Bulgarian Journal of Agricultural Science, 20 (No 6) 2014, 1386-1391
Agricultural Academy

MICROHABITAT USE IN SAND LIZARD - *LACERTA AGILIS CHERSONENSIS* (SQUAMATA, LACERTIDAE) AS AN INDICATOR FOR PLANNING OF DIFFERENT MANAGEMENT PRACTICES FOR PASTURES

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Abstract

GROZDANOV, A. P., N. D. TZANKOV, C. ANDRES and S. G. POPOVA, 2014. Microhabitat use in Sand lizard - *Lacerta agilis chersonensis* (Squamata, Lacertidae) as an indicator for planning of different management practices for pastures. *Bulg. J. Agric. Sci.*, 20: 1386-1391

Microhabitat selection is an important tool for spatial segregation among sexes and age classes in lizards. This study explored the microhabitat use in both sexes of *Lacerta agilis chersonensis* at different ontogenetic stages in order to test the generalist/specialist hypothesis already stated to be valid for this species. The study area situated in the Sofia plain, Western Bulgaria includes five isolated polygons. Both sexes were separated into groups according to age class. A total of 68 specimens were studied (18 adult and 16 juvenile females, 20 adult and 14 juvenile males). For every specimen microhabitat characteristics at 100 square meters around the observation point were recorded and classified into the next categories: grass density (4 classes), grass height (3 classes), presence/absence of country roads, trees, shrubs, stones and artificial shelters. Multivariate analyses by means of correspondent analyses well separated the four designated groups. Males were mostly found in the microhabitats with shrubs and tall/dense grasses. Females were affiliated to a microhabitat with lower height and density of grasses than males and commonly used artificial shelters. A clear segregation among sexes at their juvenile stage was also demonstrated. Grass height and density seem to be important parameters for microhabitat selection of the different age-sex classes. The present research confirms the sand lizard as an important indicator species for estimating of pasture habitats quality according to the proved selection of grass with different density and height and other microhabitat elements. The species could be used as indicator of changes in the land use and should be treated as vulnerable from human activities. The presented information could be implemented in planning of different management regimes for the pastures as one of the most important agricultural habitats and at the same time natural environment of many protected or endangered species.

Key words: habitat selection, pastures management, Sand lizard

Introduction

Community structure in terms of niche concept (Hutchinson, 1959) and evolution of life-history tradeoffs, e.g. r versus K selection (MacArthur and Wilson, 1967) have been related in recent decades to competition (Calsbeek, 2009). Competition remains a fundamentally important topic in community ecology (Tilman, 1994). The habitat selection in vertebrates is not a random process. Intraspecific competition may force subordinate individuals to accept poorer quality habitats, but the highest settling densities are nonetheless expected in the best habitats (Orians, 2000). Many factors affect the distribution of reptiles within the habitat, but climate and topography are of major importance (Gusian and Hofer, 2003). Although the sand lizard (*Lacerta agilis* Linnaeus, 1758) is one of the most widespread reptile species in the Western Palearctic and occupies a variety of habitats – from sand dunes on sea level to subalpine meadows (Yablakov, 1976; Bischoff, 1984) there is only few works towards the interspecific microhabitat choice. The influence of the vegetation changes on the sand lizard's habitats was studied at northern edge of the species distribution (Jackson, 1979; Dent and Spellerberg, 1987; Berglind,

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1995). Relationship between vegetation height and lizards abundance was studied by Gland (1991). Furthermore Märtens et al. (1996, 1997) investigated the most important microhabitat factors for sand lizard's distribution. The interactions between habitat characteristics and ecological density of this species were researched by Török (1988, 2002) and the interference between individuals by Amat et al. (2003). The microhabitat characteristics of the different age classes were studied by Nemes et al. (2006). The sand lizard has unfavorable conservation status in many European countries. The species is object of protection and special action plan in Northwestern Europe (Anonimous, 2006). In England the sand lizard is used as an indicator species for the quality of pasture habitats. The lack of in-depth researches of the species habitat selection in Bulgaria until present gives no scientific arguments to focus on the species role as indicator for meadows and pastures quality, respectively for recommending of adequate management measures and best agro ecological practices.

The present research is focused on the interspecific microhabitat use of the subspecies *L. a. chersonensis* Andrzejowski, 1832 from its southernmost edge populations. The taxon represents well-defined phylogenetic entity (Kalyabina-Hauf et al., 2004) and is insufficiently researched in general. Studying the habitat preferences could be of interests for revealing the ecological constraints of the species. Our research aims to analyze the eventual presence of microhabitat selection, to evaluate the differences between identified age-sex classes, and to determine the main habitat categories, which are important for the species. The received information should be used to confirm the species as potential indicator for grassland habitats condition of and for the effects of changing the regimes of land use.

Materials and Methods

We selected eight isolated polygons, situated in the Sofia plain, Western Bulgaria, situated between 540 and 703 m a.s.l., near two outlying neighborhoods of the city of Sofia with centroid coordinates: N42.8499, E23.1179; N42.6217, E23.3508; N42.42.6365, E23.3872; N42.6210, E23.4553; N42.6527, E23.5836; N42.7615, E 23.5489; N 42.8154, E 23.3907; N 42.8523, E 23.2441. The geographic region is characterized by weakly expressed relief, warm summers (mean temperatures in July = 21.43°C), cold winters (mean temperature in January -0.38°C; for the period 2001–2011) and respective months rainfall minimum in February 24.5 mm and maximum in July 75.4 mm (for the same period), (Mishev, 1989; NIMH-BAS).

The sites were visited between April and August 2010, April – July 2011 and May 2012, from 7:30 to 20:30 (GMT+2) as in all visits before and after that period no specimens were recorded. We attempted to catch by hand every lizard we spotted. Every individual's sex and age were identified by morphometric measures and specific color pattern characteristics. A total of 68 individuals (ind.) were captured. They were grouped in four classes' namely: adult males (m) – 20 ind., adult females (f) – 18 ind., juvenile males (jm) – 14 ind., juvenile females (jf) – 16 ind. The separation of age classes was based on seasonal sexual dimorphic pattern (greenish in adults) and stage development of the femoral pores in males and presence/absence of mating scars in females (presented in adults). We described in individual field protocols and photographed the microhabitat characteristics for every collected individual approximately at an area of 100 m^2 around the point of initial observation. Grass height was defined in three classes: 0–20 cm [H1], 20–40 cm [H2], and 40–60 cm [H3]. Grass density was separated in four classes: low – more than 90% of visible soil [D1], medium – 50% [D2], dense – 10% [D3], very dense – no soil visible [D4].

We also noted (as presence/absence) specific elements: road, trees, shrubs, stones and artificial shelters (mostly construction and household waste). Data for every class were compared with Chi-square test. Bray-Curtis similarity index for abundance data was calculated and statistically significance level was stated in order to explore the closeness of the four designated age-sex classes to one another in their microhabitat choice. Unweighted pair-group average (UPGMA) was used to visualize the similarity matrix. A correspondent analysis was used to explore the microhabitat selection of the four groups. The input matrix includes the four designated classes versus the microhabitat elements as presence/absence of the elements in all researched 100 m^2 territories for each individual (Table 1).

Shannon diversity index (H') was calculated for all age-sex groups and microhabitat classes and values were compared between groups with diversity t-test for statistical significance. Collected data were processed and analyzed with softwares PAST 2.17 and (Hammer et al., 2001).

Results

The presence of the different age- sex classes over the identified microhabitat categories defined grasses to be the most determinant for the species habitat selection (Table 2). Grass classes [H2] and [D3] were the most preferred by all groups. The selection of different microhabitat categories by all identified age-sex classes is present in percent's in Table 1. The Chi-square test does not reveal statistically significant differences among the age-sex groups ($P > 0.05$ for all combinations). There were no statistically significant differences among the age-sex classes in term of their Shannon index values (P > 0.05 for all combination) (Table 2).

According to Bray-Curtis similarity index (Table 3) adults were grouped against the juveniles (Figure 1). The first and second axis obtained through the correspondence analyses explain 79.8% of the total variance, respectively 50.2% and 29.6%. The first axis separated the age classes, adult males and females versus juvenile males and females. Second axis separated sex classes, adult and juvenile males versus adult females and juvenile females. The four groups were well separated in the multidimensional space (Figure 2, Table 4).

For adult males the more determinative microhabitats category classes were grass [H3] and shrubs and partly trees and grass [D3]. Adult females were associated with the lower grass density and height classes 9D20 and [H2] and artificial shelters. Grass category [D3] and stones tended to be associated with the juvenile males and rest of the microhabitat categories (grass classes [D1], [H1] and partly road) with the juvenile females (Figure 2, Table 4).

Discussion

We confirmed the differential microhabitat use in different age classes of *L. a. chersonensis*. In addition, we observed segregation between sexes in both age classes. Adult males as a dominant group occupied the most suitable and safe microhabitat patches as other research revealed (Glandt, 1991). The tendency for inhabiting the tall grass categories corresponds to the species biological requirements for occupying the most secured natural shelters. Märtens et al. (1996, 1997) advocated for the importance and the relationships between vegetation height and structure, as one of the most important key factors for the sand lizards distribution. As subdominant in respect to adult males and subordinate in respect the juvenile males, adult females occupied the peripheral and other microhabitat classes, which are with lower suitability. Stones are scarcely distributed over study polygons and because of their small dimension are not suitable for the adults they are occupied by the dominant class of juveniles, the males. Microhabitats with lowest suitability, such as patches without shelters and with lower grass height are inhabited by the juvenile females.

Table 1
Input matrix for the correspondent analyses

	m	f	jm	jf
Grass[D1]	1	2	1	4
Grass[D2]	2	4	0	0
Grass[D3]	17	12	12	11
Grass[D4]	0	0	1	1
Grass[H1]	1	3	3	6
Grass[H2]	11	10	4	8
Grass[H3]	8	5	7	2
road	3	4	2	3
shrubs	4	2	2	2
stones	3	1	1	2
trees	1	0	0	0
artlifical shelters	1	4	2	0

Legend: m – adult males, f – adult females, jm – juvenile males, jf – juvenile females

Table 3
Values of the Bray-Curtis similarity index and corresponding degree of statistical assurance

	m	f	jm	jf
m	1	>0.05	>0.05	>0.05
f	0.91	1	>0.05	>0.05
jm	0.67	0.72	1	>0.05
jf	0.57	0.82	0.9	1

Legend: For abbreviations see Table 1

Table 2
Presence (in %) of the four designated age-sex classes in the identified microhabitat categories in all individual polygons and the correspondent value of the Shannon index for each category

Sex	Grass density				Grass height			Road	Shrubs	Stones	Trees	Artifical shelters	*H'*
	[D1]	[D2]	[D3]	[D4]	[H1]	[H2]	[H3]						
m	5	10	85	0	5	55	40	15	20	15	5	5	***1.938***
f	11.1	22.2	66.7	0	17.6	58.8	29.4	22.2	11.1	5.6	0	22.2	***2.072***
mj	7.1	0	85.7	7.1	21.4	28.6	50	14.3	14.3	7.1	0	14.3	***1.943***
fj	25	0	68.8	6.3	35.3	47.1	11.8	18.8	12.5	12.5	0	0	***1.952***
H'	1.213	0.637	1.371	0.693	1.231	1.327	1.287	2.485	2.303	2.079	0	1.946	

Legend: For abbreviations see material and methods and Table 1

In similar studies adult and yearling sand lizards preferred different shelters compared to hatchlings, respectively compact vegetation at the base of bushes and proximity of dense vegetated patches (Nemes, 2001; Nemes et al., 2006)

Our statistical analyses confirm the priority of the multivariate analyses techniques over the classic, popular and widely used tests such as Chi-square when analyzing microhabitat use and are obviously more sensitive (Nemes et al., 2006).

The grass cover seems to be the key component of the microhabitats being present in all polygons, while dense bushes and trees were weakly represented. In polygons with species absence a tendency for increasing of bushes and trees cover was found. Although we had previous information for the presence of Sand lizard in these areas, the recent observations showed, that the species probably extinct there, probably due the changes of land use and the following succession. In other parts of the species distribution range the decrease of the sunshine index caused by the increase of the bush and tree canopy have been postulated to be a serious threat for the optimal species' habitats (Jackson, 1979; Dent and Spellerberg, 1987; Berglind, 1995). However patches with dense vegetation have practical importance for lacertids in general (Vanhooydonck and Van Damme, 2003) and are of primary importance as refuge places for *L. agilis* in particular (Török, 2002).

At the southern edge of the distribution of *L. a. chersonensis* grass cover density and height are of major importance for habitat choice and occupancy. In other populations from the southern edge of distribution this taxon inhabits places with 60–80% of surface covered by vegetation, and areas with scarcer vegetation layer not offering enough shelter

Table 4
Factor weights of the designated grass density/height and age/sex classes according to the first three axes

	Axis 1	Axis 2	Axis 3
Grass[D1]	0.6051	0.27884	0.15603
Grass[D2]	-0.7513	0.63818	0.18419
Grass[D3]	-0.0071	-0.1115	-0.029
Grass[D4]	0.96358	-0.2626	-0.5893
Grass[H1]	0.61102	0.20187	-0.0988
Grass[H2]	-0.0355	0.08349	0.18097
Grass[H3]	-0.2219	-0.2565	-0.2282
road	0.0266	0.17384	0.02307
shrubs	-0.065	-0.2055	0.09076
stones	0.09252	-0.2458	0.28324
trees	-0.7501	-0.9731	0.90408
artificial shelters	-0.4783	0.45587	-0.4865
m	-0.2311	-0.23	0.17678
f	-0.2317	0.34131	-0.0344
jm	0.06307	-0.1904	-0.3526
jf	0.53079	0.06629	0.12216

Legend: For abbreviations see material and methods and Table 1

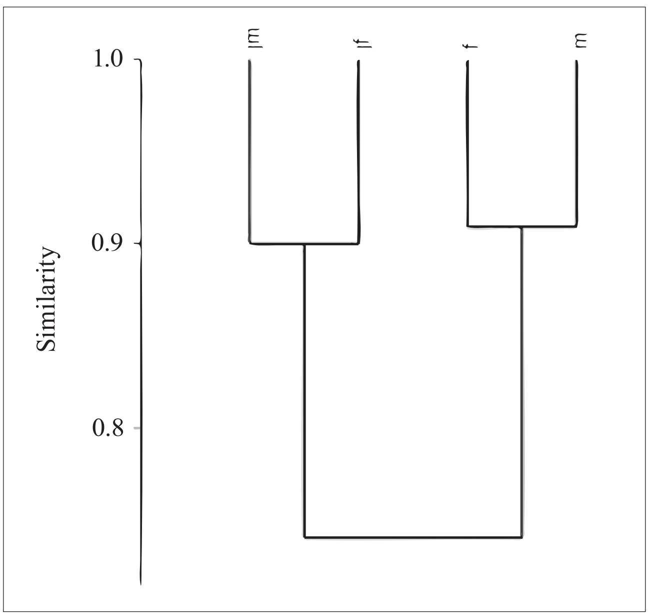

Fig. 1. Cluster based on the Bray-Curtis similarity index values

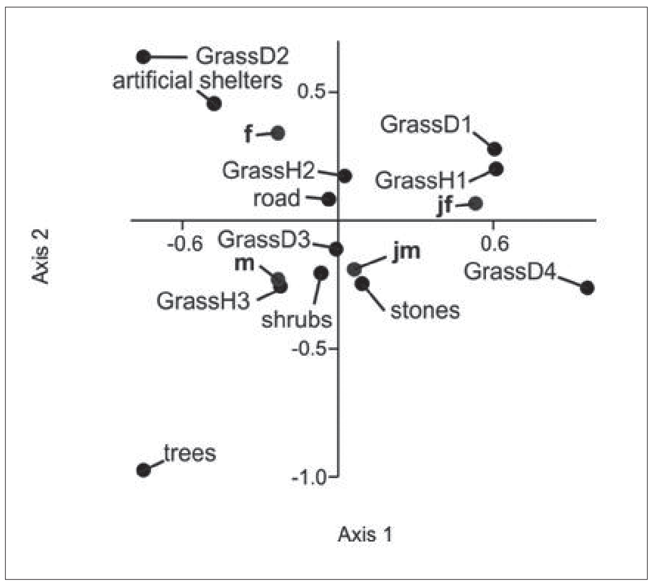

Fig. 2. Distribution of age-sex classes and microhabitat categories according to the first and second axis from the correspondent analysis

places. Dense vegetation might reduce the movement capability and the basking opportunities (Török, 1998). A different situation can be observed in the northern populations where sand lizards prefer low density cover of grasses and bushes interspersed with patches of bare ground (Glandt, 1979) or tend to occupy those microhabitats that have a higher amount of open spots and lesser bush coverage (Nemes et al., 2006). Such open territories with scarce vegetation are completely avoided by the taxon in our study, possibly because of local unfavorable microclimatic characteristics such as ground temperature, soil moisture, or habitat aridity. The key importance of isothermality and precipitation of the driest/warmest quarter were demonstrated by the spatial distribution model of *L. a. chersonensis* in Sofia plain (Tzankov et al., 2013).

Castilla and Van Damme (1996) postulated that there is a negative correlation between hatchlings' choice and bush coverage which is connected with the possible existence of cannibalism. Amat et al. (2003) stated that interference with other individuals has a genuine influence on habitat choice of the sand lizard.

Grass height and density seems to be an important parameter for microhabitat selection of the different age-sex classes. The vegetation structure and height were already determined by Märtens et al. (1996, 1997) to be the most important key factors. Glandt (1991) found a negative relationship between vegetation height and lizards abundance with preferable vegetation height up to 30 cm. For comparison, grass with height between 20 and 40 cm was the most occupied class in our study. The preferred vegetation height might be influenced by many factors like exposure through influence on sunshine index, presence of predators and type of predators (terrestrial vs. aerial) and humidity (Nemes et al., 2006).

The studied edge populations of *L. a. chersonensis* are adequately protected especially on national level in term of the legislation. The Sand lizard is included in annex III of the Biological diversity act of Bulgaria, annex IV of the Habitat directive and annex II of the Bern convention, partially because the species distribution is highly influenced by habitat loss. There is an action plan for the species for Northwestern Europe (Anonymus, 2006) that must be regarded as a good practice towards the effective species conservation and should be adopted for other regions including the researched area where the species is endangered because of the quick habitat loss. For a general plan improvement the behavioral and ecological variations induced by ontogenetic shifts (Nemes et al., 2006) and the habitat choices of all age-sex classes should be considered.

The research of the microhabitat selection has not only theoretical but also practical importance for the species conservation and habitats management (Martín and Salvador, 1995; Martín and López, 2002; James and M'Closkey, 2003; Nemes et al., 2006). The Sand lizard could be used as a good indicator for grassland habitats quality, according to the proved selection of microhabitats with the major importance of grass, followed by other factors. The increasing of bushes and trees, caused by processes of succession is probably among the main reasons for the species extinction. Other still poorly researched factors, related to survival rate of the different age-sex classes, their spatial niche and food segregation, population parameters such as abundance and density and natural habitat changes due to the succession also should be taken into account.

Conclusion

There is an obvious segregation among different age-sex classes of *L. a. chersonensis* in their microhabitat choice. Both sexes are differentiated at their juvenile stage. There is a hierarchic structure in microhabitat selection among sex-age classes, when dominate classes occupied the most suitable/secured microhabitats. Grass height and density seem to be the most important parameters for microhabitat selection of the different age-sex classes. Aridization seems to be an important negative factor for habitats choice in this species. All that facts should be considered when future researches. The sand lizard must be treated as an indicator species for grassland habitats condition. Species specific conservation measures should be specified and implemented in the agro ecological practices which will assist the sustainable habitat management and will provide good cumulative effects for the grass habitat elements as a whole.

Acknowledgements

We thank P. Stoev, H. Grozdanova, T. Popov, M. Slavchev, M. Spasov, E. Vacheva and V. Vergilov for the fieldwork assistance. We are also grateful to Y. Kornilev and B. Naumov for the suggestions and language improvements. This work was supported by the grant № BG051PO001-3.3.06-0025, financed by the European Social Fund and Operational Programme Human Resources Development (2007 – 2013) and co-financed by Bulgarian Ministry of Education, Youth and Science.

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Received December, 2, 2013; accepted for printing June, 2, 2014.