ACTA ZOOL. CRACOV. | 33 | 1 | 3—10 | KRAKÓW, 30. IX. 1990

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Habitat selection in *Psammodromus algirus* (LINNAEUS, 1758) (*Sauria*: *Lacertidae*): age related differences

Dobór środowiska u *Psammodromus algirus* (LINNAEUS, 1758) (*Sauria*: *Lacertidae*): różnice związane z wiekiem

Abstract. Habitat selection in adult and juvenile *Psammodromus algirus* was studied along a Mediterranean successional gradient in southwestern Iberia. Both age classes showed patterns of habitat selection which differed significantly from a random survey of the habitat. These patterns were different in the two age classes. Juveniles occupied less wooded microhabitats with a denser low vegetation. Some morphological parameters thought to be related to habitat-use were measured; these did not differ between adults and juveniles. The biological meaning of the observed differences is discussed: intraspecific hostile interactions and predator avoidance are though to be involved, rather than thermal requirements.

I. INTRODUCTION

Several studies of age dependant variation in habitat selection have been made in lizards, including the families *Iguanidae* (COLLETTE 1961; SCHOENER 1967; JENSSEN 1970; DAVIES and VERBEEK 1972; RUIBAL and PHILIBOSIAN 1974; MOERMOND 1979; FOX 1983; STAMPS 1983a and 1983b), *Teiidae* (SCHALL 1974) and *Agamidae* (BRADSHAW 1971). The observed differences among various populations segments were attributed to morphology-determined differences in the required structure of the environment (MOERMOND 1979), different thermal requirements (STAMPS 1983a and 1987), vulnerability to predation (STAMPS 1983b) or intraspecific competition (BRADSHAW 1971; SCHALL 1974; FOX 1983).

The aim of this paper is to analyze the habitat selection and spacing patterns of a Mediterranean species of *Lacertidae*, a family which has received little attention in this sense (see STAMPS 1977 for a review). The animal of choice is *Psammodromus algirus* (LINNAEUS, 1758), a fairly abundant but little known lizard (though see MELLADO 1980 and review by BÖHME 1981) inhabiting the Mediterranean shrublands and forests of the Iberian Peninsula. We consider whether if there are differences in habitat selection between juvenile and adult *P. algirus*, and we examine the ecomorphological, thermoregulation and social interaction hypotheses in order to suggest an explanation for the observed pattern of habitat choice.

We acknowledge Prof. F. Bernis for the translation of German bibliography and Dr. Tomás Santos for helpful comments on a previous draft of the manuscript. This paper is a contribution to the project „Biology and Distribution of Iberian Forest Vertebrates" founded by the Spanish Agencia Nacional de Evaluación y Prospección (project PB86-0006-C02).

II. MATERIAL AND METHODS

Habitat selection was studied along a habitat gradient in the coast of Cádiz, southwestern Spain (Chiclana de la Frontera, 30°26'N 00°09'W). The gradient consisted of a well defined series of forest succession stages including a cleared pine forest of *Pinus pinea* and *Quercus suber*, a Mediterranean shrubland of *Cistus* spp. and *Halimium* spp., a xerophyte grassland and a sand dune area with bushes of *Juniperus phoenicia*. For a more detailed description of the physical structure of the study area, see the values of R (random survey) in Table I.

Sampling was performed by walking in a randomly chosen direction for seven hours each morning and afternoon in April 1985. Since in this species hatching takes place in late summer and early autumn (Salvador 1985), each

Table I

Substrate and plant cover percentages (mean and standard deviation) for juvenile and adult *Psammodromus algirus* vs random (R) survey of the habitat

	Juveniles		Adults		R	
Variables	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
CS Cover of sand	31.7	29.7	35.1	35.9	50.2	40.2
CL Cover of litter	74.3	27.1	69.1	35.2	46.7	37.4
CO Plant cover at the ground level	55.9	28.8	46.4	27.3	34.7	27.4
C5 Plant cover at 5 cm above the ground	60.2	21.2	56.0	25.1	52.0	29.4
C10 Plant cover at 10 cm above the ground	49.1	20.2	45.2	23.5	42.0	26.0
C30 Plant cover at 30 cm above the ground	23.3	17.4	23.2	17.6	22.6	17.7
C50 Plant cover at 50 cm above the ground	12.2	12.0	11.9	12.4	11.5	12.2
C70 Plant cover at 70 cm above the ground	6.5	8.4	6.1	7.8	5.5	7.8
CT Cover of trees	20.9	30.0	25.7	30.5	12.6	25.8
CH Cover of herbs	67.8	24.8	58.8	26.0	53.6	30.5
CJ Cover of *Juniperus phoenicia*	1.7	6.9	4.1	12.2	3.3	8.6
CB Cover of bushes (*Cistus and Halimium*)	43.3	25.3	36.9	23.7	32.8	32.5
Number of samples	(27)		(44)		(113)	

lizard observed was assigned to one of the two following age-classes: juveniles (those born in the last breeding season) and individuals older than one year.

When a lizard was first observed, two orthogonal ten metres transects were examined, intersecting at the point of initial sighting. The presence of the habitat attributes listed in Table I was noted, with a stick scored at different heights, at 1m-intervals. This survey method provided an overall picture of habitat structure, composed of 20 sample points per lizard observation, that allowed the calculation of substrate and plant cover percentages. The same sampling design was employed at 113 randomly chosen spots that were used for comparison between availability and actual utilization of spatial resources. This sampling method is similar to the point-centered method used in studies of bird habitat selection (see for instance JAMES and SHUGART 1970; NOON 1981; and RATTI et al. 1984) and to those employed by REAGAN (1974), and SCHEIBE (1987) with different reptilian taxa.

Morphological data were obtained from alcohol-preserved specimens deposited at the Museum of Vertebrate Zoology of the School of Biological Sciences at the Universidad Complutense of Madrid. The variables considered were snout-vent length, tibia length and tail length (the later was only measured on animals with unregenerated tails). Since the measurements of the limbs could not be taken from the bones, we adopted the criteria followed by MOERMOND (1979) in his ecomorphological analysis of *Anolis* lizard communities. To avoid body size effects, biometrical variables were standardized by considering their relative proportions (see MOERMOND 1979 for a similar approach and JAMES and McCULLOCH 1985 for a general discussion).

In the statistical handling of data the t-test for means was used; though we did not find habitat-use differences between adults and juveniles, this result is interpreted as a consequence of the scarce sensibility of this test in the analysis of intraspecific differences, since population segments of a single species are expected to have similar basic ecological requirements. In addition, and despite the reasonably high available sample sizes ($n = 27$ for juveniles and $n = 44$ for adults), the high variance values produce an undesirable increase in the magnitude of type II error. Therefore, we have employed a different statistical design based on the comparison of both age classes with the series of data obtained by random sampling ($n = 113$), which can be regarded as an „ecological constant" (habitat availability) with a very low standard error. This design thereby evaluates habitat selection (use vs availability) in juveniles and adults.

III. RESULTS

T-test comparisons between mean cover values of both adults and juveniles vs random sampling (Table I) were used to identify the main trends in habitat selection. Table II shows that the species as a whole selects its position along the habitat gradient: nine out the 24 t-test performed reflect differences between availability and actual utilization of habitat variables at a significance level of 0.05, a number which is significantly higher (G-test, $p < 0.001$) than the one expected at random ($5 \times 24/100 = 1.2$).

Adult and juvenile lizards share a strong positive selection for microhabitats with a high percentage of litter cover and plant cover at the ground level (see table II). Aside from these features, there are marked differences (sometimes with one of the t-test results being non-significant and the other significant at $p < 0.01$) between the within-habitat distribution patterns of adults and juveniles. The latter differs from the former in not showing a strong selection for wooded areas and in positively selecting areas with high plant cover five and ten cm above the ground, high cover of herbs and high cover of *Cistus* and *Halimium* shrubs (Table II). Since there are no significant differences between the variances of both age-classes associated with tree cover (F-test, $p > 0.1$), it can be stated that juvenile *P. algirus* suffer a shift towards unwooded areas without increasing their spatial niche breadth. Juveniles therefore occupy relatively less wooded microhabitats with a denser vegetation of herbs and shrubs five and ten cm above the ground.

Table II

T-test comparison between mean percentages of available substrate and plant cover (random sampling) and actual patterns of habitat-use by juvenile and adult *P. algirus*; symbols of variables as in Table I. +: p 0.05; ++: p 0.01; +++: p 0.001

	CS	CL	CO	C5	C10	C30	C50	C70	CT	CH	CJ	CB
Juveniles	ns	+++	+++	+	+	ns	ns	ns	ns	++	ns	+
Adults	ns	+++	++	ns	ns	ns	ns	ns	++	ns	ns	ns

Although little is known about allometry in lacertids, it would be reasonable to suspect that anatomical structures related to locomotion (e.g., limbs or limb segments) could change their relative proportions during growth, thus enabling their owners to undergo a spatial segregation of age classes that would facilitate intraspecific resource partitioning. Nevertheless, from the results

Table III

Morphological comparison of juvenile and adult *P. algirus* (morphological ratios modified from MOERMOND 1979)

	Juveniles			Adults			t-tests
	$\bar{x}$	SD	n	$\bar{x}$	SD	n	p
Hindleg: snout-vent	0.32	0.021	15	0.32	0.019	15	0.99
Tibia: femur	0.86	0.060	15	0.84	0.057	15	0.20
Humerus: femur	0.76	0.047	15	0.74	0.051	15	0.20
Tail: snout-vent	2.38	0.171	12	2.40	0.229	13	0.50

of t-tests comparisons shown in Table III it is made clear that there are no significant differences between adults and juveniles in any of the morphological parameters considered (i.e. hind leg length relative to snout-vent length, tibia relative to femur, humerus relative to femur and tail relative to snout--vent length; see MOERMOND 1979 for an ecomorphological interpretation of these ratios). It can therefore be concluded that the functional relationship between morphology and habitat-use does not determine the observed shift of juvenile lizards towards areas with lower, more open vegetation.

IV. DISCUSSION

Previous research (see HEATWOLE 1977 for a review) has identified at least two potentially important factors for habitat-selection in reptiles: physical structure of the environment and microclimate. Habitat structure is relevant because, given a particular morphology, the geometric arrangement of the environment determines its suitability for foraging and locomotion (PIANKA and PIANKA 1976; PIANKA 1979; MOERMOND 1979). Nevertheless our results indicate a complete lack of ontogenetic change in morphology between juvenile and adult lizards, thus leaving unexplained the observed shift in habitat selection with age.

Similarly, homesite selection by juvenile *P. algirus* is apparently not related to the thermal environment, since thermoregulatory patterns seem to be fairly constant over a wide range of body sizes. Thus, circadian activity rhythms of juvenile and adult *P. algirus* are indistinguishable on a round year basis in a Mediterranean holm-oak wood (CANO 1984), and neither the basking frequency nor the relationship between the body and ambient temperatures show statistical differences associated with age or body size (DIAZ 1988).

An alternative explanation of the observed distribution pattern is that microhabitat differences could be the result of social interactions, with dominant adult lizards excluding juveniles from optimal quality homesites. According to the model of lizard spacing pattern postulated by STAMPS (1977), such dominance relationships are expected to occur among lacertid species under conditions of poor visibility (a characteristic of Mediterranean forests and shrublands) and local clumping (caused by the tendency of *P. algirus* to concentrate around the vegetation patches). The aggressiveness of adult lizards towards their smaller conspecifics is furtherly proved by the fact that they occasionally eat juveniles of their own species (MELLADO 1980). In addition, we have observed fleeing reactions in experimental enclosures, smaller males (subordinates) being displaced by larger ones (dominants) in almost every case. If we accept the influence of social hierarchies on the within-habitat distribution of the species, then the differences in body weight must be essential in determining the outcome of hostile interactions (WALLACE 1987) and hence the distribution patterns of both population segments.

The available data (VALVERDE 1967) indicate that *P. algirus* is an important prey item for many visually-guided predators in Mediterranean food chains, suggesting that a displacement towards open areas would be associated with higher predation risks. *Falco tinnunculus* and *Lanius excubitor* were present in the study area, as well as other possible predators mentioned by VALVERDE (1967). Escape speed is lower in juveniles due to their smaller body size (pers. obs.; see STAMPS 1983a; and AVERY et al. 1987). This would imply that the occupation of denser vegetated areas at the ground level (see Results and Table II) could reflect a search for predator-refuges where juveniles would be less detectable (see STAMPS 1983b for a related experiment with *Anolis aeneus*).

The foregoing arguments suggest that agonistic interactions seem to be involved in the observed habitat shift between juvenile and adult *P. algirus*, rather than ontogenetic differences in habitat selection patterns (see HEATWOLE 1977 for a similar conclusion).

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