POSSIBLE EFFECTS OF MICROHABITAT AVAILABILITY ON LIZARD DIVERSITY AND DENSITY AT BAJA CALIFORNIA SUR

A. ORTEGA-RUBIO, S. ÁLVAREZ-CÁRDENAS & P. GALINA-TESSARO

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Possible effects of microhabitat availability on lizard diversity and density.—Microhabitat preferences of the lizard species of two guilds at Baja California Sur (México), in which several Baja endemic species occur were analyzed and compared. Differences in substrate availability and vegetation structure between both habitats were also studied. Important differences in species diversity, population size, niche breadth and spatial overlaps were found between both guilds. Higher lizard diversity, population numbers and spatial niche overlap were associated with greater microhabitat diversity and complexity. The effect of spatial resource use on the structure of these guilds is discussed.

Key words: Diversity, Density, Lizards, Microhabitat availability, Spatial resource partitioning.

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Alfredo Ortega-Rubio, Sergio Álvarez-Cárdenas & Patricia Galina-Tessaro, Centro de Investigaciones Biológicas de Baja California Sur, Apdo. Postal 128, La Paz, 23000 B.C.S., México.

INTRODUCTION

Resource partitioning and consequently species separation are known to take place along three main axis: space, time and food (CODY, 1968; PIANKA, 1976, 1986; SCHOENER, 1968). The relative importance of these three main axis has been discussed for several species (SCHOENER, 1974; TOFT, 1985). It has been shown that spatial separation among animals is the most common mode of partitioning, followed by food separation and temporal partition (SCHOENER, 1974). Specifically, for lizards the relative importances of the three axis are the same as those found for animals as a whole (SCHOENER, 1986). Furthermore, comparing North American, African and Australian desert lizards, PIANKA (1973) found that microhabitat overlap is low everywhere in desert lizard communities.

Studies of resource partitioning are generally performed comparing food, spatial and temporal relationships among species of one determined guild (JOHNSON, 1986; PULLIAN, 1985; SIMON, 1976; SIMON & MIDDENDORF, 1976). However, in the case of spatial preferences, microhabitat availability is usually not considered and differences and resemblances among guilds are rarely tested.

In this work data on microhabitat use by lizard species in two communities at Baja California Sur (México) are presented. Differences in substrate availability and vegetation structure between both habitats are studied. A relationship between microhabitat availability and lizard species diversity and density is suggested and discussed.

MATERIAL AND METHODS

Observations were made at two localities, El Mogote and El Comitán, located at the northern part of the Cape Region, in State of Baja California Sur, México (fig. 1). El Mogote is located 19 km NW of La Paz City. The substrate in this habitat is mainly sand dunes and the main plants are the shrubs *Cyrtocarpa edulis, Condalia* sp. and *Lycium* sp. (LEON & TROYO, 1985), which are sparsely distributed over the area.

El Comitán is situated at 17 km N of La Paz City. It is a coastal lowland habitat with loam-sandy soils. The predominant floristic-physognomical unity is the xerophytic scrub (LEON & TROYO, 1985), composed mainly by the cacti *Pachycereus pringlei, Machacereus qumosos* and *Opuntia cholla,* the tree *Prosopis palmeri,* and the shrubs *Jatropha cinerea* and *Fouqueria diguetti* among others.

The mean annual temperature at both sites is 23.9 °C, with a mean annual precipitation of 62 mm. Most of the precipitation occurs in the summer months (August and September) (HANSTINGS & HUMPREY, 1969).

A square of 10000 m^2 was marked at each study site. All lizards observed during four consecutive days at the end of July 1986 were removed from the square. Individuals were collected using riffles, rubber bands or by hand. Time, sex and the specific substrate over which lizards were first sighted were recorded. The collected animals were weighed, sexed and deposited in the herpetological collection of the Centro de Investigaciones Biológicas of Baja California Sur.

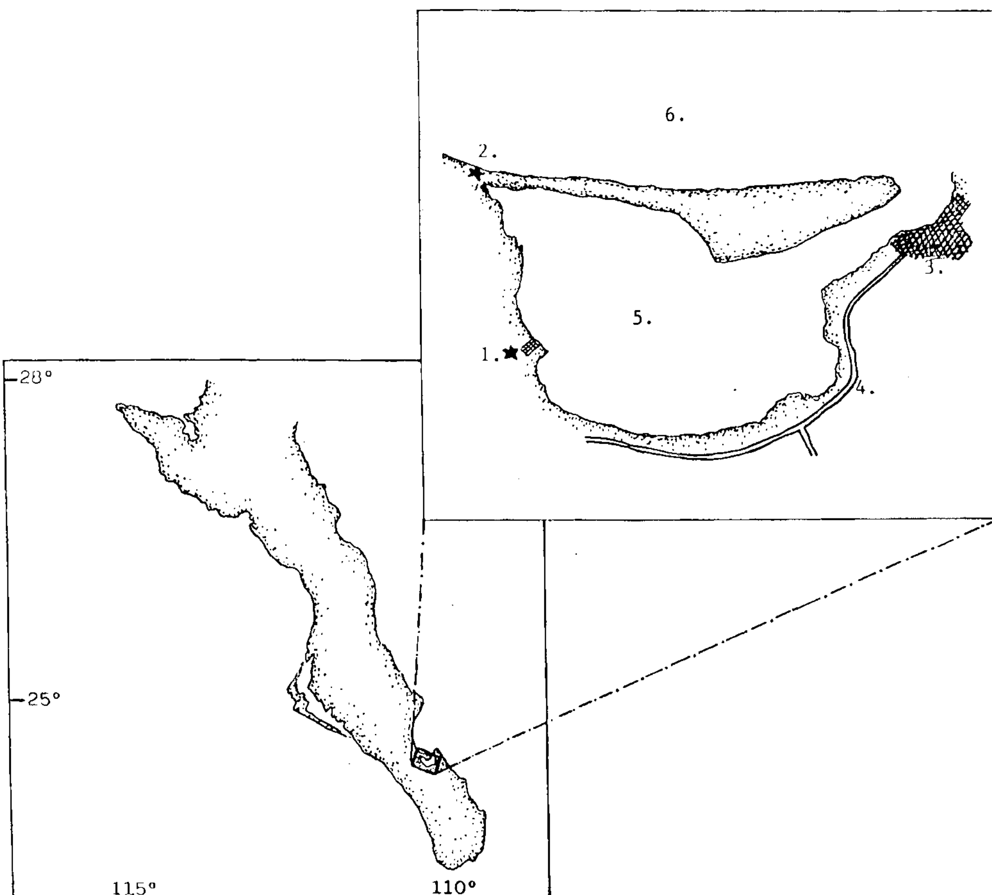

Fig. 1. Location of the two study sites: 1. El Comitán; 2. El Mogote. 3. La Paz city; 4. Transpeninsular road; 5. La Paz Inlet; 6. La Paz Bay.
Localización de las dos zonas de estudio (ver arriba).

Four additional days were spent at each study site in order to determine vegetation structure and microhabitat availability, using in both cases the minimal area method (MOORE & CHAPMAN, 1986). This method consists in the identification of the species number at increasing areas and the determination of the area at which the accumulated species numbers are asymptotic. In this case, average plant height and plant cover for each measured area were also recorded, as well as the relative percentage of the area occupied by the different kinds of recognized substrate.

Species diversity of each lizard community was estimated using the Simpson's inverse Index (LEVINS, 1968): $D=(\Sigma_{pi}{}^2)^{-1}$ where pi is the number of individuals of species i divided by the total number of individuals. Population densities were estimated using a regression line technique (DELANY, 1974), a standard minimum method originally used on rodents, but in this case applied to lizard populations.

Species utilization of spatial resources was calculated using the standardized Simpson's diversity index:

$$Ds=\frac{(\Sigma_{pi}{}^2)^{-1}-1}{N-1}$$

where pi is the relative utilization of the i^{th} substrate in the habitat and N is the number of classes of substrate.

Spatial niche overlap between species in each study site was measured using Pianka's index (PIANKA, 1973):

$$O_{jk}=\frac{\Sigma P_{ij}P_{ik}}{\Sigma P_{ij}{}^2 P_{ik}{}^2}$$

where P_{ij} is the relative usage of substrate i by species j and P_{ik} is its relative usage by species k. As RICKLEFS & LAU (1980) emphasized, the confidence limits of such estimates can not be easily estimated but this is not an obstacle for the discussion of our results.

Differences in microhabitat utilization among the species of the two lizard's guilds were analized using the Wilcoxon signed rank test (SOKAL & ROHLF, 1969). On the other hand, differences in microhabitat availability between the two study sites were analized using the Chi-square test (SOKAL & ROHLF, 1969).

RESULTS

Eleven lizard species were collected at the El Comitán study site, and seven of them were also present at El Mogote (table 1). The species diversity values and lizard densities, at both places, are showed also in table 1. Significant differences among the lizard densities of four species *(C. draconoides, U. Stansburiana, U. nigricaudus, and C. hyperythrus)* between both sites were found ($t=3$; d.f.$=3$; $p<0.05$).

In table 2 the distribution of species by microhabitat at El Comitán study site are shown. Clearly the microhabitat niche breadth (DS) is low in almost all species. This is a consequence of the relative degree of specialization in substrate use. A similar situation, and even more pronounced, was found at El Mogote (table 3): practically all of the species

Table 1. Lizard densities and lizard species diversity for both study sites.

Densidad de lagartos y diversidad de especies en ambas zonas de estudio.

	Individuals/Ha	
Species	El Comitán	El Mogote
Coleonyx variegatus	1	1
Phyllodactylus unctus	2	—
Dipsosaurus dorsalis	9	11
Callisaurus draconoides	13	32
Sceloporus monserratensis	2	—
Sceloporus zosteromus	3	1
Uta stansburiana	13	43
Urosaurus nigricaudus	40	—
Ctenosaura hemilopha	2	—
Phrynosoma coronatum	2	1
Cnemidophorus hyperythrus	42	2
Total values		
Species	11	7
Individuals	129	91
Diversity	3.88	2.76

Table 2. Distribution of species by microhabitat at El Comitán. Ds. Standardized niche breadth.
Distribución de especies por microhábitat en El Comitán. Ds. Amplitud estándar de los nichos.

	Species										
Substratum	C.v.	P.u.	D.d.	C.d.	S.m.	S.z.	U.s.	U.n.	C.h.	P.c.	C.h.
Loam-Sandy Soil	1.0	0	1.00	1.000	0.500	0	0.615	0.150	0	0.500	1.000
Over shrubs	0	0	0	0	0	0	0	0.600	1.000	0	0
Under fallen trunks	0	0.500	0	0	0	0	0	0	0	0.500	0
Over fallen trunks	0	0.500	0	0	0	0	0.385	0.250	0	0	0
Over fallen shrubs	0	0	0	0	0.500	1.000	0	0	0	0	0
DS	0	0.25	0	0	0.25	0	0.22	0.31	0	0.25	0

Table 3. Relative occurrence of species for each recognized substratum at El Mogote.
Presencia relativa de especies para cada sustrato reconocido en El Mogote.

	Species						
Substratum	C.v.	D.d.	C.d.	S.z.	U.s.	P.c.	C.h.
Sandy Soil	1.0	1.0	1.0	0	0.600	0	0
Under fallen trunks	0	0	0	0	0.050	1.00	0
Over fallen trunks	0	0	0	0	0.125	0	0
Over fallen branches	0	0	0	1.00	0.050	0	1.000
DS	0	0	0	0	0.54	0	0

Table 4. Microhabitat niche overlap values among species at El Comitán (lower part of the table), and microhabitat niche overlaps among species at El Mogote (upper part of the table). * indicates the species pair that do not co-occur in this study site.
*Valores de solapamiento de nichos entre especies en El Comitán (abajo en la tabla) y solapamiento de microhábitat entre especies en El Mogote (arriba en la tabla). * indica las parejas de especies que no coexisten en esta zona de estudio.*

	Species										
Substratum	C.v.	P.u.	D.d.	C.d.	S.m.	S.z.	U.s.	U.n.	C.h.	P.c.	C.h.
C. variegatus	–	*	1.0	1.0	*	0	0.97	*	*	0	0
P. unctus	0	–	*	*	*	*	*	*	*	*	*
D. dorsalis	1.0	0	–	1.0	*	0	0.97	*	*	0	0
C. draconoides	1.0	0	1.0	–	*	0	0.97	*	*	0	0
S. monserratensis	0.70	0	0.70	0.70	–	*	*	*	*	*	*
S. zosteromus	0	0	0	0	0.70	–	0.08	*	*	0	1.0
U. stansburiana	0.84	0.37	0.84	0.84	0.60	0	–	*	*	0.08	0.08
U. nigricaudus	0.22	0.27	0.22	0.22	0.17	0	0.39	–	*	*	*
C. hemilopha	0	0	0	0	0	0	0	0.89	–	*	*
P. coronatum	0.70	0.50	0.70	0.70	0.50	0	0.60	0.17	0	–	0
C. hyperythrus	1.0	0	1.0	1.0	0.70	0	0.84	0.22	0	0.70	–
O_{jk} El Comitán	0.55	0.11	0.55	0.55	0.48	0.07	0.53	0.28	0.09	0.46	0.55
O_{jk} El Mogote	0.34	*	0.34	0.34	*	0.10	0.53	*	*	0.01	0.18

of the zone are specialist in the use of only one kind of microhabitat.

Spatial niche overlap values are shown in table 4. Approximately half of the 55 species pairs at El Comitán show high values (>0.60), and half low values (ranging from 0 to 0.27). Thus, the average overlap for each species, in relation to all of the others, is never greater than 0.60. On the other hand, one third of the niche overlap values among El Mogote species exhibit very high values (table 4) ranging between 0.97 and 1.

From table 5, it can be observed that the El Comitán study site is more complex and diverse than El Mogote: floristic richness, main vegetation structural features, as well as the substrate resource availability are significantly different between the two study sites ($\chi^2 = 354.89$; d.f. = 9; $p < 0.001$).

Table 5. Substratum resource availabity and structural features of the two study sites.
Disponibilidad de recursos del sustrato y características estructurales de las dos zonas de estudio.

	El Comitán	El Mogote
Loam-Sandy soil cover (%)	48.00	0
Sandy soil cover (%)	0	52.20
Fallen trunks cover (%)	7.40	0
Herbaceus plant cover (%)	4.00	29.80
Shrub cover (%)	34.40	18.00
Tree cover (%)	6.20	0
Average herbaceous height (cm)	129.34	56.67
Average tree height (cm)	400.08	0
Plant species number	18	8

DISCUSSION

At the El Comitán study site four species, *Dipsosaurus dorsalis, Callisaurus draconoides, Cnemidophorus hyperythrus,* and *Sceloporus zosteromus,* were relatively specialized in the use of only one kind of microhabitat. Thus, 0.45 % of the species of this guild seems to be specialists in the use of the substrate. Furthermore, three of the eleven species (27 %) used only loam-sandy soil.

At the El Mogote study site the same highly specialized species found at El Comitán exhibited their characteristic behavior: they used only one kind of substrate. At El Mogote three of the seven species of the guild (43 %) used the same kind of substrate, but in this case it was sandy soil.

If the microhabitat availability at the two study sites is analyzed some interesting patterns emerge. At El Mogote the main kind of substrate available is open sandy soil. This substrate is used mainly by three species; *Coleoyx variegatus, Dipsosaurus dorsalis* and *Callisaurus draconoides.* However, individual numbers are high only for *D. dorsalis* and *C. draconoides.* Only two of the six species that use exclusively loam-sandy soil at El Comitán are numerically abundant, *Cnemidophorus hyperythrus* and *Dipsosaurus dorsalis.*

Although *D. dorsalis* seems to use sandy and loam-sandy soils equally, important differences exist among the other species. For example *C. hyperythrus* is more closely linked to loam-sandy soils and *C. draconoides* to sandy soils, as deduced from the data on it's densities at both sites.

In the specific case of *Dipsosaurus dorsalis,* its apparent indiscriminant use of substrate and its herviborous diet, probably enables it to coexist —even in relatively high densities— with other insectivorous lizards, such as *C. hyperythrus* and *C. draconoides.*

The total average overlap among species is greater at El Comitán ($O_{jk} = 0.38$) than at El Mogote ($O_{jk} = 0.26$). However, this difference is not significative ($t = 0.576$; d.f. = 16; $p > 0.05$). This could support the idea that microhabitat resource availability and complexity play a key role in the ecological organization of both guilds: the microhabitat overlap is similar in both study sites, thus the habitat that offers higher possibilities for the species to elude the direct competition (where the habitat and microhabitat features are more complex and the substrate availibility is more diverse) shows also higher lizard diversity and density.

As it has been outlined previously by several authors (BARBAULT et al., 1985; ORTEGA et al., 1982) the specifity of the lizards in the use of one kind of sustrate is not necessarily a competitive induced strategy. The inclusive fitness of a lizard species depends on the optimal use of adequate places for thermoregulation, predator avoidance and foraging. Thus, the evolution of microhabitat selection probably depends on more than the pressures imposed by the interspecific competition.

Certainly a lot of experimental work remains to be done to elucidate the effects and consequences of microhabitat use and its impact on the interspecific relationships of each studied guild, as well as to include other study sites and different seasons. However, it can be said that most of the lizards studied in this work are specific in the use of one substrate and thus this specifity of use of the space in interaction with the habitat and microhabitat complexity and availibility could be a key factor to understand their species diversity and density of both guilds.

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RESUMEN

Posibles efectos de la disponibilidad del microhábitat sobre la diversidad y densidad de lagartos en Baja California Sur.

En este trabajo se han analizado y comparado las preferencias en cuanto a microhábitat en dos comunidades de diversas especies de lagartos. Dichos grupos, que presentan varias especies endémicas, están localizados en El Comitán y El Mogote, en las cercanías de La Paz (Baja California Sur, México).

El Comitán muestra un hábitat de tierras bajas costeras con suelos de arenas migajonosas y vegetación predominante de variados arbustos xerofíticos, mientras que El Mogote posee un sustrato compuesto de dunas de arena y su principal vegetación son arbustos dispersos por toda la zona.

Se determinó la estructura de la vegetación y la asequibilidad del microhábitat, se estimó la diversidad de especies en cada comunidad y se calculó el uso por especies de los recursos espaciales utilizando los métodos de Simpson, se midieron los solapamientos espaciales de nichos entre especies según el exponente de Pianka y se analizaron las diferencias en la utilización del microhábitat entre las especies de los dos grupos por el test de Wilcoxon y entre los dos emplazamientos estudiados según el test de X^2.

Se han encontrado importantes diferencias entre los dos grupos en diversidad de especies, densidad de población, amplitud de nicho y solapamientos espaciales. Mayor diversidad, densidad y solapamiento estaban asociados a una mayor complejidad de las características del microhábitat y mayor diversidad del sustrato disponible. Generalmente especies diferentes usaron distintos segmentos del sustrato, exceptuando las que comparten los suelos arenosos. Se ha tratado por último el efecto del uso de los recursos espaciales en las estructuras de los grupos de lagartos.

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