SEASONAL OCCURRENCE AND HABITAT UTILIZATION BY LIZARDS IN SOUTHWESTERN NEW MEXICO

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ABSTRACT—Herein we describe how members of a lizard community in southwestern New Mexico vary in their seasonal occurrence and utilization of habitat. Except for January 1984, one or more of the following 11 species of lizards were active during each of the 24 months of study (April 1983 through March 1985): greater earless (*Cophosaurus texanus*), zebra-tailed (*Callisaurus draconoides*), leopard (*Gambelia wislizenii*), desert spiny (*Sceloporus magister*), eastern fence (*Sceloporus undulatus*), side-blotched (*Uta stansburiana*), tree (*Urosaurus ornatus*), Texas horned (*Phrynosoma cornutum*), round-tailed horned (*Phrynosoma modestum*), desert-grassland whiptail (*Cnemidophorus uniparens*), western whiptail (*Cnemidophorus tigris*). Desert-scrub vegetation covered about 20% of the study area, with bare ground (i.e., soil, sand, gravel, or rocks) accounting for about 70%, and debris (i.e., sticks, limbs, and leaf litter) the remaining 10%. Lizard species segregated into two major habitat groupings, one composed of sites having relatively abundant cover and vegetation (e.g., sites occupied by *S. magister, U. ornatus, U. stansburiana,* and *C. tigris*) and the other characterized by more open sites (e.g., sites occupied by *G. wislizenii, C. draconoides, P. modestum,* and *C. texanus*). Species such as *C. draconoides* and *G. wislizenii* utilized microhabitats in roughly the same proportions as available. Other species such as *S. magister* and *U. ornatus*, the former found in association with nests of white-throated woodrats (*Neotoma albigula*) and the latter associated with trees or dense debris, were more selective. The present study, which provides useful information for formulating land management decisions, is one of the few to study a lizard community throughout all months of the year.

Reptiles and amphibians constitute 30% (455 of 1,500 species) of the native vertebrates (excluding fish) of North America north of Mexico (Bury et al., 1980). These species are, however, often excluded from consideration in habitat evaluation and management (Clawson et al., 1984). The consequences of excluding these species from resource management consideration may be surmised given their habitat requirements, but quantitative information on the use of habitat by each species is lacking.

The magnitude of routine habitat alterations is often large, particularly over extended periods. As an example, a minimum of 35,900 acres (14,528 ha) of federal lands dominated by creosote-bush (*Larrea tridentata*) in south-central and southwestern New Mexico were subjected to brush clearing during 1982 to 1987 (B. Donaldson, in litt.). This does not represent a series of isolated incidents, nor the only major source of relatively large scale alterations of habitat. Such large acreages actually represent only a small fraction of the total land mass in the Chihuahuan Desert dominated by this vegetation. Nonetheless, the impact of the local removal of 95% or more of the woody vegetation on wildlife (particularly reptiles and amphibians) remains largely unknown.

This paper presents the findings of a portion of a 2-year study that focused on a variety of ecological questions. Here, we report on the seasonal occurrence and number of individuals of each species of lizard observed in relatively undisturbed habitat (i.e., little grazing and little if any off-road vehicle use), describe and quantify the habitat locally available to each species, and contrast and characterize microhabitat use by each species within our study area. Lizard species encountered within the study area include the greater earless (*Cophosaurus texanus*), zebra-tailed (*Callisaurus draconoides*), leopard (*Gambelia wislizenii*), desert spiny (*Sceloporus magister*), eastern fence (*Sceloporus undulatus*), side-blotched (*Uta stansburiana*), tree (*Urosaurus ornatus*), Texas horned (*Phrynosoma cornutum*), round-tailed horned (*Phrynosoma modestum*), desert-grassland whiptail (*Cnemidophorus uniparens*), and western whiptail (*Cnemidophorus tigris*).

MATERIALS AND METHODS—Our study was conducted along the New Mexico-Arizona border in western Hidalgo Co., New Mexico. Two study sites were established along the western flank of the large bajada that lies to the north of U.S. Highway 80 and to the east of San Simon Cienega. The western boundary of both areas was approximately 0.8 km east of the state line and extended eastward for approximately 1.6 km. The elevation gradient was slight and virtually the same for both areas: 1,183 to 1,219 m in the most southern of the two areas and 1,195 to 1,219 m at the most northern. Each site was characterized by a similar mixture of land forms (i.e., hillsides, flats, large arroyos, and small arroyos) that were in turn characterized by having similar vegetation. Dominant plant species found throughout each included creosote-bush, snakeweed (*Gutierrezia sarothrae*), honey mesquite (*Prosopis glandulosa*), zinnia (*Zinnia acerosa*), and tarbush (*Flourensia cernua*). Desert-scrub vegetation covered about 20% of the study area, with bare ground (i.e., soil, sand, gravel, or rocks) accounting for about 70%, and debris (i.e., sticks, limbs, and leaf litter) the remaining 10%.

Lizards were collected at monthly intervals from April 1983 through March 1985 by randomly walking throughout the area. At the time of collection, an identification tag was affixed to each lizard, with the species, the characteristics of the site where collected, and the collector's field number noted on data sheets. Beginning in February 1984, the same data were also recorded for lizards that were not collected. Sampling efforts were quantified using pedometers (Pianka and Parker, 1972) and adjusted for each pace equaling 45 cm (18 inches). The time spent searching for lizards as well as the distances traveled were noted for each collecting foray.

The overall habitat available to lizards was measured using a stratified random procedure, i.e., a single 300-m transect was randomly positioned within each of the four topographic land forms. Sampling to characterize these areas was conducted only once, as the more permanent woody vegetation was the focus of our efforts. Seasonal changes in vegetation, which included the appearance and subsequent disappearance of herbaceous plant species, were nonetheless noted throughout the course of study. Cover values were measured for vegetation ≤ 30 cm in height and for vegetation >30 cm at 5-m intervals along each transect. Small shrub and herbaceous plant cover within each of the 61 1-m^2 quadrats was measured using a 1-m^2 grid. When possible, vegetative cover of those species >30 cm was measured using the same procedures. Small tree and shrub cover too high for this method was projected onto the grid by a pole placed perpendicular to the grid. The density of woody plant species in these same areas was quantified by dividing each of the four 300-m transects into 100-m segments. Along each 100-m segment, a randomly selected 225-m^2 plot was positioned and the number of plants of each species enumerated.

With the exception of *C. texanus* ($n = 4$), *G. wislizenii* ($n = 6$), and *P. modestum* ($n = 11$), microhabitats were characterized based on 20 plots/species. Plots used in these analyses were sampled as individual lizards were encountered. Cover was based on 1-m^2 plots centered on the site of first detection and was measured in the same fashion as previously described. The density of woody plant species in these areas was measured by expanding the same 1-m^2 plots used to obtain cover to an area of 25-m^2 and subsequently counting the number of individual plants of each woody species within this newly defined area. To detect seasonal shifts in microhabitat use, the dominant plant species and physical attributes (i.e., dead limb, tree trunk, bare ground, sandy wash) of the sites where lizards were first seen were noted as lizards were encountered or collected.

The mean and standard deviation were calculated for each microhabitat variable for each species. These data were used in multivariate procedures (NT-SYS; Rohlf et al., 1972) that standardized each microhabitat variable across species (i.e., each had a mean of 0 and *SD* of 1) and correlation and distance matrices (Sneath and Sokal, 1973) were calculated. To elucidate relationships among and between species (based on their microhabitat use), a dendrogram was constructed from the correlation matrix of the standardized data. Cluster analyses were performed on distance matrices, and the results plotted on principal component axes.

RESULTS AND DISCUSSION—*Seasonal Occurrence and Number of Individuals*—With the exception of January 1984, at least one species was active each month. The maximum number of species observed during any month was nine in July 1984, although eight were observed during August and September 1984. Only one species (*U. stansburiana*) was observed during December, January, and February, months that were characterized by relatively cool daytime temperatures and nighttime temperatures that were well below freezing.

TABLE 1—Seasonal occurrence and number (including young) of *Callisaurus draconoides* (CDRA), *Cophosaurus texanus* (CTEX), *Cnemidophorus tigris* (CTIG), *Cnemidophorus uniparens* (CUNI), *Gambelia wislizenii* (GWIS), *Phrynosoma cornutum* (PCOR), *Phrynosoma modestum* (PMOD), *Sceloporus magister* (SMAG), *Sceloporus undulatus* (SUND), *Urosaurus ornatus* (UORN), and *Uta stansburiana* (USTA).[1]

	Species										
Date	CDRA	CTEX	CTIG	CUNI	GWIS	PCOR	PMOD	SMAG	SUND	UORN	USTA
Apr 1983	6	0	13	0	0	0	2	2	1	1	3
May 1983	20	0	29	0	4	0	1	1	0	0	0
Jun 1983	8	0	21	0	1	0	0	1	1	0	1
Jul 1983	21	0	25	0	4	0	1	0	0	0	0
Aug 1983	22	0	10	0	6	0	1	2	0	0	4
Sep 1983	41	1	26	0	1	0	2	5	0	0	19
Oct 1983	37	0	14	0	2	0	0	2	0	1	9
Nov 1983	3	0	0	0	0	0	0	0	0	1	16
Dec 1983	0	0	0	0	0	0	0	0	0	0	6
Jan 1984	0	0	0	0	0	0	0	0	0	0	0
Feb 1984	0	0	0	0	0	0	0	0	0	0	22
Mar 1984	54	0	6	0	0	0	0	1	0	3	5
Apr 1984	44	0	43	0	1	0	0	7	0	3	15
May 1984	35	0	75	0	0	0	1	14	0	9	7
Jun 1984	27	0	46	0	3	0	1	13	0	6	6
Jul 1984	32	3	51	0	1	0	1	9	1	7	11
Aug 1984	47	1	25	0	0	1	1	11	0	16	26
Sep 1984	53	0	13	1	1	0	5	8	0	5	12
Oct 1984	45	0	7	0	0	0	3	4	0	6	37
Nov 1984	2	0	0	0	0	0	0	0	0	3	33
Dec 1984	0	0	0	0	0	0	0	0	0	0	3
Jan 1985	0	0	0	0	0	0	0	0	0	0	9
Feb 1985	0	0	0	0	0	0	0	0	0	0	25
Mar 1985	47	0	1	0	0	0	4	1	0	28	26

[1] Numbers for April 1983 through January 1984 are collected specimens; beyond the latter date they also include lizards that were not collected.

Although incomplete, the data recorded during the first 10 months of our study (based only on collected specimens) are still informative in showing seasonal continuity and providing a crude estimate of the number of individuals of each species (Table 1). A more complete measure of seasonal activity and differences in individual numbers among species is provided by the data beginning with February 1984. Seasonal activity among the most common species of lizards was confined primarily to the period March to October for *C. draconoides,* from April to September for *C. tigris,* and from February to November for *U. stansburiana.* The activity pattern for *U. ornatus* was of comparable length to the former species but was characterized by relatively fewer individuals. Activity patterns for the remaining species were reduced in length (i.e., *G. wislizenii, P. modestum,* and *S. magister*), especially in the case of those species noted only through the rare and often irregular occurrence of isolated individuals (i.e., *C. texanus, C. uniparens, P. cornutum,* and *S. undulatus*). Large increases in the number of individuals during periods other than the beginning of spring were the result of the emergence of young for all species except *C. tigris.* In the case of *C. tigris,* sudden changes in the number of individuals were brought about in part by the emergence of young, but these changes also reflect the disappearance of adults.

Habitat Utilization—The habitat available to lizards inhabiting the bajada just east of San Simon Cienega is characterized in Table 2. Areas most often utilized by the eight most abundant species of lizards during periods of peak seasonal activity are shown in Table 3. Visual comparisons of the data sets in Table 3 with those in Table 2 indicate that some species of lizard utilized the available habitat in roughly the same proportions in which it occurred (i.e., numeric values were similar be-

TABLE 2—Habitat available to lizards inhabiting the bajada just east of San Simon Cienega. Cover reported as the average amount as summed across individual plots within a given height class and category (i.e., bare ground, vegetation, debris), expressed as a percentage of the total area sampled; density reported as the average number of plants per hectare based on the number of plants per unit area as summed across all plots.[1]

Cover ≤30 cm tall	Cover >30 cm tall	Density
65.3% bare ground	76.0% bare ground	1,974 creosote-bush
18.4% debris	23.7% vegetation	1,033 snakeweed
16.3% vegetation	0.3% debris	263 honey mesquite
		174 zinnia
		159 tarbush
		328 (15 species)

[1] Plant species: creosote-bush (*Larrea tridentata*), honey mesquite (*Prosopis glandulosa*), snakeweed (*Gutierrezia sarothrae*), tarbush (*Flourensia cernua*), zinnia (*Zinnia acerosa*).

tween a given species and those presented in Table 2), while other species were more selective in their use of habitat (i.e., numeric values were different).

Statistical analyses of the relationship between available habitat and those portions of the habitat occupied by each lizard species, based on the eight microhabitat variables shown in Table 4 (as derived from Tables 2 and 3), support the observation that some species of lizard were more selective than were others. Nearly 90% of the variability associated with habitat utilization is explained by the first two principal components. There is a strongly negative association on the first principal component (PC1) with vegetative coverage and a correspondingly positive association with the amount of bare ground (Table 4). Approximately 71% of the differences in habitat use among lizard species can be explained in terms of the amount of bare ground that is present. For the second principal component (PC2), which explains an additional 18% of the variability (Table 4), the most strongly associated variables are debris coverage >30 cm (−0.683) and total number of woody plant species (−0.665). These variables contribute substantially to PC2 and separate species along this axis. Further interpretation of the relationship between available habitat and the use of habitat by each species of lizard is graphically depicted in Fig. 1.

The interpretation of Fig. 1 and the positioning of each species of lizard within this figure is most easily explained by the summation of various individual data sets presented in Table 3. Two major groupings, each composed of two subgroups with two species of lizard in each, are apparent. The interpretation of the lower portion of Fig. 1 is confounded somewhat by the fact that an asymptote occurs in the analysis. This break in the continuum from areas having abundant debris and abundant vegetation to areas of sparse debris and sparse vegetation is depicted by the dotted line, which necessitates the creation of two separate labels for PC2. The positioning of each lizard species in the dendrogram, and along the horizontal axis (PC1) and vertical axis (PC2) of the lower portion of the figure, is largely determined by the total amount of cover (PC1 = percent vegetation + percent debris) and the total amount of debris and the number of woody plant species (PC2 = percent debris + number of woody plant species) found in the plots of each lizard species. Values summed from Table 3 are 155.8 (PC1) and 73.7 (PC2) for *S. magister,* 114.2 and 55.2 for *U. ornatus,* 138.5 and 50.7 for *U. stansburiana,* 134.7 and 37.4 for *C. tigris,* 100.9 and 31.3 for *G. wislizenii,* 84.5 and 24.2 for *C. draconoides,* 29.2 and 15.9 for *P. modestum,* and 0.0 and 10.0 for *C. texanus.*

The only species that utilized habitat in approximately the same proportions as it occurred were *C. draconoides* and *G. wislizenii* (Tables 2 and 3). Both species, at least during periods of peak seasonal activity, were found in relatively open areas that were often interspersed with moderate amounts of vegetative cover. Slightly more vegetative cover was, however, found in areas occupied by *G. wislizenii* than was found in areas occupied by *C. draconoides* (Table 3, Fig. 1).

The most highly selective of the eight species were *S. magister* and *U. ornatus.* Nests of white-throated woodrats (*Neotoma albigula*) were always closely associated with the habitat of *S. magister.* These nests were characterized by extensive piles of debris in dense stands of honey mesquite, creosote-bush, and tarbush (Table 3,

TABLE 3—Microhabitats utilized by lizards inhabiting the bajada just east of San Simon Cienega during periods of peak seasonal occurrence. Cover reported as the average amount as summed across individual plots within a given height class and category (i.e., bare ground, vegetation, debris), expressed as a percentage of the total area sampled; density reported as the average number of plants per hectare based on the number of plants per unit area as summed across all plots.[1]

		Microhabitat		
Lizard species	n	Cover ≤30 cm	Cover >30 cm	Density
Callisaurus draconoides	20	52.2% bare ground	63.4% bare ground	1,820 cresosote-bush
		29.7% vegetation	36.6% vegetation	900 snakeweed
		18.2% debris	0.0% debris	340 tarbush
				300 honey mesquite
				60 (2 species)
Cophosaurus texanus	4	100% bare ground	100% bare ground	300 snakeweed
		0.0% debris	0.0% debris	200 creosote-bush
		0.0% vegetation	0.0% vegetation	200 honey mesquite
				200 crucifixion-thorn
				200 zinnia
				500 (5 species)
Cnemidophorus tigris	20	41.7% vegetation	63.6% vegetation	2,620 creosote-bush
		29.4% debris	36.5% bare ground	940 snakeweed
		28.9% bare ground	0.0% debris	440 honey mesquite
				280 tarbush
				180 gray thorn
				200 (3 species)
Gambelia wislizenii	6	40.3% bare ground	58.7% bare ground	1,933 creosote-bush
		33.3% vegetation	41.3% vegetation	1,000 snakeweed
		26.3% debris	0.0% debris	600 zinnia
				400 honey mesquite
				133 cholla
Phrynosoma modestum	11	82.3% bare ground	88.3% bare ground	1,527 creosote-bush
		10.9% debris	11.5% vegetation	836 snakeweed
		6.8% vegetation	0.0% debris	255 zinnia
				327 (2 species)
Sceloporus magister	20	58.2% debris	65.7% vegetation	1,480 creosote-bush
		29.4% vegetation	31.8% bare ground	1,440 snakeweed
		12.4% bare ground	2.5% debris	740 honey mesquite
				100 zinnia
				480 (9 species)
Urosaurus ornatus	20	44.2% debris	50.7% bare ground	1,000 snakeweed
		35.2% bare ground	49.4% vegetation	540 creosote-bush
		20.6% vegetation	0.0% debris	280 honey mesquite
				200 desert willow
				100 wait-a-bit
				300 (6 species)
Uta stansburiana	20	41.9% vegetation	58.9% vegetation	1,620 creosote-bush
		37.7% debris	41.2% bare ground	1,160 snakeweed
		20.5% bare ground	0.0% debris	520 tarbush
				500 honey mesquite
				480 zinnia
				540 (8 species)

[1] Plant species: cholla (*Opuntia bigelovii*), creosote-bush (*Larrea tridentata*), crucifixion-thorn (*Koeberlinia spinosa*), desert willow (*Chilopsis linearis*), gray thorn (*Condalia lycioides*), honey mesquite (*Prosopis glandulosa*), snakeweed (*Gutierrezia sarothrae*), tarbush (*Flourensia cernua*), wait-a-bit (*Mimosa biuncifera*), zinnia (*Zinnia acerosa*).

TABLE 4—Loading of microhabitat variables on the first four principal components (PC1 = 70.77%, PC2 = 17.90%, PC3 = 7.16%, and PC4 = 3.33%).

Microhabitat variables	Principal components			
	I	II	III	IV
Bare ground coverage ≤30 cm	0.991	−0.049	−0.028	0.106
Vegetative cover ≤30 cm	−0.860	0.484	0.064	0.090
Debris coverage ≤30 cm	−0.908	−0.317	−0.005	−0.246
Bare ground coverage >30 cm	0.989	−0.061	−0.036	0.089
Vegetative cover >30 cm	−0.986	0.087	0.057	−0.094
Debris coverage >30 cm	−0.483	−0.683	−0.535	0.102
Woody stem density	−0.822	0.418	−0.195	0.314
Total no. of woody plant species	−0.507	−0.665	0.489	0.246

Fig. 1). The habitat used by *U. ornatus* was characterized by trees or large amounts of debris (Table 3, Fig. 1), the latter not necessarily associated with woodrat nests.

Both *U. stansburiana* and *C. tigris* occupied the same type of habitat (Table 3, Fig. 1). Each species occurred in areas characterized by relatively abundant vegetation and moderate amounts of ground cover (Fig. 1), the latter composed primarily of leaf-litter debris as opposed to debris consisting of dead twigs and larger sticks. Nonetheless, *U. stansburiana* tended to occur more frequently in areas with denser stands of vegetation such as snakeweed than the areas occupied by *C. tigris* (Table 3, Fig. 1).

The most open habitat was where *P. modestum* and *C. texanus* were found (Tables 2 and 3, Fig. 1). However, *P. modestum* tended (n = 11) to occur in slightly less open areas than *C. texanus* (n = 4). Though fewer plant species were found in areas occupied by *P. modestum* compared to *C. texanus* (Table 3), such areas usually were structurally more diverse.

Seasonal Shifts in Habitat Utilization—Seasonal shifts in habitat use, or perhaps differences in activity patterns within the same habitat, were noted for two of the eight species. Seasonal shifts exhibited by *C. tigris* and *U. stansburiana* were short-lived, persisting no longer than 2 months in the case of *C. tigris*. Except for September and October, *C. tigris* predominantly occurred in association with honey mesquite and creosote-bush. During September and October, following a decrease in lizard abundance, *C. tigris* spent a disproportionate amount of time in areas dominated by snakeweed. Seasonal shifts in habitat use by *U. stansburiana* were surprisingly few, given the fact that it remained active throughout the year. The species generally was found in association with honey mesquite and creosote-bush. Only during October and January were the majority of individuals encountered in other segments of the habitat. In October, as was the case with *C. tigris*, most individuals were encountered in dense stands of snakeweed, whereas in January individuals were more frequently found basking in the open on bare ground. The shift in occurrence of *U. stansburiana* and *C. tigris* to snakeweed during late summer may have been associated with flowering and the resulting increase in prey abundance.

Shifts in habitat use were not detected for the six remaining species. Areas of bare ground were where *C. draconoides* was usually encountered, although vegetative cover often was not too distant. The majority of *S. magister* were found in association with honey mesquite, and all were associated with woodrat nests. Desert willow trees (*Chilopsis linearis*) or areas with considerable amounts of debris were sites where *U. ornatus* was consistently found. Too few data are available for *C. texanus*, *G. wislizenii*, and *P. modestum* to detect any shift in habitat use.

CONCLUSIONS—The traditional methods we used, as well as those used by virtually all previous investigators, have been a series of point estimates. This method has been criticized by Pietruszka (1984), and we share many of his concerns. Nonetheless, a sufficient proportion of the total population throughout the entire day and season was sampled to offset much of the criticism associated with point estimates. We, therefore, minimized the bias associated with our methods and believe that our results provide an accurate picture of habitat utilization by the various species.

Lizard species occurring at San Simon Cienega

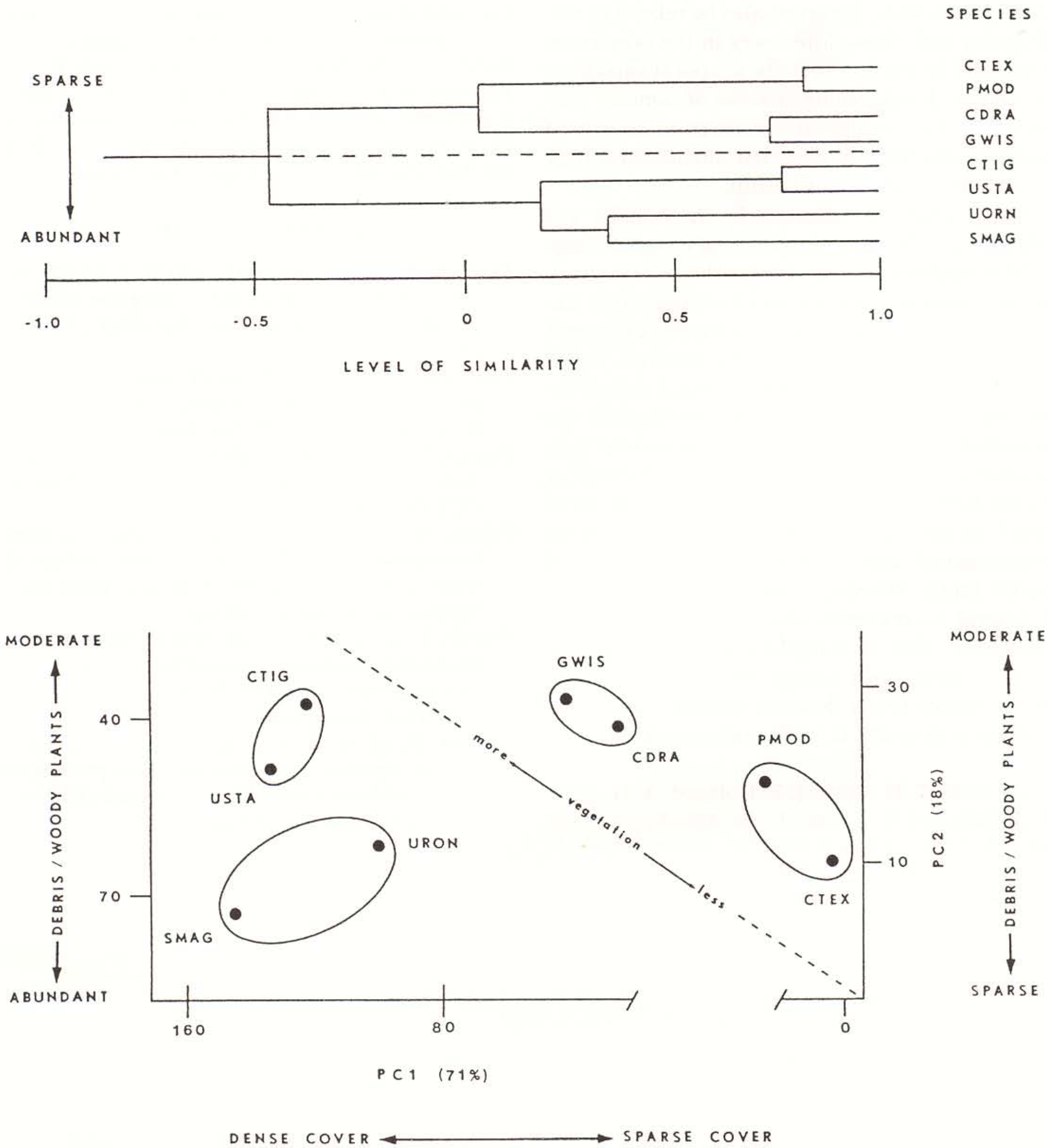

FIG. 1—Dendrogram produced by UPGMA clustering as applied to lizard microhabitat variables (cophenetic correlation coefficient = 0.79) and principal component analysis of the same variables (Table 4) contrasting microhabitats based on the first two principal component axes for eight species of lizard: (CDRA) *Callisaurus draconoides,* (CTEX) *Cophosaurus texanus,* (CTIG) *Cnemidophorus tigris,* (GWIS) *Gambelia wislizenii,* (PMOD) *Phrynosoma modestum,* (SMAG) *Sceloporus magister,* (UORN) *Urosaurus ornatus,* (USTA) *Uta stansburiana.*

segregated into two major habitat groupings, one composed of sites having relatively abundant cover and vegetation and the other characterized by more open sites. Within each of these two groupings, lizards partitioned the habitat in even finer detail, such that two additional subgroups with two species each were apparent. The entire array of available habitat types produced by variations in cover and density appeared to be utilized by one or more species. The various species pairs appear to coexist, at least in part, through slight differences in habitat utilization. Coexistence within some species pairs may also be primarily attributable to differences in microhabitat usage (e.g., *U. ornatus* and *S. magister*). The coexistence of other species pairs such as *C. tigris* and *U.*

stansburiana may, however, also be related to size disparity and, thus, differences in the prey items consumed by each or to daily temporal variations in activity. Forthcoming analysis of stomach contents and daily temporal variations in activity of lizards collected and observed during this study should clarify this relationship.

Given what we believe to be the broader applicability of the data, the potential effects of large habitat modifications involving reductions in shrub density upon various species of southwestern lizards can be more accurately surmised. Additional population studies designed to measure lizard densities and having an experimental design involving a "before" and "after" component are nevertheless needed. Until such time as these data become available, however, existing knowledge of lizard habitat requirements should be factored into land management decisions, particularly by governmental agencies overseeing large tracts of public lands. Whether habitat alterations are of a natural successional process, the result of urbanization, due to overgrazing, or the result of brush control, such a large and diverse segment of the native fauna deserves serious attention if biological diversity is to be maintained.

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