angle formed by the supraorbital and postocular crests equals 105°.

In contrast, typical B. w. woodhousei lacks knobs on the supraorbital crests; parotoids are usually elliptical in shape; venter is normally unicolor; only a very slight depression is present between supraorbital crests; postocular crests are usually in contact with the supraorbital crests, the eyelids, and the parotoids; the dorsal and lateral surfaces are normally thickly covered with warts and tubercules without smooth surfaces between; warts are not paired to each side of the distinct middorsal stripe; and the angle formed by the supraorbital and postocular crests equals 90°. Unfortunately a larger sample could not be obtained from the central portion of the Valley to determine the extent of these variations in the population in this area.

The series of B. w. woodhousei from the Great Sand Dunes National Monument, on the eastern edge of the Valley floor, grade from almost

typical B. w. woodhousei to a toad strongly resembling B. hemiophrys with a full, heavily ossified boss extending the length of the supraorbital crests. The dorsum of toads in this area is usually a uniform dark brown with little or no contrast with the wart coloration, a character unusual in B. w. woodhousei from other areas of its range. Blair (1963) presented good evidence for the closeness of relationship of woodhousei and hemiophrys, and both were considered subspecific races of B. woodhousei until fairly recently. The ranges of B. w. woodhousei and B. hemiophrys are closely complementary, but not sympatric, in Montana and North Dakota, with B. hemiophrys occupying the colder, higher latitudes of the northern Great Plains northward to the southern Northwest Territories. A Pleistocene glacial relictual population of B. hemiophrys also occurs at higher elevations in Wyoming on the Laramie Plains. Very likely B. hemiophrys evolved from the woodhousei stock filling the otherwise unoccupied cold areas of the northern Great Plains, and the heavy ossification of the skull of B. hemiophrys apparently reflects in some way an important adaption to colder climates. W. Charles Kerfoot has informed me that he collected several B. w. woodhousei in Wyoming at elevations approaching that of B. hemiophrys. These also have the supposedly diagnostic boss region elevated into a hemiophrys-like condition. The San Luis Valley and Wyoming B. w. woodhousei populations containing individuals with the ossified intercrest condition are probably in a state of rapid evolutionary change in response to lower temperatures and relative isolation. The present state of these populations could be comparable to the state during the original speciation of hemiophrys from the woodhousei ancestor. The

Wyoming and the San Luis Valley specimens do not appear to be either hybrids or intergrades, having most of the minor diagnostic characters of B. w. woodhousei, and few of those of B. hemiophrys. There is the possibility that the development of the ossified boss is an acquired phenotypic response to low temperatures during some stage of development. This seems unlikely, however, since only about 10 percent of the adults have developed these crests. This is a low figure for a factor that seemingly would influence an entire generation almost uniformly during development. Experimental work involving the raising of larval B. w. woodhousei at various temperatures might shed some light on this problem.

It is interesting to note that the three recognizable populations in the Valley occur in three rather distinct habitats. The Monte Vista area lies on the edge of the dry rocky foothills and is extensively grazed by sheep. Sagebrush is the dominant plant. The Alamosa area is in the floodplain of the Rio Grande River and is surrounded by the greasewood-Rabbitbrush association. The Great Sand Dunes National Monument area consists, for the most part, of shifting sand dunes and large expanses of level sandy areas devoid of most vegetal cover.

Dates of activity for this species in the San Luis Valley range from 28 May to 15 July. This is another species in which a comprehensive study of geographic variation is needed. Data for the San Luis Valley specimens are given in Table 6.

FAMILY PELOBATIDAE

Scaphiopus bombifrons Cope

Specimens examined: *Alamosa Co.*, San Luis Lakes, LSUMZ 13832, 13832, 11219-240; Alamosa, LSUMZ 11241, UMMZ 62203.

Literature records: *Alamosa Co.*, Great Sand Dunes Nat'l. Monument Headquarters (Maslin, 1959); *Rio Grande Co.*, Monte Vista (Smith *et al.*, 1965).

Twenty-three *Scaphiopus bombifrons* were taken after a heavy rain as they were breeding in the flooded sandy areas about San Luis Lake from 7 to 9 July 1965. A single individual was collected on a lawn in the city of Alamosa after a light rain on 26 July 1964. Breeding took place in a shallow, flooded low area with many emergent clumps of grass. *Bufo cognatus* and *Pseudacris triseriata* were found breeding at the same time but occupying different niches. The spadefoots were usually found floating in shallow water some distance from the edge, while *Bufo cognatus* preferred clumps of emergent grass in very shallow water. Chorus frogs were found only in the emergent vegetation in the deepest portions of the temporary pond.

Valley *Scaphiopus* seem to be isolated from the main population to the east and south, having a distributional pattern somewhat similar to that of *Bufo cognatus*. I can find no obvious differences between the Valley population and specimens from other localities. While taking various measurements on these animals I noticed two distinct "types," one with a distinct tympanum and the other with the tympanum much reduced or almost absent. There is no correlation with sex, and the

reason for this dichotomous variation is unknown. I can find no previous reference to it in the literature. Various ratios of body, head and leg measurements are given in Table 6.

FAMILY HYLIDAE

Pseudacris triseriata maculata (Agassiz)

Specimens examined: Alamosa Co., San Luis Lakes, LSUMZ 13820; 5.0 mi. WNW Alamosa, LSUMZ 13828; 1.9 mi. S. Alamosa, LSUMZ 13829; 8.1 mi. S Alamosa, LSUMZ 13830; near Mosca, LSUMZ 13831; 4 mi. W. Alamosa, ASC (no number); Conejos Co., 2 mi. SW Summit of La Manga Pass, LSUMZ 13821; Summit of Cumbres Pass, LSUMZ 13822; 1 mi. S, 19 mi. W. Antonito, KU 33710-711; Rio Grande Co., 2 mi. NE Monte Vista, LSUMZ 13823-827; Monte Vista, UMMZ 62205.

Literature records: Alamosa Co., Alamosa (Smith et al., 1965); Conejos Co., 1 mi. S, 19 mi. W. Antonito (Smith et al., 1965); Costilla Co., Ft. Garland (Yarrow, 1875); County record only (Smith, 1956); Mineral Co. (Smith, 1956); Creede (Smith et al., 1965); Rio Grande Co., Monte Vista (Smith et al., 1965); 7 mi. N Monte Vista (Smith et al., 1965); Saguache Co., Russell Lakes, 10 mi. S Saguache (Smith et al., 1965); between Center and Saguache (Burnett, 1926).

In the most recent review of this species which includes the Valley area, Smith (1956) placed the entire Colorado population in the subspecies maculata. Colorado data were lumped with that for specimens from Utah and southern Wyoming with little consideration given for either altitudinal or latitudinal variation. In New Mexico, just to

the south of the San Luis Valley, Smith tentatively assigned the relatively few available specimens as a disjunct population of the eastern race of P. t. triseriata. This race ranges principally in the midwestern United States to as far west as central Kansas and Oklahoma, and resembles the New Mexico population primarily in the similarity of relative tibia length. There was, however, no evidence presented that these two disjunct populations of triseriata were ever connected.

As stated before, the primary character separating triseriata and maculata is the ratio of tibia length to body length, a character shown by Smith's (1956) work to vary slightly with latitude and probably also with altitude. Due to the small size of my sample from higher altitudes I have been unable to show any definite correlations, but there seems to be a trend for longer legs at higher elevations, Smith's (1956) latitudinal data also showed an increase in relative tibia length in those states containing a high proportion of mountainous areas.

As shown in Table 4, which correlates taxonomic characters with latitude, it can be seen there is more of a gradual cline in relative tibia length than an abrupt change where the races supposedly meet as should be the case when dealing with distinct subspecies. The New Mexico-Arizona population probably varies with altitude, latitude, and perhaps genetic drift in areas where the distribution seems spotty, but the over-all tibia-body length ratio similarity is probably due to convergence rather than an actual disjunction of triseriata populations.

With the New Mexico-Arizona populations being in actuality the southern extreme of a north-south cline of maculata, together with lack

Table 3

Taxonomic Characters of Pseudacris triseriata
Correlated with Altitude

	Tibia / Body Length	Head Width / Body Length	Head Length / Body Length
Valley Floor 7,500-7,600 ft.	39.8 37.1-41.8	26.9 23.0-30.6	30.7 28.0-32.9
Mountains over 10,000 ft.	43.1 42.6-43.5	30.9 30.4-31.3	32.5 30.0-34.9

Table 4

Taxonomic Characters of Pseudacris triseriata
Correlated with Latitude

	Tibia / Body Length	% Specimens Striped	Latitude
Colo., Utah and Southern Wyoming	39.6 36-45	69	40°-37°
San Luis Valley	40.4 37.1-43.5	75	38°-37°
Zuni Mts. New Mexico	40.9 38.8-43.5	100 (3 specimens)	36.5°-35°
New Mexico and Arizona	42.8 39-46	84	36°-32°

Table 5

Comparisons of *P. t. triseriata*, *P. t. maculata*, and San Luis Valley Specimens

	Tibia / Body Length	Head Length / Body Length	Head Width / Body Length
P. t. maculata	39.3 32-46	29.3 24-34	30.0 25-35
San Luis Valley *Pseudacris*	40.4 37.1-43.5	31.0 28.0-34.9	27.6 23.0-31.3
P. t. triseriata	42.6 37-40	27.4 23-32	29.0 25-34

of support from other taxonomic character differences, I do not feel it wise to name the extreme ends of a geographical cline, leaving the great bulk of the population as intermediates or intergrades. Thus the name Pseudacris triseriata maculata rather than P. t. triseriata should be applied to the southern portion of this species' range in New Mexico and Arizona.

This species seems relatively common on the Valley floor and also near timber-line in the Canadian Life Zone. Pseudacris has been collected in bogs, marshes, transient ponds, road-side ditches and the edges of mountain lakes if emergent or floating vegetation is present.

Breeding pairs and choruses were observed from 27 April to 9 July on the Valley floor and on 27 June above 10,000 feet in the San Juan Mountains. In most amphibians occurring in the Valley, breeding activity usually starts with the first spring rain and Pseudacris has been found in the same breeding ponds with Ambystoma tigrinum, Scaphiopus bombifrons, and Bufo cognatus. After the breeding season these frogs become very uncommon, as is the case with most of the amphibians occurring in the San Luis Valley. The latest date these specimens were taken was 1 October. These late specimens were collected from can traps set out across the Valley.

FAMILY RANIDAE

Rana catesbeiana Shaw

Specimens examined: Alamosa Co., Alamosa, LSUMZ 13819; UCMZ 25961.

Literature records: Alamosa Co., Alamosa (Smith et al., 1965).

While this frog is not native to Colorado, it has been widely introduced throughout western North America, chiefly as a possible food source.

On 18 August 1963, 2 newly transformed specimens measuring 50 mm snout-vent, were taken along the Rio Grande under a bridge in Alamosa. One of these specimens was donated to the University of Colorado Museum of Zoology and has been previously reported (Smith et al., 1965). No other specimens were heard or seen anywhere else in the Valley during the five years in residence there. It will be interesting to see if this introduced species can establish and maintain a population in the harsh environment of the San Luis Valley.

Rana pipiens Schreber

Specimens examined: Alamosa Co., 5 mi. S. Alamosa, LSUMZ 13859; 5 mi. WNW Alamosa, LSUMZ 13863; Alamosa, LSUMZ 13864-865, 13860, UMMZ 61198-220; 0.5 mi. NW Alamosa, ASC (unnumbered); 7 mi. W Mosca, LSUMZ 13866; 7 mi. E Alamosa, LSUMZ 13933-939; Conejos Co., 3 mi. N La Sauses, LSUMZ 13846-858; near Platoro, LSUMZ 13861; Summit of Cumbres Pass, LSUMZ 13862; 5 mi. S Platoro, LSUMZ 13867; Rio Grande Co., Monte Vista, UMMZ 62187-92, 62196-7, 62199.

Literature records: Alamosa Co., Medano Ranch (Ellis and Henderson, 1913; Maslin, 1959); Alamosa (Ellis and Henderson, 1913; Maslin, 1959); Conejos Co., W Bank Rio Grande River, 13 mi. E Antonito (Smith et al., 1965); Costilla Co., Fort Garland (Yarrow, 1882; Cope, 1889);

Rio Grande Co., Rio Grande River, 2 mi. N Monte Vista (Smith et al., 1965); Monte Vista (Smith et al., 1965); Spring Creek near Gunbarrel Road, Monte Vista (Smith et al., 1965); Saguache Co., 1 mi. N Moffat (Smith et al., 1965); San Luis Valley (Yarrow, 1875).

Various modern herpetologists have assigned different subspecific names to the leopard frogs of the San Luis Valley. Stebbins (1966) recognized but two subspecies in western North America and assigned all Colorado specimens to Rana p. pipiens. Wright and Wright (1949) assigned Valley Rana pipiens to the subspecies berlandieri while Smith et al. (1965) listed them as R. p. brachycephala. Moore (1944) found it impossible to recognize any of the previously named geographical races of Rana pipiens, including brachycephala, in eastern North America. Due to the extreme variability, confusion, and conflicting opinions as to the subspecific status of R. pipiens anywhere within its range (Moore, 1944; Ruibal, 1957) I feel it best not to place any subspecific name on the San Luis Valley population until a range-wide revision is made of this species.

Post and Pettus (1966) discovered that Rana pipiens from eastern Colorado represented two allopatric populations that could be readily distinguished on the basis of the following contrasting traits: continuous or discontinuous dorsolateral folds; presence or absence of vestigal oviducts in adult males; and certain coloration differences. No evidence of gene flow between the two complexes was found in the areas of closest contact. The complex with the continuous dorsolateral fold occupies the colder, higher elevations and latitudes in eastern Colorado.

Of the 29 specimens of R. pipiens from the San Luis Valley that I examined, 26 had a continuous dorsolateral fold, the remaining 3 had discontinuous dorsolateral folds on one or both sides.

Ruibal (1957) determined the relative length of the snout in selected populations of R. pipiens from throughout the United States, Mexico, and southern Canada by measuring the straight line distance from eye to nostril (L) and nostril to lip (H). When the H/L values were plotted, a trend for shorter snouts was evident at higher latitudes and elevations. The San Luis Valley specimens were found to have an H/L value ranging from 0.93 to 1.43, mean 1.13. The range of values for Valley specimens exceeds that of any given by Ruibal (1957) for a single population. The 1.13 mean value is intermediate between those of the long and short snout types and is probably meaningless since both long- and short-snouted frogs occur in the Valley. No correlation with H/L value and altitude was discernible within the Valley. The widespread use of the leopard frog in hospital laboratories for pregnancy tests and as experimental animals in colleges has undoubtedly led to numerous introductions and probable alterations of genotypes in many local populations throughout the U. S., and makes assessment of variation in this species difficult. I am aware of male specimens of R. pipiens from Minnesota being released at Fort Carson, Alamosa, and Sanford, Colorado.

This frog is undoubtedly the commonest amphibian occurring in the Valley and has been taken at elevations of over 11,000 feet. The relatively small sample taken reflects only lack of collecting interest in this common species. Rana pipiens was observed or collected in nearly

all portions of the Valley where permanent water occurs, being commonest along the river banks and irrigation canals. This species has greatly extended its range within the Valley since 1900, when farmers and ranchers began digging extensive irrigation ditches and boring numerous artesian wells in drier portions of the Valley which were formerly unavailable to this species. This species is unusual in being active throughout the year in this area. Several were taken during January and February under cover in pools formed by warm artesian wells. Water temperature varied in these pools depending on size, air temperature, and temperature of water feeding into the pools, but was usually near 10°C. Air temperature occasionally fell as low as -50°F during the colder months.

Transformation occurred on the Valley floor near San Luis Lakes on 24 July. At 10,500 feet transformation was delayed until 2 August. Transforming individuals collected at 7,600 feet averaged 29.7 mm.

CLASS REPTILIA

ORDER SQUAMATA

FAMILY IGUANIDAE

Phrynosoma douglassi hernandesi Girard

Specimens examined: Alamosa Co., near Alamosa, LSUMZ 13839; 2 mi. E Alamosa, ASC uncatalogued; 5 mi. NW Blanca, UCM 3894-95; Conejos Co., 9 mi. SW Mesita, LSUMZ 13834-35; 9 mi. W Mesita, LSUMZ 13836; 3 mi. S Antonito, UCM 9698-99; Costilla Co., 1 mi. W Mesita, LSUMZ 13840, UCM 3896-98; 9 mi. W Mesita, LSUMZ 13837; Rio Grande Co., Monte Vista (7,600-8,000 feet), UMMZ 62241-268.

Table 6

Body, Head, and Tibia Ratios for Various Species of San Luis Valley Anurans

	Tibia / Snout-Vent	Head Length / Snout-Vent	Head Length / Head Width
Rana catesbeiana N = 2	50.0	35.8	100.0
Rana pipiens N = 63	51.5 40.5-57.0	36.2 31.5-41.2	108.9 84.3-129.6
Bufo boreas N = 8	43.4 39.4-46.1	31.3 27.7-35.5	79.5 72.2-96.0
Bufo cognatus N = 48	37.3 34.0-40.4	31.0 25.9-34.1	77.4 68.6-94.3
Bufo w. woodhousei N = 50	40.9 38.5-48.3	29.1 26.4-31.6	77.7 70.6-93.5
Scaphiopus bombifrons N = 25	37.1 33.1-40.4	34.9 31.5-38.0	87.9 80.2-94.0
Pseudacris triseriata N = 16	40.4 37.1-43.5	31.0 28.0-34.9	27.6 23.0-31.3

Literature records: Alamosa Co., 2 mi. SE Medano Ranch (Ellis and Henderson, 1913); 5 mi. NW Blanco /sic/ Peak (Maslin, 1959); Conejos Co., Antonito (Ellis and Henderson, 1913); Costilla Co., 1 mi. W Mesita (Maslin, 1959); Garland (Yarrow, 1875; Reeve, 1952); Rio Grande Co., Monte Vista (Smith et al., 1965).

Reeve (1952), in the most recent revision of this species, relegated the San Luis Valley specimens to the subspecies ornatissimum. Stebbins (1966), Smith et al. (1965), and Maslin (1959) followed Reeve in this opinion. Gehlbach (1965), however, presented evidence that P. d. ornatissimum is the product of environmental gradients in the same geographic area, and concluded that this subspecies is no more than a highland expression of the race hernandesi. Gehlbach (1965) also listed many previous authors who have held this or a similar opinion, including Stejneger (in Cope, 1900), Bailey (1913), Eaton (1935), Durham (1956), Bragg and Dundee (1949), and Lowe (1947). The range of P. d. hernandesi, as mapped by Reeve (1952), occupies most of Arizona and southern Utah, while P. d. ornatissimum occurs throughout New Mexico, and portions of western Texas and southern Colorado.

The San Luis Valley specimens tend to support Gehlbach's view, having diagnostic characteristics of both ornatissimum and hernandesi. The primary characters differentiating P. d. ornatissimum from P. d. hernandesi are: (1) width of head at temporal area wider (hernandesi) or narrower (ornatissimum) than the width of head at angle of jaws; (2) dorsal spots bordered by light areas mesially (ornatissimum) or posteriorly hernandesi) and (3) temporal spines longer or shorter (hernandesi or ornatissimum, respectively) than basal diameter of spines. On the basis

of the first character, Valley Phrynosoma would clearly belong to the race hernandesi, with 98 percent having the head broader at the temporal area than at the angle of the jaws, and the remaining 2 percent having the widths equal. Approximately 73 percent of the Valley specimens have their dorsal spots bordered with light scales posteriorly or lack light area about spots completely, also a hernandesi feature.

The remaining major separating character of temporal spine length and diameter at base was found difficult to determine accurately in all specimens due to the small size of Valley specimens and the small size of the spines. Based on only the largest specimens available from the Valley, about half would key out to hernandesi on the basis of this character. Reeve (1952) gave the mean number of femoral pores in P. d. ornatissimum as 17, and that of P. d. hernandesi as 15.5. The mean number for Valley specimens was 14.8 with a range of 13 to 18. Reeve (1952) also presented a great deal of proportional data for P. d. ornatissimum and hernandesi, reproduced here in Table 7 along with values obtained from Valley specimens. The various proportions in Table 7 were calculated from the following formulae given by Reeve: Body = snout-vent length/total length x 100; Head - head width/head length x 100; Tail = tail length/snout-vent length x 100; Eye = eye-snout length/head length x 100; and Frontal = frontal width/head width x 100. In these proportions the San Luis Valley specimens are either closer to ornatissimum or are intermediate. It is also of interest that the Valley specimens show a greater range of variation in nearly every proportional character than Reeve (1952) found in ornatissimum.

Table 7

Proportional Variation in *Phrynosoma douglassi*

	Body	Head	Tail	Eye	Eye-Ear	Frontal[1]
San Luis Valley males	68.0 64.4 - 75.8	117.6 109.0 - 123.0	47.5 40.8 - 55.4	48.3 41.9 - 54.5	48.4 44.5 - 52.6	62.8 58.3 - 66.6
ornatissimum males	67.2 64.5 - 70.1	117.4 106.0 - 133.2	48.9 42.8 - 54.8	51.9 50.0 - 54.2	52.2 50.0 - 56.5	60.7 61.2 - 64.4
hernandesi males	65.1 63.1 - 67.0	125.4 111.6 - 143.0	53.7 49.4 - 58.4	52.5 47.0 - 57.0	50.5 47.0 - 53.4	54.6 50.0 - 58.4
San Luis Valley females	71.4 65.1 - 73.8	121.6 112.1 - 130.0	40.5 36.4 - 42.7	48.3 39.6 - 54.5	47.0 37.5 - 52.3	60.8 56.6 - 66.6
ornatissimum females	70.1 66.7 - 74.2	123.8 120.2 - 131.1	43.2 34.6 - 50.0	52.5 50.0 - 56.2	47.5 44.4 - 50.0	57.6 52.2 - 61.1
hernandesi females	69.6 65.6 - 72.0	126.7 113.8 - 143.0	44.6 36.9 - 53.0	50.4 44.4 - 58.9	47.5 42.1 - 52.7	56.1 47.8 - 60.7

[1]Formulae for calculating these ratios given in text.

Of the series of 42 Valley Phrynosoma douglassi the largest specimen, a female, measured 65.9 mm in snout-vent length, and 91.4 mm total length. Adults in this series average 46.7 mm snout-vent length and 71.7 mm total length. The subspecies ornatissimum, as previously understood, reaches its maximum known size near Raton Pass, Colorado, about 90 air miles east of the San Luis Valley across the Sangre de Cristo Mountains. Kerfoot (1962) recorded a female from this area with a total length of 149 mm and a snout-vent length of 104 mm. Specimens examined from Las Vegas, San Miguel Co., New Mexico, just to the south of Raton Pass are also much larger than the diminitive Valley specimens.

The cause of the dwarfed condition of Phrynosoma douglassi and Bufo cognatus from the San Luis Valley is difficult to explain. Most selective pressures in colder climates would theoretically tend to eliminate smaller adults in a population of ectotherms. Long hibernation periods, as are necessary for both Bufo and Phrynosoma in the Valley, also would seem to favor larger individuals, as energy stores are used more rapidly in smaller animals since the basal metabolism requirement per unit weight is less in larger individuals (Lindsey, 1966). Likewise, since all animals generate some body heat, larger individuals would have a survival advantage at low temperatures due to their low surface to volume ratios and subsequent lower loss of heat (Lindsey, 1966). Larger size also would probably allow for slightly larger individual ranges, thus increasing the amount of food available during periods of scarcity and would have a positive selective value (Newell, 1949). Both animals under consideration are primarily arthropod predators. Increased size

in such a predator would seem advantageous because of the wider size range of prey the animal could overcome.

Smaller size in Valley Bufo cognatus may be of some advantage in that the larvae transform at a much smaller size and in a much shorter time than that recorded for this species in warmer, lower portions of its range, thus partially offsetting the highest mortality period. With a shorter growing period between last killing frost and first killing frost of the summer, animals and plants reaching sexual maturity at a smaller size in a reduced period of time would also have a definite selective advantage over more slowly developing ectotherms under the same conditions.

Fitch (1940) explained a similar dwarfed condition in garter snakes with the following statement: "Small size is probably an advantage to poikilothermal terrestrial animals in a cold climate in that a small body mass makes for rapid adjustment to environmental temperatures. When temperatures become favorably high, the animal quickly recovers from a torpid state and resumes activity. Also, it is easier for a small snake to find shelter, since smaller niches can be utilized.

"Since the body surface increases as the square of the linear dimensions, and its bulk as their cube, large garter snakes have a much greater bulk in proportion to surface than do small ones. In an environment in which temperatures during the snake's active season are often much below its threshold of activity, or fluctuate near this threshold, snakes of large bulk would be at a disadvantage, since, being much more slowly warmed to an active condition, they would be in a semidormant and

helpless condition much more of the time. If this hypothesis is correct, the cool summer climates of northern regions indirectly cause the dwarfing there."

Phrynosoma douglassi appears to be limited to the central and southern Valley floor between the elevations of 7,600 and 8,000 feet. This is the only ectothermic vertebrate taken any great distance from permanent water, preferring open, sparsely vegetated areas.

Sceloporus undulatus (Latreille)

Specimens examined: Alamosa Co., 5 mi. W Mosca, LSUMZ 13921; Great Sand Dunes National Monument, LSUMZ 13922; Mosca Pass 3/4 mi. E Headquarters Great Sand Dunes National Monument, KU 74340; Conejos Co., 9 mi. W Mesita, LSUMZ 13871-74, 13879-84; 9 mi. SW Mesita, LSUMZ 13919; 2.6 mi. S La Sauses, LSUMZ 13916-18; 14.0 mi. W Antonito, LSUMZ 13911-15; 14 mi. E Conejos, Rio Grande River, UCM 3899-3938; Costilla Co., 9 mi. W Mesita, LSUMZ 13875-78, 13885; 4.5 mi. S Blanca, LSUMZ 13886-93; 4.0 mi. S Blanca, LSUMZ 13894-905; Jct. Colo. Hwy. 142 and Rio Grande River, LSUMZ 13906-10; Rio Grande Co., near Monte Vista, UMMZ 62241; Saguache Co., 3 mi. N La Garita, LSUMZ 13920.

Literature records: Alamosa Co., Great Sand Dunes National Monument (Maslin, 1959); Conejos Co., 14 mi. E Conejos, Rio Grande River (Maslin, 1959); Costilla Co., 3.5 mi. S Blanco [sic] (Maslin, 1959); vicinity of San Luis (Maslin, 1959); near Garcia (Maslin, 1959); Rio Grande Co., near Monte Vista (Smith, 1938); Saguache Co., 5 mi. NE Saguache (Maslin, 1959); 5 mi. S Saguache, La Garita Hills (Maslin, 1959).

Prior to 1956 Sceloporus undulatus elongatus was believed to occur on both sides of the Continental Divide in Colorado without direct gene flow across the mountains. In 1956 Maslin described the eastern portion of this population as a distinct subspecies characterized by the red coloration of the lip area in males during the breeding season, having the gular patches in contact in both sexes, the lack (usually) of dorsolateral light stripes, and higher dorsal and circumabdominal scale counts. The San Luis Valley specimens available to Maslin were considered to belong to this new race (S. u. erythrocheilus) and were listed as paratypes.

Sceloporus undulatus tristichus ranges from central Arizona and central and north-central New Mexico into southern Archuleta County, Colorado, just west of the Valley. It is the only other race of this species which occurs near the San Luis Valley. Cope (1875) originally described this race from a single specimen, with the type locality at Taos, New Mexico, which lies 40 miles down the Rio Grande from the San Luis Valley. Maslin (1956) listed paratypes of S. u. erythrocheilus from Santa Fe County, New Mexico, 28 miles farther south than Taos. This assignment of New Mexican specimens places the type locality of S. u. tristichus within the range of S. u. erythrocheilus. Should a re-examination of fresh material from Taos prove to have the characteristics of S. u. erythrocheilus, this name will then become a junior synonym of S. u. tristichus. The name tristichus will then be applicable only to the race currently recognized as erythrocheilus, and the subspecies now known as S. u. tristichus will be nameless. It is

likely that the Taos specimen collected by Yarrow's 1871-74 survey of Nevada, Utah, California, Colorado, New Mexico, and Arizona was collected elsewhere and only shipped from Taos, a common occurrence during the early surveys.

Most Valley specimens agree well with Maslin's (1956) original description of S. u. erythrocheilus. Only an occasional specimen larger than 50 mm in snout-vent length has gular patches which do not overlap medially. The red lip character could not be widely applied in this study as this character appears only in adult males during the breeding season, and the color quickly fades in preservative. Many Valley males collected during May and June, however, were noted to have the rust red labials characteristic of erythrocheilus. Scale counts also closely correspond to the values given by Maslin for this race. Circumabdominal scales range from 44-50 (47.2) in females and 45-50 (47.5) in males. Maslin gave means of 47.96 and 48.00 for females and males, respectively, for his series. Dorsal scale counts for Valley males range from 42-53 (46.4) and for females 43-52 (46.8). Maslin reported mean values of 45.73 and 46.74 for females and males, respectively. Femoral pore counts range from 14-20 (16.9) in Valley males, and 14-19 (16.7) for Valley females. Maslin's sample averaged 17.21 and 17.07 for males and females, respectively. The largest specimen examined, a female, measures 73.9 mm snout-vent length.

Five adult specimens from 14 miles W Antonito, 8,400 feet, in the extreme southwestern corner of the San Luis Valley have characteristics of both S. u. tristichus and S. u. erythrocheilus, and were not included

in the data given above. This locality is just across the Continental Divide from the localities for S. u. tristichus in Archuleta County, Colorado, reported by Yarrow (1875), Cary (1911), Ellis and Henderson (1913), Dean and Stock (1961), and Harris (1963). There apparently is some gene flow across the lower mountain passes in this area. In all five specimens the gular patches are distinct and well separated medially, a S. u. tristichus characteristic. Forty percent have dorsolateral light stripes present, another tristichus character. Published scale count ranges for S. u. tristichus are unreliable as they predate Maslin's (1956) description and include data from many specimens now considered S. u. erythrocheilus. Smith's (1938) data indicate slightly lower mean dorsal and circumabdominal scale counts occurring in the subspecies tristichus. Conejos River Valley specimens also averaged slightly lower than other San Luis Valley Sceloporus in both characters, having a mean of 45.2 circumabdominal scales and 44.9 dorsal scales. Much field work is necessary to define the ranges of both S. u. erythrocheilus and S. u. tristichus in northern New Mexico and to redefine the variation in latter race.

In the San Luis Valley this species always seems to be associated with rocks, and its local distribution is greatly influenced by this factor. Swifts in this area are restricted primarily to the rocky foothill habitat about the circumference of the Valley and to canyons extending out onto the Valley floor.

FAMILY SCINCIDAE

Eumeces multivirgatus multivirgatus
Hallowell x E. m. epiplurotus Cope

Specimens examined: Alamosa Co., 8 mi. S. Great Sand Dunes National Monument, LSUMZ 10082; Conejos Co., 9 mi. W Mesita, LSUMZ 10077-80; 14 mi. W Antonito, LSUMZ 10081; 1 mi. S La Sauses, LSUMZ 10083; Costilla Co., 4.5 mi. S Blanca, LSUMZ 10093-99; 4 mi. S Blanca, LSUMZ 10074-75; 9 mi. W Mesita, LSUMZ 10076; Saguache Co., Valley View, LSUMZ 10084.

Literature records: Alamosa Co., Great Sand Dunes National Monument, 8,000 feet (Maslin, 1950, 1959); Conejos Co., 1 mi. W Rio Grande on Colo. Hwy. 142 (Smith et al., 1965); Costilla Co., San Luis, 8,000 feet (Maslin, 1950, 1959).

This species and its taxonomic problems have drawn the attention of many herpetologists recently. Lowe (1955, Maslin (1957), Mecham (1957), Heyl and Smith (1957), Tanner (1957), Axtell (1961), and Gehlbach (1962, 1965) have all contributed measurably to our knowledge of ontogenetic pattern changes, ranges, pattern variants, etc. in this species. The current concensus is that Eumeces multivirgatus has but two allopatric races, the northern nominate subspecies occurring in eastern Colorado, southeastern Wyoming, western Nebraska, extreme southern South Dakota, and northeastern New Mexico, and E. m. epipleurotus (= E. m. gaigeae; see Axtell, 1961), ranging throughout most of New Mexico, northwestern Arizona, southeastern Utah, western Texas, southwestern Colorado, and the San Luis Valley. Eumeces taylori has been shown by Mecham (1957) to be an allelomorphic pattern variant which occurs in both subspecies.

Maslin (1950) first recorded this species from the San Luis Valley on the basis of two specimens which he stated, "do not differ morphologically from the plains form but the habitat from which they were collected is distinctly different....The San Luis Valley specimens were both found in rocky areas between large boulders. The sand areas nearby were searched but apparently are unoccupied. It seems likely on geographical and ecological grounds that the San Luis Valley population is a tongue of the New Mexico-Arizona population with which it may be continuous." Mecham (1957), in a review of this species, mentioned Maslin's (1950) records for the Valley but did not examine the specimens. Mecham (1957) examined no material he considered intermediate between E. m. multivirgatus and E. m. gaigei (= epipleurotus), but still considered them to belong to one species on the basis of scale and pattern similarities. Maslin (1959) and Smith et al. (1965) listed the available Valley specimens as E. m. gaigeae.

Gehlbach (1965) listed the following characters as useful in differentiating E. m. multivirgatus and E. m. epiplurotus: (1) "ontopattern reduction (not present in nominate subspecies)," (2) "distinctive juvenile pattern," and (3) "posterior border of last supralabial confluent with posterior border of last infralabial (supralabial projecting caudad at least 15 percent of its length in nominate subspecies)." Maslin (1957) clarified the conditions of pattern reduction and juvenile pattern with the following remarks: "It is in the juveniles that the races differ most strikingly. The juvenile pattern of multivirgatus is much darker than that of the adult and with less sharply delineated lines, but

essentially the same pattern. The juveniles of gaigeae (= epipleurotus), on the other hand show strikingly brilliant three-lined pattern with more sharply delineated lines.... The ontogenetic change from a bold pattern of this sort to the typical gaigeae pattern of the adult is a major difference between these two races." Mecham (1957) described the adult of E. m. multivirgatus as "characterized by a pale body color with dorsolateral light stripes only slightly lighter than the ground color, and a broad, clearly defined dorsal dark line (with uninterrupted margins) on adjacent portions of the first and second scale rows." The adult of E. m. epipleurotus is described as being "darker, having strongly contrasting middorsal light line in the young), and exhibit a variable degree of reduction of dorsal dark lines through invasion of ground color from the sides" (Mecham, 1957).

Gehlbach (1965) considered the Zuni Mountain population of this species as intergrades between E. m. multivirgatus and E. m. epipleurotus, chiefly on the basis of the labial character mentioned earlier. Also of considerable interest was the evidence that the Zuni population goes from a multivirgatus-patterned juvenile to an epipleurotus-patterned adult. This finding, while well documented by Gehlbach, is contrary to the ontogenetic pattern change described by Maslin (1957), Mecham (1957), and others, in which epipleurotus changes from a three-lined hatchling to the two-lined adult. Curiously these "intergrades" occur in the center of the range of epipleurotus. This assignment puts populations from northern New Mexico, southeastern Utah, western Colorado, and the San Luis Valley in a somewhat uncertain taxonomic position.

An examination of the 18 Valley specimens revealed a significant difference in ontogenetic pattern change, previously unrecorded for this species, which I feel represents the true intergrade condition. The smallest (and presumably youngest specimens, 33.6-36 mm) have the typical juvenile pattern of epipleurotus, with three light lines on a dark ground color. Adult Valley specimens (60.7-72 mm) have an almost typical E. m. multivirgatus pattern, gaining extra stripes (or rows of nearly connecting light dots) between the vertebral and dorsolateral stripes present in the young. Specimens intermediate in size (47-58.5 mm) show a transition from the three-lined to the many-lined pattern. Maslin (1950) presumably based his records of E. m. gaigeae from the Valley on adult specimens since he states that they "do not differ morphologically from the plains form" (i.e., E. m. multivirgatus).

The San Luis Valley population most closely agrees with E. m. multivirgatus in labial pattern. Only in two specimens was the posterior border of the last supralabial confluent with the posterior border of the last infralabial, and in both individuals this occurs on one side only. In all other specimens the supralabials extend noticeably caudad beyond the posterior edge of the last infralabial.

I am uncertain of the status of Gehlbach's Zuni material, but both he (1956) and Mecham (1957) have discussed the greater adaptive value of having a variety of phenotypes in such an ecologically wide-ranging species. Actual intergradation would be more likely in the San Luis Valley, which adjoins the range of E. m. multivirgatus, than in an area near the center of the range of epipleurotus. The presence of an intergrading population in the Valley proves these two forms to be conspecific (see Mecham, 1957).

This species was found in a number of habitats in the San Luis Valley from 7,600 to 8,500 feet in elevation. Specimens taken on the Valley floor were almost all found in rocky canyon-edge situations, with but two exceptions. These individuals were taken under a board and from within a large pile of tarpaper in dry, sandy, Greasewood-Rabbitbrush association some distance from the nearest rock cover. Eumeces multivirgatus was taken twice in the Pinyon-Juniper association at 8,300 and 8,500 feet in the lower Sangre de Cristo Mountains. In the San Juan Mountains a single specimen was taken from under a pine log in the Conejos River bottom at about 8,300 feet. Mecham (1957) found the highest elevation recorded for this species to be 8,200 feet in the Transition Life Zone of the Guadalupe Mountains of southeastern New Mexico.

Nearly all skinks were collected beneath cover of some type, usually rocks. Only two were observed foraging, both between 9 and 10 AM, in a rocky canyon edge habitat. The greatest number of specimens were collected in May and June, individuals becoming much more difficult to find in later summer.

Maslin (1959) changed the original spelling of gaigei to gaigeae, a feminine ending, as this race was named in honor of Mrs. Helen T. Gaige.

FAMILY COLUBRIDAE

Thamnophis sirtalis dorsalis (Baird and Girard)

Literature records: Alamosa Co. (Maslin, 1959); (Smith et al., 1965); Conejos Co. (Fitch and Maslin, 1961); Costilla Co. (Fitch and Maslin, 1961); Rio Grande, Colorado (Yarrow, 1875, 1882; Cope, 1900).

Yarrow (1875) listed two specimens of Eutaenia sirtalis dorsalis (= Thamnophis s. dorsalis) from "Rio Grande, Colorado," collected in June, 1873, by H. W. Henshaw, and given original numbers of 313 and 313a. In 1882, Yarrow listed a single specimen of Eutaenia macrostemma megalops (USNM 8418) from the same locality and with the same collector and date. Cope (1900) again reported on specimen USNM 8418, this time as Eutaenia megalops. Maslin (1959) placed Yarrow's 1882 record in the synonymy of Thamnophis c. cyrtopsis, which is otherwise unknown from the San Luis Valley, and Yarrow's 1875 record, obviously for one of the same specimens, under the name Thamnophis sirtalis parietalis. Without explanation, Maslin (1959) also added "Alamosa Co." to the "Rio Grande, Colorado" locality for T. s. parietalis. In 1961, Fitch and Maslin redescribed Thamnophis sirtalis ornata (Baird), giving as its range "Rio Grande, and vicinity, from Conejos and Costilla counties in extreme south-central Colorado south ...." No specimens, however, were examined from either Conejos or Costilla counties. Smith et al. (1965) referred to Fitch and Maslin's 1961 paper and remarked, "Yarrow's 1875; 544 record for the "Rio Grande, Colorado" is tentatively pinpointed to Alamosa Co. and referred to T. s. ornatus /sic/ as the only record available for Colorado." Webb (1966) applied the name T. s. dorsalis to the upper Rio Grande population. Fitch (1965) and Stebbins (1966) also gave the range of T. s. dorsalis as extending into the San Luis Valley.

Fortunately, USNM 8418 (original number 313) is still available. This specimen, although showing the effects of age, is typical of specimens of Thamnophis elegans presently found in the San Luis Valley. The

specimen is a male measuring 645 mm total length, and 484 mm snout-vent. Head scalation is as follows: supralabials 8-8, infralabials 10-10, and preoculars 1-1. Ventral scutes number 170, caudals 82. Scale rows at neck, midbody, and just anterior to vent number 19-17-17, respectively.

Correct identification of this specimen eliminates T. sirtalis dorsalis from the fauna of the San Luis Valley as well as the state of Colorado. Although there are literature records from approximately 35 miles south of the Colorado-New Mexico border at Taos and San Idlefonso in the upper Rio Grande Valley (Ruthven, 1908), the specimens on which these records are based should be re-examined in light of the notorious amount of confusion which has plagued this genus. The nearest acceptable records to the San Luis Valley are those examined by Fitch and Maslin (1961) from the Albuquerque, New Mexico, area.

Thamnophis elegans vagrans (Baird and Girard)

Specimens examined: Alamosa Co., 2.5 mi. SE Alamosa, LSUMZ 12805-10, 12789, 12786, 10616-19, 9076-86, 9088; 20 mi. SE Alamosa, LSUMZ 11608; 1 mi. SE Alamosa, LSUMZ 11610, 11619; 3 mi. S Alamosa, LSUMZ 11613; 1 mi. NW Alamosa, ASC uncatalogued; 4 mi. W Alamosa, ASC uncatalogued; 0.5 mi. NW Alamosa, ASC uncatalogued; Alamosa, ASC uncatalogued; Great Sand Dunes National Monument, GSDNM uncatalogued; Conejos Co., 9 mi. W Mesita, LSUMZ 11566-75, 11624, 11626-33; 3 mi. N La Sauses, LSUMZ 11609, 11611, 11615, 11617-18, 11620-22; 14 mi. W Antonito, ASC uncatalogued; 5 mi. S, 24 mi. W Antonito, 9,600 feet, KU 33660-62; Costilla Co., 9 mi. W Mesita at Rio Grande River, LSUMZ 13818, 11625, 11634-35; 4.5 mi. S Blanca, LSUMZ

13923-32, 11559-65, 11576-93, 11603-04, 11607; 4 mi. S Blanca, LSUMZ 7981-85; 2 mi. S Jct. Colo. Hwy. 142 and Rio Grande River, LSUMZ 11594-97; Jct. Colo. Hwy. 142 and Rio Grande River, LSUMZ 11614, 11616, 11623; 0.5 mi. W Blanca, LSUMZ 11605-06; Mineral Co., 5 mi. SW Creede, LSUMZ 11612; Rio Grande Co., Empire Ditch, 5 mi. SE Monte Vista, LSUMZ 11599; 2 mi. NE Monte Vista, Home Lake, LSUMZ 11600-02; 19 mi. W Del Norte, UMMZ 121476; near Monte Vista, UMMZ 62462-63; near South Fork (albino), private collection B. J. Banta; Saguache Co., 6 mi. NW Saguache, LSUMZ 11598; Elko, UMMZ 72694; 5 mi. N, 28 mi. W Saguache, KU 33651, 5 mi. N, 22 mi. W Saguache, KU 33656; Rio Grande, Colorado, USNM 8418.

Literature records: Alamosa Co., 1.5 mi. S Alamosa (Smith et al., 1965); Conejos Co., Conejos (Yarrow, 1875, Fitch, 1940, Ruthven, 1908); 14 mi. E Conejos, Rio Grande River (Maslin, 1959); Spectacles Lake, Conejos Canyon (Maslin, 1959); 10 mi. E Antonito (Maslin, 1959); 5 mi. up Alamosa River Canyon (Maslin, 1959); Cumbres Pass Lake (Ellis and Henderson, 1913); Costilla Co., Fort Garland (Yarrow, 1875, Ruthven, 1908); 3.5 mi. S Blanco [sic] (Maslin, 1959); Mineral Co., Regan's Lake, 25 mi. W Creede (Smith et al., 1965); Rio Grande Co., 7 mi. N, 2.5 mi. W Monte Vista (Smith et al., 1965); 7 mi. W Del Norte (Smith et al., 1965); near Monte Vista (Fitch, 1940); Saguache Co., 3 mi. N Elko (Fitch, 1940); 2 mi. NE Saguache (Smith et al., 1965); 2 mi. S Saguache (Smith et al., 1965); 2 mi. E Saguache (Smith et al., 1965); Rio Grande, Colorado (Yarrow, 1875).

The most recent complete revision of this species was that of Fitch (1940). In that work he considered the subspecies vagrans to occupy a vast range that includes many varied physiographic areas. This single

ubiquitous race occurs from central British Columbia to southern New Mexico, and from western California to southwestern South Dakota.

In comparing the data obtained from Valley specimens with that given by Fitch (1940) for specimens obtained from throughout Colorado, I find no significant differences in scalation. Values obtained from Valley specimens, however, showed a slightly wider range of variation than the values given by Fitch for several of the characters he utilized. Ventral number in Valley females range from 162-171, mean 167.7, as opposed to 162-174 (166) for the entire state. Valley males range from 167-178 (171.1), while Fitch (1940) gave a range of 162-181 (172) for the state-wide sample. Caudals, likewise, agree with the values given by Fitch. Valley females range from 64-81 (75.5) and Valley males from 71-95 (85.0). Values for the state sample were 71-83 (77) and 80-94 (86) for females and males, respectively. Numbers of preoculars, supralabials and infralabials also varied but slightly from Fitch's entire Colorado sample.

The one distinguishing difference found in the Valley population of Thamnophis elegans was the total lack of the black ventral pigmentation which is almost characteristic for the subspecies vagrans in Colorado. Fitch (1940) says, "In occasional specimens from almost any part of the range, ventral pigmentation is nearly or entirely lacking, although others from the same or nearby localities may be heavily pigmented ventrally" (emphasis mine). I can see no selective advantage or disadvantage for the presence or absence of ventral pigmentation in this species.

Two aberrant specimens from the San Luis Valley deserve comment. The only known albino specimen of Thamnophis elegans was taken near South Fork, Rio Grande Co., and has been previously reported (Banta and Hahn, 1966). The other, an adult female from 3 mi. N La Sauses, Conejos Co., has a striking reduction in head scutes. Infralabials numbered 7-8 (usually 10-10), supralabials 7-7 (usually 8-8), and lacked a mental. This specimen was also the largest individual examined from the Valley measuring 760 mm total length, 590 mm snout-vent length.

In the vicinity of permanent water Thamnophis elegans vagrans is usually the commonest reptile occurring in the San Luis Valley. Relative abundance and size of individuals seem to decrease with an increase in altitude but several individuals were noted at approximately 11,000 feet near timber line in the vicinity of Platoro, Rio Grande Co., in various glacial kettle lakes and bogs. Specimens from the Valley floor seemed to range further from water than those at higher elevations, which were in all cases first seen either in water or very close to it. But I have seen very few individuals from the higher altitudes.

Food items disgorged by freshly captured specimens included unidentifiable rodents, tenebrionid beetles, Sceloporus undulatus, unidentified fish, and Rana pipiens. All of these food items have been previously recorded (Fitch, 1940) with the exception of the beetles, which may have been remnants of secondary ingestion. Fitch also commented: "Generalized feeding habits in vagrans may be correlated with the absence of other garter snakes throughout much of its range; it has not been forced into a narrow ecologic niche by the competition of closely related specialized forms."

This species has been found denning with Pituophis melanoleucus, Lampropeltis triangulum, and Crotalus viridis. Descriptions of these dens are included in the species account of Crotalus viridis. Dates of emergence and disappearance at one denning site near Smith Reservoir, Costilla Co., was 25 April and 16 September, respectively.

Pituophis melanoleucus sayi (Schlegel x P. m. deserticola Stejneger x P. m. affinis Hallowell

Specimens examined: Alamosa Co., 4 mi. N U.S. Hwy. 160 on Sand Dunes Rd., LSUMZ 11542; Great Sand Dunes National Monument, GSDNM, one specimen unnumbered; Conejos Co., 9 mi. W Mesita at the Rio Grande, LSUMZ 11535, 11537-39; Costilla Co., near San Acacio, LSUMZ 11541, 11543; 4.5 mi. S Blanca, LSUMZ 11544-46, 11548-50, 11536, 11540; 2 mi. S Jct. Colo. Hwy. 142 at the Rio Grande, LSUMZ 11547, 11551; 9 mi. W Mesita at the Rio Grande, LSUMZ 11552; Saguache Co., 2 mi. NE Mineral Hot Springs, LSUMZ 11553.

Literature records: Alamosa Co., 12 mi. E Alamosa (Smith et al., 1965); Conejos Co., 14 mi. E Conejos, Rio Grande (Maslin, 1959); Costilla Co., 3 mi. N San Luis (Maslin, 1959); Saguache Co., 8 mi. N Saguache (Smith et al., 1965).

The San Luis Valley is surrounded by the ranges of three subspecies of Pituophis melanoleucus. To the west P. m. deserticola occupies the western areas of Colorado up into the valleys of the San Juan Mountains near the northwestern edge of the San Luis Valley. The subspecies affinis ranges over the western two-thirds of New Mexico, intergrading

with deserticola in the Zuni area of northwestern New Mexico (Gehlbach, 1965), and with sayi in eastern New Mexico and Colorado. Northward, affinis presumably ranges into Colorado in La Plata Co. and Archuleta Co., immediately southwest of the San Luis Valley (Smith et al., 1965). These specimens need to be re-examined as Klauber (1947), the most recent reviser of the western subspecies, placed them in the subspecies deserticola. Maslin (1959) followed Stull's 1940 revision in assigning specimens from this area to affinis. Dean and Stock (1961) stated that their La Plata Co. specimen appeared to be an intergrade between deserticola and affinis. Harris (1963) also reported Pituophis from Archuleta Co. but did not designate in which subspecies his specimens fitted. The subspecies affinis does, however, extend up the Rio Grande Valley to near the southern edge of the San Luis Valley (Klauber, 1947). The range of P. m. sayi bounds the Valley to the east of the Sangre de Cristo Mountains. There seems to be few major barriers to the dispersal of any of these wideranging forms into the Valley. All three subspecies under consideration have been recorded at elevations high enough to enable them to traverse lower passes through the San Juan and Sangre de Cristo Mountains, or the lower Taos Hills to the south.

Various authors have had different views on the subspecific status of the population of Pituophis melanolecus occurring in the San Luis Valley. Most of these conclusions have been based on little or no actual material. Stull (1940) assigned the Valley population to the subspecies affinis on her range map (p. 66), but examined no material from the area. Klauber (1947) also had no San Luis Valley specimens and left the area a blank on

his range map (p. 6). Stebbins (1954) seemed to follow Klauber's range map closely, and again Pituophis did not appear to occur in the San Luis Valley. Wright and Wright (1957) showed affinis ranging into the San Luis Valley on their range map (p. 589), probably based on Stull's (1940) monograph. Maslin (1959), who had 6 specimens from the Valley, assigned them to the subspecies sayi. Smith et al. (1965), with 2 additional specimens available, also listed the Valley population as sayi. Stebbins (1966, map no. 141) showed the subspecies affinis extending into the lower San Luis Valley on his range map for the western forms of Pituophis melanoleucus.

A total of 20 specimens of Pituophis melanoleucus from the San Luis Valley were examined during this study. Various characters for the Valley population are compared in Table 8 with those given by Klauber (1947) for the three surrounding subspecies. From Table 8 it is apparent that the Valley population of P. melanoleucus cannot be assigned to any one of the races, but shows some characteristics of all three. In number of ventrals and infralabials, the Valley population most closely approximates values found in P. m. sayi. In number of caudals, supralabials, and preoculars the affinities of the Valley form lie with P. m. affinis. In number of postoculars, scale rows at mid-body, and dorsal blotches, the relationships seem to be with P. m. deserticola. In terms of tail length/total length the San Luis Valley population is intermediate between P. m. sayi and P. m. affinis.

It is particularly interesting that the San Luis Valley population has lower mean numbers of ventrals, supralabials, infralabials, and dorsal scale rows, than any of the surrounding subspecies. Number of

Table 8

Analysis of Taxonomic Characters in Western Populations of *Pituophis melanoleucus*

	San Luis Valley Population		*P. m. sayi*		*P. m. deserticola*		*P. m. affinis*	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Ventrals	212-227 (221.5)	213-231 (222.2)	213-233 (222.8)	218-238 (227.7)	220-249 (234.5)	224-254 (239.7)	220-245 (233.6)	226-251 (238.6)
Caudals	57-67 (62.3)	51-65 (58.1)	51-67 (59.0)	46-60 (53.0)	60-75 (66.7)	53-68 (59.9)	56-71 (64.5)	50-64 (57.6)
Supralabials	7-9 (8.2)		7-10 (8.5)		7-10 (8.3)		6-10 (8.2)	
Infralabials	10-13 (11.5)		10-15 (12.3)		10-15 (12.5)		11-16 (12.7)	
Preoculars	1-2 (1.6)		1-3 (1.3)		1-3 (1.8)		1-3 (1.6)	
Postoculars	3-6 (3.7)		2-5 (3.4)		2-6 (3.5)		2-6 (3.5)	
Scale Rows at mid-body	24-30 (28.0)		29-37 (32.0)		27-35 (31.1)		29-35 (32.0)	

(Continued)

Table 8 (Continued)

	San Luis Valley Population		*P. m. sayi*		*P. m. deserticola*		*P. m. affinis*	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Body Blotches	54-76 (60.3)		36-66 (50.7)		43-71 (56.4)		34-63 (48.0)	
Tail Blotches	12-21 (15.5)		9-19 (13.0)		12-22 (16.2)		9-21 (13.6)	
Total Length: Tail Length	(0.130)	(0.121)	(0.125)	(0.117)	(0.148)	(0.136)	(0.136)	(0.125)

body blotches and postoculars averaged higher than in any of the three surrounding populations. Fox (1948, 1961) showed experimentally that embryos of Thamnophis elegans atratus undergoing gestation at lower temperatures than normal showed a significant reduction in numbers of ventrals, caudals, scale rows, and labials. Other characters showed a wider range of variation than the values found in the wild and control groups. Fox (1948) also cited several examples of scale reductions occurring in natural populations of snakes at higher latitudes and altitudes, which thus would be developing in cooler temperatures. Perhaps the much cooler temperatures occurring in the San Luis Valley due to altitude has a phenotypic effect of reduction on various scale characters in this population also.

Other characters frequently used in keys separating sayi, affinis and deserticola were also examined in the Valley population, and I again found a somewhat intermediate situation. In rostal length and width, and bluntness of snout, the Valley population of Pituophis resembles the condition found in affinis and deserticola. Other rostral characters such as degree of bulge above surrounding scales, angle between internasal scales, and degree of penetration along the internasal suture corresponds well with the sayi condition. Labial sutures are all darkly marked as in sayi and affinis. Anterior blotches are black in 58 percent of the Valley population, a sayi and deserticola characteristic, and brown in 42 percent, an affinis characteristic. Interspace scales are streaked with dark pigment along the keel in most Valley specimens examined, a deserticola characteristic. The anterior blotches are separate as in sayi and affinis.

In the Valley, bullsnakes have been found denning with Crotalus viridis, Lampropeltis triangulum, and Thamnophis elegans. Denning sites are discussed in the section on Crotalus viridis. As is the case with Lampropeltis triangulum and Crotalus viridis, the primary limiting factor for Pituophis melanoleucus in the Valley area seems to be suitable denning sites, which occur mainly about the periphery of the Valley floor and in rocky canyons out into the Valley floor.

Earliest and latest collection dates during the five-year collecting period were April 19 and August 18, respectively. Largest individual taken, a male, measured 1,749 mm total length, 1,551 mm snout-vent length. Smallest specimen measured 342 mm total length, 288 mm snout-vent. Bullsnakes were most frequently taken during the summer while sunning themselves under bushes, and less frequently under rocks and trash in dumps. Very few DOR's were found, presumably due to the distance of denning sites from well-traveled roads. Specimens of Pituophis melanoleucus in the San Luis Valley were found from about 7,500 feet on the Valley floor to about 8,300 feet in the Pinyon-Juniper zone at the Great Sand Dunes National Monument. I have taken P. m. affinis at an elevation of over 9,000 feet in the Jemez Mountains of New Mexico just southwest of the San Luis Valley, and the species probably reaches this elevation in the mountain passes surrounding the Valley. Again, more collecting is needed at higher elevations in Colorado to fully understand vertical distribution and the effects of mountain ranges as barriers for certain species.

Lampropeltis triangulum taylori Tanner and Loomis x L. t. celaenops Stejneger x L. t. gentilis (Baird and Girard)

Specimens examined: Conejos Co., 9 mi. W Mesita at Rio Grande River, LSUMZ 13812-815; near Manassa, LSUMZ 13816.

Literature records: Conejos Co., near Manassa (Burnett, 1926).

Burnett's (1926) specimen from "near Manassa" was listed as L. t. gentilis. Tanner and Loomis (1957) subsequently separated the western populations of milk snakes, all of which pertinent to this study were previously recognized as L. t. gentilis. In that paper they resurrected the Stejneger name celaenops for the New Mexico population, and named a new subspecies, taylori, from the Great Basin, western Colorado, and northern Arizona. No specimens from the San Luis Valley were examined in that study and their range map (p. 18) shows the Valley to be surrounded by taylori and taylori x celaenops intergrades to the west, celaenops to to the south, and gentilis to the east. Maslin (1959) listed Burnett's (1926) specimen as L. t. gentilis but did not examine it.

The 5 specimens I collected from the San Luis Valley show varying degrees of similarity to gentilis, celaenops, and taylori, and cannot be assigned definitely in any of these using the Tanner and Loomis (1957) key and descriptions (see Table 9). In scutellation the Valley population falls in the range of celaenops for number of ventrals, and overlap somewhat with the known values for taylori in this character. Caudal counts are similar in all subspecies under consideration. The number of scales in the first white annulus also seems to be variable among the three

Table 9

Analysis of Taxonomic Characters in Western Populations of *Lampropeltis triangulum*

	Ventrals	Caudals	Number of White Annuli	Ventrals minus Annuli
* *L. t. gentilis*	187-207 (195.0)	37-57	26-38 (31.4)	155-176 (164.8)
* *L. t. taylori*	175-198 (184.3)	38-53 (44.7)	30-48 (37.4)	140-155 (146.7)
* *L. t. celaenops*	173-181	44-47	30-33	140-155
San Luis Valley specimens	167-188 (177.4)	42-45 (43.2)	32-36 (34.2)	132-152 (144.5)

*Data from tanner and Loomis, 1957.

subspecies and the Valley specimens could fit into any of the western geographical races. In another character used by Tanner and Loomis, the number of white annuli in the Valley Lampropeltis fits the values given for both gentilis and taylori, and overlaps slightly with the range given for celaenops. For the character ventrals minus number of white annuli, the Valley specimens could be placed with either celaenops or taylori. The number of infralabials is a fairly constant 9-9 in celaenops and gentilis, while in taylori 53 percent are 9-9, 47 percent 8-8 or 8-9. Valley specimens would fit best with taylori in this character, 60 percent having 8-9 or 9-8 infralabials and 40 percent 9-9. Sexual dimorphism is not indicated in any character under discussion.

In color pattern, again I find an intermediate condition between those described for celaenops, taylori, and gentilis. All five of the San Luis Valley specimens have black flecks on the chin shields, a character shared by taylori and celaenops but lacking in gentilis. Other than this the color pattern of the Valley specimens is basically that of the subspecies gentilis with the exception that the white annuli are expanded on the middorsal line, as in celaenops, and the triads are occasionally united laterally, also the condition found in celaenops.

With the Valley specimens being intermediate both geographically and in the various taxonomic characters listed above, and not caring to weigh certain characters over others with the limited amount of material available, I feel these specimens represent a three-way intergradation of the races surrounding the San Luis Valley.

Four specimens were collected as they emerged from hibernation on 4 and 7 June 1965 at a small den on the west wall of the Rio Grande Canyon, 9 mi. W Mesita. The den entrance lies just above the high water mark near a fault in the canyon wall. Several fault crevices in the water-eroded volcanic rock slope downward into the wall of the canyon at a moderate angle, and much loose volcanic rock is scattered about the entrance. This same den is also used as a hibernaculum by Pituophis melanoleucus, Crotalus viridis, and Thamnophis elegans, but these species leave the den as much as three weeks earlier than Lampropeltis. As is the case with Pituophis and Crotalus, Lampropeltis triangulum seems to be restricted in the San Luis Valley to lower elevations with deep rock crevices suitable for avoiding the extremes of the long winter.

One specimen was taken 16 July 1964 under debris on the floor of an abandoned turquoise mine near Manassa, Conejos Co. This specimen disgorged seven reptilian eggs of an unknown species. Moist, abandoned mines also occasionally serve as a refuge for Bufo woodhousei and Ambystoma tigrinum during the dry portions of the year.

Size (total length) varies from 171 mm to 485 mm in the specimens of Lampropeltis obtained. Three of the specimens taken at the den were obviously hatchlings of the previous year and measured 171, 178, and 204, respectively.

FAMILY CROTALIDAE

Crotalus viridis viridis (Rafinesque)

Specimens examined: *Alamosa Co.*, 9 mi. ENE Blanca, LSUMZ 11505; 4.2 mi. N U.S. Hwy. 160 on Sand Dunes Road, LSUMZ 11516; *Conejos Co.*, 14 mi. W Antonito, Fox Creek, LSUMZ 11534; 9 mi. W Mesita, LSUMZ 11510-512, 11517; 11 mi. E Manassa, LSUMZ 11529; *Costilla Co.*, 4.5 mi. S Blanca, LSUMZ 11554-558, 11508-509, 11513, ASC (no number); 4.0 mi. S Blanca, LSUMZ 11524-527, 11521-522; 3.5 mi. S Blanca, LSUMZ 11528, 11523; 2 mi. S Jct. Colorado Hwy. 142 and the Rio Grande, LSUMZ 11506-507, 11515; 9 mi. W Mesita, LSUMZ 11518; *Rio Grande Co.*, 2 mi. N Del Norte, LSUMZ 11519; 18 mi. SSW Monte Vista, Cat Creek, LSUMZ 11520.

Literature records: *Alamosa Co.*, 12 mi. W Fort Garland (Maslin, 1959); *Conejos Co.*, Mogote Peak, Antonito, 9220-9320 feet (Klauber, 1956); 1-2 mi. W the Rio Grande on Colo. Hwy. 142 (Smith *et al.*, 1965); *Costilla Co.*, 5 mi. SSE Fort Garland (Smith *et al.*, 1965); 14 mi. W San Luis (Smith *et al.*, 1965); *Rio Grande Co.*, 1 mi. S Rock Creek Park (Klauber, 1956); Gate Creek Park (Klauber, 1956); *Saguache Co.*, between Mineral Hot Springs and Saguache (Klauber, 1956).

A total of 20 males and 13 females of *Crotalus viridis* were examined from various localities in the San Luis Valley. All data taken on these specimens agree in every respect with the normal ranges given by Klauber (1956) for the subspecies *viridis* (see Table 10). In coloration, Valley specimens also match well with the descriptions given by Klauber (1956). It is interesting to note that a brood of young had a much

Table 10

A Comparison of Taxonomic Characters in
Crotalus v. viridis

	San Luis Valley Population	Entire Range of the Subspecies[1]
Ventral range		
Male	166-178 (172.9)	164-187 (177.4)
Female	177-188 (182.1)	171-196 (184.4)
Caudal Range		
Male	23-28 (25.0)	21-31 (26.1)
Female	16-22 (19.4)	16-25 (20.2)
Body blotches	38-50 (44.0)	33-57 (43.7)
Tail blotches	6-12 (8.7)	4-15 (8.7)
Supralabials	12-18 (15.6)	10-18 (14.8)
Infralabials	13-19 (16.5)	11-19 (15.8)
Scale Rows at Mid-body	23-27 (25)	23-29 (27)
Largest specimen (Total length)	1,057 mm	1,448 mm
Smallest specimen (Total length)	289 mm	212 mm

[1]Data from Klauber, 1956.

browner ground color than their yellowish-green (live coloration) female parent, and that all adults taken throughout the Valley had some shade of greenish base coloration.

Six denning sites used by this species were discovered during the course of this investigation, and the majority of specimens taken were from these localities and immediate area. I feel a brief description of each denning site would be of interest due to the amount of current work on snake hibernacula.

Three dens are located approximately 4.5 mi. S Blanca, Costilla Co., west of Smith Reservoir along the appropriately named Rattlesnake Canyon. The first is located twenty feet from the dammed reservoir on the south wall of the canyon and contains the largest number of individuals of this species found at any den in the Valley. The opening to this den consists of fault crevices in the water-eroded volcanic rock of which the canyon wall is formed. Much loose rubble surrounds the entrance due to cattlemen's blasting efforts to erradicate the snakes. Each spring and fall large numbers are shot as they leave or enter this den, or as they sun near the entrance. Large numbers of Thamnophis elegans and a few Pituophis melanoleucus also utilize this den, and are also slaughtered by cattlemen.

The second den is locally called "the snake bush" and is located approximately a quarter of a mile west of Smith Reservoir along the canyon on the northern side. This hibernaculum is on the top of the canyon edge and consists of a single large crevice under a huge, partially buried, volcanic rock surrounded by a dense thick of greasewood (Sarcobatus

vermiculatus) about 5 feet in height and 20 yards in diameter. This site is primarily used by Thamnophis elegans, with smaller numbers of Crotalus and Pituophis also denning here.

The remaining den in this area is located 0.5 mi. W Smith Reservoir, also on the north canyon wall, in a fault which has buckled the canyon wall downward. The deep crevices usually accompanying such a fault are present. This den appears to be used only by small numbers of Crotalus.

Two dens were found along the Rio Grande Canyon separating lower Conejos and Costilla Counties. One has been previously described with the account of Lampropeltis triangulum. The other den in this area is located approximately 2 miles south of the junction of the Rio Grande and Colorado highway 142 on the east side of the canyon in Costilla Co. This site, too, consists of a major fault in the volcanic canyon wall, and Pituophis and Thamnophis have also been taken coming out of hibernation in about equal numbers with Crotalus at the site. All of the previously described dens are on the level of the Valley floor and range in altitude from 7,600 to 7,800 feet.

The remaining den is located approximately 14 miles W Antonito at Fox Creek. This hibernaculum is at the base of the west side of a rocky ridge in the foothills of the San Juan Mountains at about 8,300 feet.

As shown by the locations of these 6 dens, no particular directional facing is seemingly preferred for denning sites in the San Luis Valley.

I have heard of other dens in the Del Norte, and Cat Creek, Rio Grande Co., and Antonito, Conejos Co. areas, but I have been unable to find them, although I have found wandering specimens of Crotalus in the first two areas. An occasional "Rattlesnake Roundup" is held in the Antonito area by ranchers when this species seems numerous.

The highest altitude at which I have taken this species in the Valley was at 8,300 feet. Klauber (1956) listed altitudinal records for the San Luis Valley at "9,400 feet, one mile south of Rock Creek Park, and at 9,500 feet at Gate Creek Park, Rio Grande County, Colorado," and also 9,200 to 9,320 feet on Mogote Peak, near Antonito, Conejos Co.

Klauber (1956) quoted a letter from M. A. Shoeneman, U. S. Forest Service, Antonito, Colorado, which states, "Rattlesnakes are quite numerous in parts of the San Luis Valley. They seem limited quite definitely to certain particular areas. No strays are found beyond areas." Available locality records from the Valley show a general distribution around the periphery of the Valley floor in the foothills, in canyons extending onto the Valley floor, and across the low hills forming the southern natural boundary of the San Luis Valley. The availability of deep denning sites is probably an important limiting factor in the distribution of this form in the Valley, as it also appears to be in Pituophis and Lampropeltis, due to the harsh winter extremes. The old record (Klauber, 1956) from between Mineral Hot Springs and Saguache, Saguache Co. indicates a former more widely spread distribution in the Valley 20 to 30 years ago before the wholesale poisoning of the local prairie dogs (Cynomys g. gunnisoni) by ranchers and farmers. In most areas throughout the range of Crotalus

v. viridis, prairie dog towns are used as denning sites and a ready source of food. In 1965 only a small colony of Cynomys remained in the San Luis Valley in the area just southwest of Saguache, Saguache Co.

Most of the dens described probably harbor fewer than 30 individuals, with the exception of the one closest to the Smith Reservoir Dam at which probably 80 to 100 Crotalus den together. The relatively low density per den in the San Luis Valley, when compared with other areas, is probably due to the availability of a number of suitable hibernacula concentrated in a relatively limited area. The maximum distance this species was found from an area containing a suitable denning situation was about two miles. During the summer specimens of this species were most often found lying in the mouths of rodent burrows sunning or under trash at dumps. Less commonly, I have found Crotalus crossing roads during the day, under bushes and in pack rat (Neotoma cinerea) nests on canyon walls. While most of the denning individuals leave the hibernaculum area early in June, a rich mammal food source in the canyon areas tends to retain and support many snakes during the summer. The commonest mammals encountered in the canyon areas were Perognathus flavus, Neotoma cinerea, and 2 or more species of Peromyscus. Dipodomys ordii and Thomomys talpoides are common in the areas surrounding the canyons.

Over the five-year collecting period, the earliest date of observed emergence from the dens was 19 April 1965. On 25 April 1965, 2 individuals of this species, along with a single Pituophis, were found out in the open, perhaps some 25 yards away from the den, during a sudden temperature drop and snow storm. All three were quite sluggish and would have probably been killed by the freeze. As stated before, most individuals leave the den area in early June.

The latest date this species has been collected before retiring into the dens was 14 September 1964. The majority of individuals begin returning to the dens at the first frost, usually in late August or early September, and do not remain out sunning many days.

On 3 September 1961, an adult female was found in the act of giving birth at the entrance to the Smith Reservoir Dam den. This young individual and another born shortly thereafter measured 289 and 289 mm total length, respectively. Klauber (1956) has discounted stories of young being born at dens, which would make it possible for the young to find the dens for their first hibernation.

SPECIES OF QUESTIONABLE OCCURRENCE IN THE SAN LUIS VALLEY

Cnemidophorus sexlineatus (Linnaeus)

Dr. T. Paul Maslin once told me about a specimen of Cnemidophorus sexlineatus collected by Dr. Joseph C. Daniel in the San Luis Valley. In response to a later inquiry, Maslin (1964, personal communication) wrote, "The Cnemidophorus sexlineatus that Daniel collected was a small juvenile. It may be in our collection somewhere or put aside for processing. I don't think it is lost. Joe gave us his collection but there was some question as to whether it was a loan, permanent loan or a gift. So, the processing was a little confused."

In 1964, when I asked about this specimen, Daniel wrote that he no longer had any collecting data available for this specimen and could only remember that it had been collected near Saguache.

Several collecting days have been spent in the Saguache area without seeing this species. With the presence of scattered populations of several other normally Great Plains species in the Valley, it would not surprise me to find a population of this lizard here also.

Heterodon nasicus nasicus Baird and Girard

Dr. James H. Griffin, formerly of San Luis, Colorado, described to me two DOR specimens he examined from four miles west of San Luis, Costilla Co., that I would have to attribute to this species. The area was thereafter investigated several times, without results, and was found to be a sandy, greasewood association, not unlike habitat for this form further east. Until specimens are taken, Heterodon can only be listed as a possible inhabitant of the Valley.

Opheodrys vernalis blanchardi Grobman

Literature records: Spanish Peaks, 8,000 feet, Costilla Co.(Grobman, 1941).

Maslin (1959) corrected the above record to "Spanish Peaks, 8,000 feet /probably Huerfano Co./ Colorado." The Spanish Peaks form an east-west extension of the generally north-south course of the Sangre de Cristo range with both East and West Spanish Peaks lying along the boundary of Huerfano and Las Animas counties, and are at the closest point some eight miles from the Costilla Co. boundary. This places the species in the Sangre de Cristo Mountains which border the eastern portion of the San Luis Valley, but out of the Valley proper. Other locality records show that the

range of this species surrounds the Valley to the north, east, and west in both the Sangre de Cristos and the San Juans (Hinsdale Co., Los Pinas River, 8,000 feet; Montrose Co., Black Canyon, Gunnison National Monument, S Rim [Maslin, 1959]; La Plata Co., Rio Pinos, near Vallecito [Cary, 1911]; Park Co. [Ellis and Henderson, 1915]; Las Animas Co. [Grobman, 1941]; Archuleta Co. [Grobman, 1941]). I have also found a single DOR specimen of this species in the Sangre de Cristos between Mora and Holman, Mora Co., N. M. The above records indicate a widespread, but spotty distribution in this general area, and lack of specimens from the San Luis Valley is probably attributable to both the relative scarcity of the species and the lack of collecting effort at the higher altitudes to which this form seems to be restricted.

Order Testúdines

There are no published accounts or specimens of turtles from the Rio Grande drainage closer than the Albuquerque, Bernalillo Co., area. Valley residents, however, have reported seeing turtles in the Rio Grande near Alamosa, but all trapping and other efforts to secure specimens met with failure. A "box turtle" was reportedly found crossing a highway just north of La Jara, Conejos Co., during the summer of 1965. Since both reports have come from populated areas, and with the popularity of turtles as pets resulting in their being picked up and brought into the Valley, I would attribute these reports as escaped or released pets and doubt the existence of an established breeding population of any species.

ZOOGEOGRAPHY OF THE SAN LUIS VALLEY

The Rocky Mountain System forms one of the major geographical barriers to east-west animal dispersal in the United States. This barrier effectively separates the Great Plains to the east from the Colorado Plateau, Great Basin, and Columbia Plateau on the west. The Rocky Mountain System is composed of four fairly distinct geographical provinces, the Northern, Middle, and Southern Rocky Mountain provinces, and the Wyoming Basis (see Fenneman, 1931). Dice (1943) divided the Rocky Mountain area into two Biotic Provinces, a northern Montanian, and a southern Coloradan. The San Luis Valley is an intermontane basin located in the Southern Rocky Mountain province between the narrow Sangre de Cristo and the much wider San Juan ranges. The Rocky Mountain System has a breadth of some 110 miles at the narrowest point in the Valley area.

Despite the size and general formidability of this geographical and ecological barrier, several reptiles and amphibians have been able to penetrate partially or to span it completely. Other species occurring on both sides of the Rockies have avoided crossing the mountain barrier by flanking its southern end in New Mexico. Some of these species have reached the San Luis Valley via three principal routes. The lowest connections, and thus paths of least resistance, to areas surrounding the Valley appear to be (1) the Rio Grande Canyon cutting through the Taos Plateau to the south and connecting the San Luis Valley with the lower Rio Grande Valley in New Mexico; (2) the Conejos River Valley-Cumbres Pass area, where the San Juan Range is relatively narrow; and (3) the low (9,010) feet in elevation)

Poncha Pass at the northern end of the Valley, which connects with the Arkansas River Valley, and in turn extends through the mountains onto the eastern plains of Colorado.

The invasions of the San Luis Valley by the reptiles and amphibians presently occurring there can be assumed to have taken place since late Pleistocene. Prior to this period (earlier Pleistocene) the Valley must have been totally unsuited for most terrestrial ectotherms, having been glaciated three times (Knight, 1964). The latest glacial period in this area occurred during the Cary advance in the Wisconsin glacial stage (Darrow, 1961). Antevs (1955) dates the Cary maximum at 24,000 years, B. P. Suess (1956), however, assigns it to a period 13,500 to 14,500 years ago. Extensive glaciation occurred in the upper water courses in both the San Juan and Sangre de Cristo Ranges, and prominent moraines are still present (Ramaley, 1942). Pocket glaciers remain at present in both ranges in sheltered situations at higher elevations. Antevs (1954) considered that the snow line was depressed 3,500 feet on Mount Blanca (14,290 feet in elevation) in the Sangre de Cristo Range during the Cary advance. Assuming this depression would move all Life Zones downward 3,500 feet, all zones present now with the exception of the Arctic-Alpine, would be absent in this area. Antevs (1955) also suggested that the area had a decrease in temperature of 10°F, and an increase in precipitation of 9 inches during this period.

The second factor that prevented most reptiles and amphibians from invading the San Luis Valley before late Pleistocene was the presence of an extensive lake occupying what is now the floor of the Valley. During

late Pleistocene the Rio Grande Canyon, forming the outlet to the lake, became so deep as to cause the lake to be drained (Ramaley, 1942).

Prior to the glacial periods the San Luis Valley was probably very similar to the present. Stewart (1940) listed 34 fossil species of Tertiary seed plants from the Creede Valley that are all related to present day species of the area. Some of these plant seeds were practically identical with their modern counterparts. There is no fossil evidence for the presence of modern herpetofaunal species in the Valley area prior to the Pleistocene.

Most neontologists believe that with the onset of glaciation faunal and floral distributions in the southwest were greatly influenced by the extreme fluctuations in climatic conditions corresponding with glacial advances and retreats. Gehlbach (1965) suggested that Ambystoma tigrinum, Thamnophis elegans, Phrynosoma douglassi, and perhaps other species were present in the general area during this period and remained locally at lower elevations on the Colorado Plateau during cold periods. For the general western area, Antevs (1955) has designated three postglacial periods, Medithermal, Altithermal, and Anathermal, in reference to the thermal progression from the Anathermal toward a warm Altithermal stage between 4,000 and 7,500 years B. P., followed by a cooler Medithermal period from 4,000 B. P. to the present. Life Zones would then be lowered during cool periods and elevated during warmer ones. Great fluctuations in amounts of precipitation probably accompanied these temperature changes. Bogert and Oliver (1945) stated, "the existence of populations belonging to the same species or subspecies that are now represented on mountaintops along the periphery of the deserts (but not in intervening territory)

is interpreted as evidence for the belief that a moist period followed the last period of glacial cold."

An analysis of the present total ranges of the reptiles and amphibians occurring in the San Luis Valley shows 53 percent (8 species) to have a transcontinental pattern of distribution, 34 percent (5 species) are restricted to western United States, and 13 percent (2 species) are primarily Great Plains in distribution (see Table 11). No typically southwestern or Mexican Plateau forms extend into the San Luis Valley although several species reach the lower areas of both eastern and western Colorado.

Several similarities in distributional patterns are evident and reflect information on dispersal routes used by various species. Pseudacris triseriata, Bufo boreas, Thamnophis elegans, and Opheodrys vernalis all tolerate colder temperatures than most ectotherms and have apparently used the Rocky Mountain highlands as a southward dispersal route.

The two typical Great Plains species, Bufo cognatus and Scaphiopus bombifrons, as well as the transcontinental Bufo woodhousei, also show a distinct distributional pattern. The primary ranges of these three toads occur to the east and south of the San Luis Valley, but all have disjunct relictual populations in the central portion of the Valley. These species have basically similar ecological requirements and probably invaded the San Luis Valley together, either from the eastern Plains up the Arkansas River Valley and over Poncha Pass, or, more likely, up the Rio Grande Valley northward over the Taos Plateau during a warmer, moister,

post-glacial period. Most of the other species of reptiles and amphibians occurring in the Valley have a sufficient vertical distribution at present to allow some gene flow with populations outside the Valley via low passes or over the Taos Plateau.

Prior to this study the San Luis Valley was generally considered a mountainous cul-de-sac of little zoogeographic interest. I found, however, that no fewer than 6 of the 14 species native to the Valley intergrade in the area, and that in two species a three-way intergradation occurs. The most probable explanation of the intergradation occurring in this area is that during the Pleistocene a number of forms flanked the Rocky Mountains to the south through the mountain gaps in New Mexico. Many of these species were isolated into eastern and western (and southern in a few cases) populations during cooler climatic conditions with the usual accompanying floral changes. These isolated populations then probably differentiated from the main body of the species before warmer periods came once more. With the onset of warmer periods these subspecies undoubtedly expanded their ranges both northward and altitudinally, crossing the major barriers in the area (the San Juan and Sangre de Cristo Mountains and the Taos Plateau) and rejoined their ranges. Intergrading populations present today in the San Luis Valley are probably the result of this rejoining of separated populations.

Eastern and western races of Ambystoma tigrinum, Pituophis melanoleucus, and Lampropeltis triangulum intergrade within the Valley. The latter two species also show influences from races to the south of the Valley. Other species intergrading in the Valley in a strictly

north-south pattern include Eumeces multivirgatus, Sceloporus undulatus, and possibly Pseudacris triseriata.

Much of the herpetofauna of Colorado consists of wide-ranging, highly adaptable forms, most species having more than one geographical race. A number of these species have been successful in establishing themselves in the Valley. Thus, of a total of 47 species occurring in eastern Colorado, 14 or 37.8 percent also range into the San Luis Valley. Thirty-four species occur in Colorado west of the Valley. Of this number 13 species or 38.3 percent also occur in the Valley. To the south, in the Rio Grande Valley in northern New Mexico, a total of 44 species of reptiles and amphibians are known to occur. Fourteen species or 31.8 percent of these also range into the San Luis Valley.

That isolation does play a role in speciation is clearly evident in several animal groups in the San Luis Valley. Although few Valley reptiles and amphibians show any major morphological distinctions, most show minor character distinctions at variance with the populations surrounding the Valley. Nearly all of the Valley herpetofauna have a sufficient vertical distribution to allow some gene flow with surrounding populations, and thus only partial isolation is effected. Bufo cognatus is the chief exception, and the relictual, isolated Valley population probably represents an undescribed subspecies.

Other examples of speciation which have undoubtedly occurred in the Valley include nine races of endemic mammals and two species of fish. Endemic invertebrates known to me include one species of leech and three insects (a moth and two beetles). A number of Ichneumon wasps collected

during this study were sent to Dr. Henry Townes, Ann Arbor, Michigan, and he has informed me that several of these Valley specimens represent new species. Whether these flying insects are really restricted to the San Luis Valley or not will require much more entomological investigation in the area. Species endemic to the San Luis Valley are listed in Table 12.

Internal ecological barriers and limiting factors for distribution within the Valley have been previously discussed.

Table 11

Over-all Distribution Patterns of Species of Reptiles and Amphibians Occurring in the San Luis Valley

Transcontinental	Western United States
Ambystoma tigrinum	*Bufo boreas*
Bufo woodhousei	*Crotalus viridis*
Pseudacris triseriata	*Thamnophis elegans*
Rana pipiens	*Eumeces multivirgatus*
Sceloporus undulatus	*Phrynosoma douglassi*
Pituophis melanoleucus	
Lampropeltis triangulum	Great Plains
Opheodrys vernalis	*Bufo cognatus*
Rana catesbeiana[1]	*Scaphiopus bombifrons*

[1]Introduced.

Table 12

Animals Endemic to the San Luis Valley

Mammalia

Ochotona princeps incana Howell

Eutamias minimus caryi Merriam

Marmota flaviventris obscura Howell

Thomomys umbrinus pervagus Merriam

Thomomys talpoides agrestis Merriam

Perognathus flavus sanluisi Hill

Perognathus apache relictus Goldman

Dipodomys ordii montanus (Baird)

Reithrodontomys megalotis caryi Howell

Pices

Gila nigrescens (Girard)

Plantosteus plebeius (Baird and Girard)

Insecta

Cicindela theatina Rotger

Serica bruneri Dawson

Pseudohazis hera mangifica Rotger

Hirudinea

Theromyzon sp. (*see* Daniel and Blain, 1959).

SUMMARY AND CONCLUSIONS

This thesis has only partially fulfilled the stated objectives of this study. The chief problem with a study of this type is the lack of comparative data on geographical variation for many of even the commonest western species. This information is especially lacking for the anurans, which make up almost half of the total herpetofauna of the San Luis Valley. To examine the number of specimens needed to obtain these data would be in most species a thesis problem in itself. Because of this lack of data, some taxonomic conclusions are only tentative and will be the subject of further research.

Some of the more significant findings of this study include the discovery of the first known intergrades of Eumeces multivirgatus in the Valley, proving E. m. multivirgatus and E. m. epipleurotus to be conspecific. A previously unknown ontogenetic pattern change is also described for this species. Data on San Luis Valley specimens of Phyrnosoma douglassi support Gehlbach's (1965) conclusion that in the Zuni Mountains of New Mexico and probably elsewhere in the range of this species, what is currently known as the subspecies ornatissimum is actually only a highland expression of P. d. hernandesi. The isolated relictual population of Bufo cognatus in the San Luis Valley is considered to have reached subspecific status on preliminary analysis, and a range-wide review of this species will be the subject of further research. Thamnophis sirtalis dorsalis is removed from the faunal lists of Colorado

upon re-examination of the specimen upon which this record was based. It is recommended that the name of the New Mexico-Arizona population of Pseudacris t. triseriata, currently considered a western relictual colony of the eastern population of P. t. triseriata, be changed to P. t. maculata. Specimens of this species from the supposed intergrade area show a smooth north-south cline in taxonomic characters, rather than the abrupt change usual in such an area. Sceloporus undulatus, Pituophis melanoleucus, and Lampropeltis triangulum were also discovered to intergrade in the Valley confines.

A great deal of information is still needed on the life history and ecology of the species occurring in the area. Further collecting in the Valley will undoubtedly raise the known vertical range of many species and add numerous locality records throughout the Valley. Some of the species listed as doubtfully occurring in the Valley will more than likely be found. The Rio Grande Valley of northern New Mexico, and the Arkansas Valley north of the San Luis Valley remain poorly known herpetologically. Extensive collecting in these areas will probably provide more definite evidence on dispersal routes and subspecific relationships of Valley forms.

The effects of cooler temperatures on reptilian and amphibian embryos and larvae and the subsequent expression of these influences on adult characters also need further investigation. The fact that nearly all species in this isolated high mountain valley have a wider range of variability in many characters than do populations in other areas where the same species have free gene flow over wide areas is contrary to the usual phenomenon occurring in isolated populations with much inbreeding.

This situation could possibly be linked to the cooler temperatures acting on the immature animals (see Fox 1948, 1961). The cause of dwarfism in some Valley ectotherms also needs further investigation.

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VITA

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Major Field: Vertebrate Zoology

Title of Thesis: A Biogeographic Analysis of the Herpetofauna of the San Luis Valley, Colorado

Approved:

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Date of Examination:

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