# LIZARD SPATIAL ORGANIZATION and HABITAT PARTITIONING in LA SIERRA DE GUADARRAMA, SPAIN

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## ABSTRACT

During the summer of 1984, the spatial structure of a mountain lizard assemblage, located at la Sierra de La Guadarrama in Spain, was studied. The assemblage is composed of six abundant species. The habitst partitioning and microhabitat specialization of these species show that the differential use of spatial resources establishes a clear separation among most of the species. Regarding the habitat partitioning, the assemblage appears to be spatially subdivided into two categories: those species restricted to almost a single habitat, and those widely distributed along several habitat types. Among the latter subset of species, it is possible to further differentiate among the species restricted to the ground and those specializing in the use of rocks; and finally, there exists among the latter species differences in the size of the rocks used. The ecological meaning of this differential spatial use is discussed.

## INTRODUCTION

Lizards are generally the most abundant diurnal vertebrates in a variety of ecosystems (Mou and Barbault, 1986; Pianka, 1973; Schoener, 1968). For this reason and because they can be easily studied in the field and laboratory, lizards are model organisms in many works accomplished in modern ecology (Fuentes, 1976; Huey and Pianka, 1977; Pianka, 1966; Simon, 1976).

Spatial segregation presumably is one of the most important factors in minimalizing the actual or potential competition among sympatric species, and also one of the dominant factors in organizing natural guilds and communities (Barbault, 1985; McArthur and Pianka, 1966; Schoener, 1974).

In spite of these facts, relatively few studies have been done concerning the spatial organization of lizard assemblages in Spain (Mellado, 1980; Mellado et al., 1975).

In this paper the spatial structure, both at habitat and microhabitat level, of a Spanish lizard assemblage is analyzed as a first step to deal with more detailed studies. The work accomplished may enable us to elucidate the role played by spatial relationships in the organization of locally well-defined communities.

## MATERIALS AND METHODS

### The Study Area.

The field work was carried out along an altitudinal gradient ranging from 900 to 2200 m, at la Sierra de Guadarrama on the southern slopes of the el Sistema Central, toward the

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north of Madrid, Spain. The climate varies along the altitudinal gradient (Gandullo *et al.*, 1976) from typical mediterranean at the lower parts, to characteristic high-mountain climate in the upper parts, which comprises 5 months with minimal temperatures under 0 degrees C, and 1,033 mm of annual precipitation, concentrated in two peaks: April and November. Geologically the area lies on igneous and metamorphic rocks, mainly granites and gneiss (Gandullo, 1976).

There are four physiognomic-floristic unities at the zone (Ruiz del Castillo, 1976): the Piso Basal, a mediterranian forest with jara pringosa (*Cistus ladaniferus*), encino (*Quercus ilex*), fresno (*Fraxinus angustifolia*) and enebro (*Juniperus oxicedrus*) as the main species; the Piso Montano, a forest with encino (*Quercus pyrenaica*) as the dominant species, accompanied by enebro (*Juniperus communis*) and escobon (*Sarothanus vulgaris*); the Piso Subalpino, a pine forest dominated by pino (*Pinus silvestris*), accompanied by piorno (*Cytisus purgans*), enebro (*Juniperus communis*), *Sambucus nigra* and *Pteridium aquilinum*; uppermost is the Piso Alpino with piorno (*Cytisus purgans*) as the only species.

## The Species.

The lizard assemblage of the zone contains six abundant species which were studied during this work, the lacertids: *Lacerta monticola*, *L. lepida*, *Podarcis hispanica*, *P. muralis*, *Psammodromus algirus*, and *P. hispanicus*.

Although most of the species involved in this study are insectivorous, *Lacerta lepida* could also be considered a vertebrate-eater (Salvador, 1974).

## Methods.

The four types of vegetation considered in this study were systematically searched for lizards from June to August, 1984. For each lizard observed the following data were recorded: species, hour, habitat and microhabitat or substrate. Five types of microhabitat were recognized: ground, ground under vegetation, small rocks (<50 cm in diameter), median-sized rocks (>50 cm and <100 cm) and large rocks (>100 cm). Habitat and microhabitat niche breadth were calculated using the diversity measure of Simpson (Levins, 1968): $B = (pi^2)^{-1}$, where pi is the proportion of individuals found in the $i^{th}$ substrate or habitat. A standardized measure, Bs, was also calculated to range between 0 (only one sort of habitat used) to 1 (equipartition over all the habitats): $Bs = \frac{B-1}{N-1}$

where N is the number of kinds of microhabitats considered.

Microhabitat niche overlaps between species were measured using Pianka's index (Pianka, 1973):

$$Ojk = \frac{\Sigma Pij \quad Pik}{\sqrt{\Sigma Pij^2 \quad \Sigma Pik^2}}$$

Where Pij and Pik are the frequencies of utilization of the $i^{th}$ microhabitat by, respectively, the $j^{th}$ and $k^{th}$ species.

As emphasized by Ricklefs and Lau (1980), there are not simple statistical methods for calculating the confidence limits of such estimates, but this lack did not impede the discussion of the obtained results.

## RESULTS

### Habitat Distribution:

Among the species recorded in the area, four, *Podarcis hispanica*, *Psammodromus algirus*, *P. hispanicus* and *Lacerta lepida*, are widely distributed, whereas the other two, *Podarcis muralis* and *Lacerta monticola* appear generally limited to a single habitat, the Piso Subalpino for the former and the Piso Alpino and upper parts of the Piso Subalpino for the latter (Table I).

Habitat results are summarized by calculating the spatial niche width for each species (same Table I) and plotting their observed range in Figure No. 1.

The overlap values of the habitat niche among the studied species are relatively low for two of them (Table II): *Lacerta monticola* and *Podarcis muralis*, whereas they are relatively high for the other species.

### Microhabitat Use:

To more precisely analyze the data, the use of the various microhabitats or substrates by these species is also presented (Table III). Only *Lacerta lepida* appears restricted to a well defined category of microhabitat, and to a

Table I.- Number of individuals by species occupying each recognized habitat, and their standardized spatial niche breadth (Bs).

| Species<br>Habitat | L. monticola | L. lepida | P. hispanica | P. muralis | P. algirus | P. hispanicus |
|---|---|---|---|---|---|---|
| Piso basal | 0 | 11 | 184 | 0 | 108 | 127 |
| Piso montano | 0 | 21 | 228 | 0 | 162 | 84 |
| Piso subalpino | 104 | 6 | 116 | 283 | 69 | 30 |
| Piso alpino | 264 | 0 | 0 | 28 | 0 | 0 |
| Totals | 368 | 38 | 528 | 311 | 339 | 241 |
| Bs | 0.22 | 0.48 | 0.61 | 0.06 | 0.57 | 0.46 |

lesser degree so does Psammodromus hispanicus. The other four species appear as poorly specialized to any microhabitat category. For this reason, microhabitat overlap values are relatively high among several pairs of species (Table IV). Such is the case of Lacerta monticola with Podarcis muralis and Podarcis hispanica, and of the latter species with Podarcis muralis.

Spatial Structure:

Assuming that the overlap values of spatial niches at the level of habitat and microhabitat utilization are independent measures, then mean spatial overlap values among the paired-species were calculated as the product of these two indices (Table V).

The only large overlap value recorded was between Psammodromus algirus and P. hispanicus (0.81), with all other mean measures among species around a mean of 0.50.

## DISCUSSION

This descriptive study of the general patterns of spatial use, at the levels of habitat and microhabitat, in this lizard assemblage of la Sierra de Guadarrama points out some features that deserve further attention.

Regarding habitat partitioning, the overall assemblage appears to be spatially subdivided into two categories: on the one hand, those species restricted to almost a single habitat, such as Podarcis muralis in the Piso subalpino and Lacerta monticola in the Piso alpino, and, on the other hand, those species that are widely distributed along two or three habitat types.

Among the latter subset of species it is possible to further differentiate two groups of species: those restricted to the ground, including Psammodromus algirus and P. hispanicus, and those restricted to the use of the rocks: Podarcis hispanica and Lacerta lepida.

Podarcis hispanica and Lacerta lepida are further ecologically separated by their differential utilization of microhabitats: L. lepida shows a preference for larger rocks. Both ground-dwelling species, Psammodromus algirus and P. hispanicus show high overlap values, both at habitat (0.91) and microhabitat (0.70) levels. Out of the six species studied these are the only pair that are not clearly separated by spatial differentiation. Their separation could probably be achieved, however, by the different body size of these lizards, a difference that could expose them to

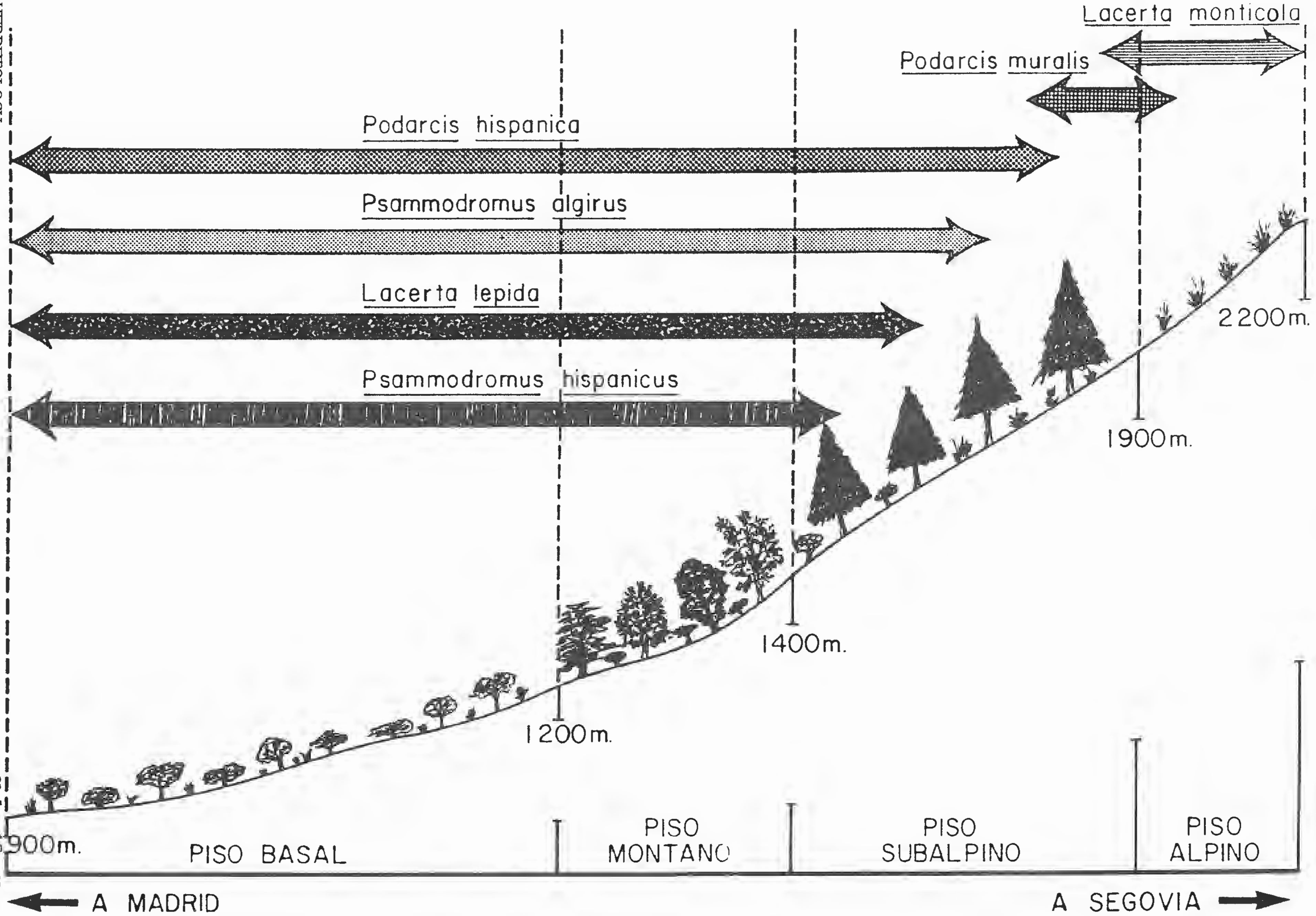

FIG. 1. - Lizard species distribution by habitat along the topographic gradient.

a different spectrum of food items. This hypothesis, however, remains to be tested by the study of stomach contents.

The results of this study agree with those obtained in many other lizard assemblages (Barbault and Grenot, 1977; Jenssen, 1973; Lister, 1976; Mellado et. al., 1975; Ortega, et. al., 1982; Pianka, 1966; Schoener, 1977; Simon, 1976.): differential utilization of the spatial resources is sufficient to separate most of the species in each specific guild.

However, because lizards strongly depend on close substrate adaptation to avoid predators, to thermoregulate efficiently, and to be successful in mating and defending territory, such specializations are not necessarily nor likely a competitively-induced phenomenon as has previously been discussed (Barbault, et. al., 1985; Ortega, et. al., 1982). Thus, the substrate selection that these species show may be a response evolved to cope with a complex combination of various selective pressures, and not only with the pressure exerted by interspecific competition (Ortega et. al., 1982).

In spite of this line of reasoning, the possibility of high diffuse competition between both *Psammodromus* species remains to be studied. First, both species (being of the same genus) are, logically, highly taxonomically related and by this reason the pressures exerted by interspecific competition could be high (Barbault, 1981; Pianka, 1977). Secondly, the species with greater body size (*P. algirus*) is not only the most widely distributed of both at the habitat level, but also this species apparently is rather more abundant than *P. hispanicus* (pers. observ.). Generally in the case of lizards, body size is the main feature that determines the dominance hierarchies among species (Gutierrez, 1983).

Thus, the competitive pressures exerted by *P. algirus* over *P. hispanicus* could exclude the smaller lizard from several parts of the habitat (for example the upper and median parts of the Piso Subalpino) and also maintain it at low population levels. However, the only way to firmly assess this competitive effect between the two *Psammodromus* species is to experimentally excluse *P. algirus* from several areas of the zone and observe the population response of *P. hispanicus*, an experiement which remains to be done.

Although this study does not allow us to draw definite conclusions about the ecological forces involved here, it does show the importance of habitat and microhabitat partitioning in the structuring of this mountain lizard assemblage.

Table II.- Habitat overlap values among the six species studied.

| | *L. monticola* | *L. lepida* | *P. hispanica* | *P. muralis* | *P. algirus* | *P. hispanicus* |
|---|---|---|---|---|---|---|
| *L. monticola* | - | | | | | |
| *L. lepida* | 0.08 | - | | | | |
| *P. hispanica* | 0.13 | 0.98 | - | | | |
| *P. muralis* | 0.45 | 0.26 | 0.35 | - | | |
| *P. algirus* | 0.13 | 1.00 | 1.00 | 0.32 | - | |
| *P. hispanica* | 0.06 | 0.89 | 0.94 | 0.19 | 0.91 | - |
| Ojk | 0.17 | 0.64 | 0.68 | 0.31 | 0.67 | 0.60 |

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Table III.- Mean standardized microhabitat niche breadth (Bs) and proportion of individuals occupying each recognized substrate per species.

| Species<br>Substrate | *L. monticola* | *L. lepida* | *P. hispanica* | *P. muralis* | *P. algirus* | *P. hispanica* |
|---|---|---|---|---|---|---|
| Open Ground | 0.17 | 0.05 | 0.14 | 0.16 | 0.62 | 0.27 |
| Ground with vegetation | 0 | 0 | 0 | 0 | 0.24 | 0.63 |
| Small rocks (< 50 cm) | 0.18 | 0 | 0.44 | 0.30 | 0.11 | 0.10 |
| Mid-sized rocks (> 50 cm < 100 cm) | 0.49 | 0.08 | 0.33 | 0.40 | 0.03 | 0 |
| Large rocks (> 100 cm) | 0.16 | 0.87 | 0.09 | 0.14 | 0 | 0 |
| N | 368 | 38 | 528 | 311 | 339 | 241 |
| Bs | 0.51 | 0.07 | 0.51 | 0.58 | 0.40 | 0.27 |

Table IV.- Microhabitat niche similarity values among the six species studied.

| | *L. monticola* | *L. lepida* | *P. hispanica* | *P. muralis* | *P. algirus* | *P. hispanicus* |
|---|---|---|---|---|---|---|
| *L. monticola* | - | | | | | |
| *L. lepida* | .38 | - | | | | |
| *P. hispanica* | 1.00 | 0.22 | - | | | |
| *P. muralis* | 0.95 | 0.33 | .95 | - | | |
| *P. algirus* | 0.42 | 0.06 | 0.38 | 0.38 | - | |
| *P. hispanicus* | 0.15 | 0.02 | 0.20 | 0.18 | 0.70 | - |
| Ojk | 0.58 | 0.20 | 0.55 | 0.56 | 0.39 | 0.25 |

Table V.- Mean spatial niche overlap values among the paired species.

| | *L. monticola* | *L. lepida* | *P. hispanica* | *P. muralis* | *P. algirus* | *P. hispanicus* |
|---|---|---|---|---|---|---|
| *L.monticola* | - | | | | | |
| *L. lepida* | 0.23 | - | | | | |
| *P.hispanica* | 0.57 | 0.60 | - | | | |
| *P. muralis* | 0.70 | 0.30 | 0.65 | - | | |
| *P. algirus* | 0.28 | 0.53 | 0.69 | 0.35 | - | |
| *P. hispanicus* | 0.11 | 0.46 | 0.57 | 0.19 | 0.81 | - |
| Ojk | 0.38 | 0.42 | 0.62 | 0.44 | 0.53 | 0.43 |

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