Russian Journal of Herpetology Vol. 14, No. 3, 2007, pp. 172 – 176

MICROHABITAT CHARACTERISTICS FOR REPTILES *Lacerta agilis*, *Zootoca vivipara*, *Anguis fragilis*, *Natrix natrix*, AND *Vipera berus* IN LATVIA

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Submitted August 22, 2006.

Vegetation characteristics for reptile microhabitats were described in circular plots using modified Braun–Blanquet method. The total number of all plots was 280, and they covered the whole territory of Latvia. Microhabitat use among reptile species was examined using Discriminant Function Analysis. The first dicriminant function indicated gradient from mesic to xeric sites, and the second — from disturbed sites to intact dry pine forest sites. Group centroids showed good separation among species. *Lacerta agilis* preferred xeric sites, and, at the other end of the gradient, both snake species preferred mesic sites with tall herb layer and shrubs. *Anguis fragilis* often was associated with relatively intact pine forest, while other reptiles — with mainly disturbed sites with grass cover. Important vegetation characteristics for reptile microhabitats are given in an appendix.

Keywords: reptiles, microhabitats, vegetation, Latvia.

INTRODUCTION

The spatial distribution of reptiles in habitats of the temperate climate zone is very uneven. In the majority of habitats only some specific microhabitats are actually used by reptiles, and these microhabitats often are not typical for the given habitat in general. Thus, lacertids may have been virtually absent from forest habitats in Europe before the onset of human economic activity and the creation of disturbed sites (Strijbosch, 1999). In a closed forest habitat, however, suitable microhabitats may also develop under wind-created canopy gaps (Greenberg, 2001), and several species (including lacertid *Zootoca vivipara*) are also frequent in natural, undisturbed habitats, such as open stunted pine stands on the periphery of raised bogs (Boshansky and Pishchelev, 1978; Zamolodchikov and Avilova, 1989).

Although temperate reptile habitats generally have been described in numerous faunistic studies, few surveys on microhabitats with detailed vegetation analysis exists. Relatively well-studied is the Sand Lizard — *Lacerta agilis*, with relevant surveys carried out in Spain (Amat et al., 2003), Great Britain (House and Spellerberg, 1983; Dent and Spellerberg, 1987), Germany (Glandt, 1991), Netherlands (Stumpel, 1988), Sweden (Berglind, 2000), etc. Less studied are the Common Lizard — *Zootoca vivipara* (Dent and Spellerberg, 1987; Strijbosch, 1988; Glandt, 1991; Zamolodchikov and Avilova, 1989), and the Slow Worm — *Anguis fragilis* (e.g., Stumpel, 1985). Some information on microhabitats of snakes in temperate Europe is presented in wider surveys (Viitanen, 1967; Prest, 1971; Madsen, 1984). However, all of the studies mentioned above have at least one of the following shortcomings: i) the survey is limited to only one or few sites; ii) the survey does not include all potentially suitable habitats; and iii) the survey is limited to 1 – 2 reptile species.

This paper presents a part of the results of a wide survey conducted to clarify factors determining the distribution and abundance of reptiles in Latvia. The effect of large-scale factors, such as climate and macro-habitats, is published else (Čeirāns, 2006). In this paper I present the analysis of a small-scale factor — microhabitat, with a description of vegetation characteristics for reptile sites. The present survey covered whole diversity of reptile species and habitats in a large area — the whole territory of a state. Only terrestrial microhabitats were surveyed and aquatic or semi-aquatic (banks of waterbodies) microhabitats were omitted. Habitats of the Smooth Snake (*Coronella austriaca*) in Latvia (this species is extremely rare and was not found in the present survey) are described else (Čeirāns, 2000).

MATERIAL AND METHODS

Data were collected in 1999 – 2003 on transects (total length 689.3 km) that covered whole territory, and lo-

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cated in all main habitat groups of Latvia. Although censuses were carried out mostly along verges of minor roads and paths to facilitate walking and observation of reptiles, intact habitats were sampled as well (~15% of total transects length). A more detailed description of transect selection principles and censuses is published else (Čeirāns, 2006). In the present analysis, only data from period with fully developed vegetation (3rd decade of May – 1st decade of September) was used.

Microhabitat (vegetation) was described in circular plots with the centers in point, where reptile specimens were first spotted. The total number plots were: 27 for *L. agilis*, 136 for *Z. vivipara*, 57 for *A. fragilis*, 28 for *N. natrix*, and 32 for *V. berus*. The radius was 1.5 m for the moss layer and herbs, 5.0 m for shrubs, and 10.0 m for trees. In some cases the plots, however, had elongated or irregular shape, because parts with very different vegetation (e.g., near forest edges, on verges) were excluded. A modified Braun–Blanquet method was used. Vegetation data was described as coverage, which was evaluated visually. To reduce possible estimation error, the coverage was estimated as belonging to the coverage classes coded as whole number as follows (except for the moss layer): 0, absent; 1, scanty (coverage 1 – 5%); 2, rare (6 – 14%); 3, medium (15 – 33%); 4, common (34 – 67%); 5, abundant (>67%). For the moss layer: 0, not developed (coverage <10%); 1, poor (10 – 32%); 2, medium (33 – 67%); 3, well developed (>67%). It was described separately for different height classes, taxons and ecological groups. The latter were selected arbitrary, on the basis of literature sources (Pētersone and Birkmane, 1980; Fitter at al., 1984; Fitter et al., 1996) and author's personal experience. Easily identifiable and frequent taxons (trees, undershrubs, some herbs) were treated at the species level.

Microhabitat use among reptile species was examined using discriminant function analysis (DFA). Although the data did not meat the Box'M test of homogeneity of covariance matrices, this requirement is rarely met in ecological analysis, and DFA is robust enough to withstand some violation of homogeneity assumption (Tabachnik and Fidell, 1996). The majority of the correlations between variables were well below 0.50, and all were included in analysis. Raw data were used because transformations produce biologically similar or identical results in DFA (McAlpine and Dilworth, 1989). All statistics were conducted using the SPSS® for Windows Version 11.5 (2002) program package.

TABLE 1. Summary of DFA statistics

Statistic	DF1	DF2
Eigenvalue	0.771	0.518
% of variance	38.7	26.0
Wilks Lambda	0.204	0.361
Chi-Square	395.69	253.36
df	220	162
p	<0.001	<0.001

RESULTS

Predominantly grassy medium-height vegetation with some wooded vegetation cover was typical for all species (*Appendix 1*). Two discriminant functions derived from the DFA correctly classified 60.7% of original cases (Table 1). The first dicriminant function (DF1) showed positive correlations with variables characterizing low vegetation (small "succulents" (mainly *Sedum acre*, lichens on ground, small tufted grasses, and heath *Calluna vulgaris*), typical for very poor soils and relatively xeric conditions (Table 2). DF1 had negative correlations with variables characterizing generally moist (mesic) conditions: tall herbs with large, broad leaves (umbellifers — Apiaceae etc.), mesic grasses (*Festuca*,

TABLE 2. DFA structure matrix

Variable	DF1	DF2
Small succulents	0.448*	0.004
Lichens on ground	0.402*	0.071
Xeric grasses	0.329*	–0.014
Calluna vulgaris	0.320*	0.001
Tall dune grasses	0.277*	–0.056
Broad-leaved (tall) herbs	–0.258*	–0.042
Mesic grasses	–0.236*	–0.082
Salix	–0.207*	0.006
Betula	–0.195*	–0.028
Meso-xeric grasses	0.191*	0.141
Low (≤0.15 m) vegetation	0.158*	–0.003
Narrow-leaved (medium) herbs	0.138*	–0.068
Vaccinium myrtillus	–0.054	0.457*
Trees ≥10 m	–0.099	0.438*
Moss layer	0.186	0.394*
Pinus sylvestris	0.161	0.310*
Hypericum	–0.012	0.279*
Tall (0.5 – 0.99 m) herbaceous vegetation	–0.230	–0.240*
Plantago	–0.032	0.237*
Juniperus communis	–0.010	0.222*
Calamagrostis	–0.029	–0.222*
Melamphyrum	–0.118	0.196*
Vaccinium vitis-idaea	–0.06	0.181*
Fabaceaceae (tall)	0.011	–0.125*
Rumex	0.106	0.123*

Variables with best correlation with given function marked with asterisk; only variables with correlation <0.1 are shown; for variable explanations see also *Appendix 1*.

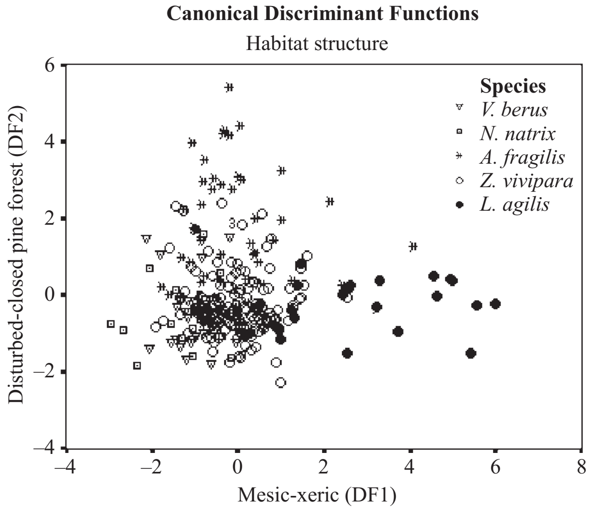

Fig. 1. Discriminating among reptile species for microhabitat.

Poa, *Dactylus glomerata*, etc.), and some deciduous trees (*Salix*, *Betula*). Hence, this function discriminated species along a xeric — mesic vegetation gradient.

The second discriminant function (DF2) had positive correlation with variables characterizing *Myrtillosa*-type and similar forests (Bušs, 1997), belonging to *Vaccinio myrtilli – Pinetum* association (Priedītis, 1999). Such forests are common in Latvia; they are dominated by pine (*Pinus sylvestris*) in canopy, with well-developed moss layer, and bilberry (*Vaccinium myrtillus*)-dominated herb layer. The positive correlations with St. John's wort (*Hypericum*), plantain (*Plantago*), and sorrel (*Rumex*) were due to observations on small forest paths as these species are typical for verges, and not for intact forest (Bušs, 1997). DF2 had a negative correlation with small-reeds (*Calamagrostis*) and some other herb vegetation typical for disturbed sites, such as roadsides and clearings (Bušs, 1997). Thus, this function discriminate reptiles along a disturbance gradient in upland pine forests.

Although habitats greatly overlapped (Fig. 1), group centroids showed good separation among species (Table 3). *Lacerta agilis* prefers xeric sites (see centroid at DF1), while both snake species preferred sites with

TABLE 3. Functions at Group Centroids

Species	DF1	DF2
Lacerta agilis	2.458	–0.337
Zootoca vivipara	–0.056	–0.296
Anguis fragilis	–0.091	1.401
Natrix natrix	–0.942	–0.531
Vipera berus	–0.852	–0.490

tall herb layer and shrubs. Two other lizard species had intermediate positions along this gradient. *Anguis fragilis* often were associated with relatively intact pine forest (centroid at DF2), while other reptiles with mainly disturbed sites with grass cover.

DISCUSSION

The microhabitat niches of two species are very different from those occupied by the other species. The Sand Lizard (*L. agilis*), can occur on open, very xeric habitats with low succulent-like herbs (*Sedum acre*), low densely-tufted grasses, heath (*Calluna vulgaris*) and lichens. However, normal microhabitat for *L. agilis* in Latvia is less xeric than the described above (*Appendix 1*). It is most often found in sparse low pine (*Pinus sylvestris*) stands, with herb cover dominated by various grasses, and a relatively large proportion of heath. *Lacerta agilis* avoids sites with tall broad-leaved herbs, although some ferns (e.g., *Pteridium aquillinum*) may be present (Dent and Spellerberg, 1987). These habitats are generally similar to *L. agilis* habitats in Western Europe (House and Spellerberg, 1983; Strijbosch, 1986;, Dent and Spellerberg, 1987; Stumpel, 1988; Glandt, 1991), but there are some differences in ground cover — e.g., *Erica* undershrubs are naturally absent in Latvia, and the grass cover can have a different taxonomic composition.

The other species with a very distinctive microhabitat niche is the Slow Worm (*A. fragilis*). It is the only species found in virtually intact forest: dry or drained pine-dominated forests, where undershrubs (mainly Bilberry — *Vaccinium myrtillus*) dominate the ground cover. The moss cover is composed of a thick but loose feather moss (*Pleurozium*, *Hylocomium*) mat, which creates good hiding places for this secretive species. In most cases observations in such forests were made on paths, near canopy gaps or close to the forest edge. However, in some cases there were no open sites nearby. The canopy in these forests is relatively diffuse, and the ground cover apparently receives sufficient heat for this species. The importance of these forests as *A. fragilis* habitats is confirmed by previous studies (Čeirāns, 2002, 2004), although their ecotops and borders with other habitats are still more important than the intact forest (Stumpel, 1985).

DF centroids for both snake species were very close, indicating similar microhabitat composition preferences. Both prefer sites with some (~10 – 30%) shrub (*Betula*, *Salix*) coverage and tall grass vegetation. Characteristic also is the presence of tall herbs with broad leaves, e.g., umbellifers (*Appendix 1*). Such vegetation offers good shelter and supports small prey vertebrates, although the presence of more open basking places may also be a requirement. The above characteristics describe only the summer habitat for *N. natrix* and *V. berus*, which may use different habitats for wintering, mating, and feeding (Viitanen, 1967; Prest, 1971; Madsen, 1984).

The lack of discrimination along a mire function was unexpected; the reptile species generally avoid (*L. agilis*, *A. fragilis*) or are frequent (*Z. vivipara*, both snake species) in such habitats (Viitanen, 1967; Belova, 1976; Zamolodchikov and Avilova, 1989). This may be explained by undersampling of microhabitats with distinct mire vegetation, characterized by Cotton-grass (*Eriophorum vaginatum*), Northern Bilbery (*Vaccinium uliginosum*), Labrador Tea (*Ledum palustre*), Bog Rosemary (*Andromeda polifolia*), etc., since transects were located mostly along paths, cuttings and other sites with disturbed vegetation. Or, these microhabitats may be less important for reptiles than disturbed sites (Bozhansky and Pishchelev, 1978; Čeirāns, 2004) where the typical mire vegetation is degraded or disappeared. We did not find any association with some other wetland vegetation (e.g., Purple Moor-grass *Molinia coerulea*) in Latvia, as has been described in Western Europe (Dent and Spellerberg, 1987; Strijbosch, 1988).

Site occupancy by reptiles, of course, is not only the consequence of microhabitat characteristics, but also many other factors, such as site exposure, spatial heterogeneity of environment, the presence of water bodies, more open or more closed microhabitats in vicinity, shelters, prey availability etc. However, the present work revealed differences in vegetation structure and composition among reptile microhabitats, indicating the relative role of disturbance for various species in habitats.

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APPENDIX 1. Vegetation cover values (mean ± S.D.) and weighted average for coverage, % on plots; unimportant factors are not included

Variable	*L. agilis*	*Z. vivipara*	*A. fragilis*	*N. natrix*	*V. berus*
Vegetation height layer					
≥10 m	0.0 ± 0.0; 0	0.4 ± 1.2; 5	1.4 ± 2.0; 18	0.5 ± 1.4; 7	0.2 ± 0.8; 2
1.0 – 9.99 m	1.3 ± 1.4; 9	1.7 ± 2.0; 21	2.0 ± 2.0; 25	2.4 ± 2.1; 31	2.7 ± 2.0; 32
0.99 – 0.5 m	1.1 ± 1.1; 7	1.6 ± 1.8; 17	1.2 ± 1.8; 13	2.9 ± 1.8; 35	2.3 ± 1.8; 26
0.49 – 0.16 m	3.0 ± 1.4; 31	3.1 ± 1.4; 36	3.4 ± 1.3; 40	3.0 ± 1.7; 34	3.3 ± 1.7; 44
≤0.15 m	1.5 ± 1.5; 12	0.9 ± 1.3; 7	0.9 ± 1.5; 8	1.0 ± 1.6; 11	0.5 ± 1.0; 3
Mosses	1.1 ± 1.1; 24	0.6 ± 1.0; 16	1.3 ± 1.4; 34	0.4 ± 0.8; 12	0.3 ± 0.8; 12
Wooded vegetation					
Pinus sylvestris	1.0 ± 1.1; 6	0.5 ± 1.1; 4	1.2 ± 1.8; 14	0.5 ± 1.1; 4	0.2 ± 0.5; 1
Picea abies	0.1 ± 0.6; 1	0.3 ± 0.7; 2	0.6 ± 1.3; 10	0.1 ± 0.4; 1	0.7 ± 1.4; 7
Betula	0.4 ± 0.9; 3	0.6 ± 1.2; 5	0.8 ± 1.1; 5	1.3 ± 1.8; 15	1.2 ± 1.5; 11
Salix	0.2 ± 0.5; 1	0.8 ± 1.5; 9	0.9 ± 1.6; 11	1.2 ± 0.8; 13	1.3 ± 1.7; 13
Juniperus communis	0.0 ± 0.0; 0	0.0 ± 0.0; 0	0.1 ± 0.3; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Grasses					
Xeric grasses[a]	0.6 ± 1.1; 4	0.1 ± 0.5; 1	0.1 ± 0.5; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Meso-xeric grasses[b]	0.7 ± 1.2; 5	0.3 ± 0.9; 2	0.5 ± 1.2; 5	0.1 ± 0.4; 1	0.1 ± 0.4; 1
Mesic grasses[c]	0.8 ± 1.2; 7	1.9 ± 1.6; 16	1.5 ± 1.6; 14	2.5 ± 1.8; 26	1.7 ± 1.5; 14
Calamagrostis	1.0 ± 1.3; 7	1.1 ± 1.6; 11	0.6 ± 1.2; 5	0.9 ± 1.5; 11	1.6 ± 1.9; 19
Tall dune grasses[d]	0.2 ± 0.7; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Undershrubs					
Calluna vulgaris	1.2 ± 1.7; 13	0.3 ± 1.0; 3	0.4 ± 1.1; 4	0.1 ± 0.4; 1	0.2 ± 0.6; 1
Vaccinium vitis-idaea	0.2 ± 0.6; 1	0.2 ± 0.7; 2	0.4 ± 1.1; 4	0.1 ± 0.4; 1	0.2 ± 0.6; 1
Vaccinium myrtillus	0.0 ± 0.0; 0	0.1 ± 0.6; 1	0.7 ± 1.4; 7	0.0 ± 0.0; 0	0.2 ± 0.6; 1
Other herbs					
Broad-leaved (tall) herbs[e]	0.0 ± 0.0; 0	0.7 ± 1.2; 6	0.7 ± 1.3; 6	1.1 ± 1.5; 10	1.2 ± 1.7; 13
Narrow-leaved (medium-size) herbs[f]	0.6 ± 1.0; 4	0.3 ± 0.7; 2	0.3 ± 0.5; 1	0.3 ± 0.5; 1	0.3 ± 0.6; 1
Fabaceaceae (tall)[g]	0.3 ± 0.5; 1	0.2 ± 0.5; 1	0.1 ± 0.4; 1	0.3 ± 0.5; 1	0.3 ± 0.6; 1
Melamphyrum	0.1 ± 0.2; <0.1	0.2 ± 0.6; 1	0.4 ± 0.8; 2	0.1 ± 0.6; 1	0.4 ± 0.8; 2
Small "succulents"[h]	0.3 ± 0.6; 1	0.0 ± 0.0; 0	0.1 ± 0.2; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Rumex (medium-size)	0.1 ± 0.4; 1	0.1 ± 0.2; <0.1	0.1 ± 0.4; 1	0.0 ± 0.0; 0	0.1 ± 0.2; <0.1
Plantago	0.0 ± 0.0; 0	0.1 ± 0.2; 1	0.1 ± 0.5; 1	0.1 ± 0.2; <0.1	0.0 ± 0.0; 0
Hypericum	0.0 ± 0.0; 0	0.0 ± 0.0; 0	0.1 ± 0.4; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Moss layer					
Lichens on ground	0.8 ± 1.5; 11	0.1 ± 0.3; 1	0.2 ± 0.7; 1	0.0 ± 0.0; 0	0.0 ± 0.0; 0
Sphagnum	0.0 ± 0.0; 0	0.1 ± 0.4; 1	0.0 ± 0.0; 0	0.1 ± 0.6; 1	0.0 ± 0.0; 0

[a] Small, tufted grasses on infertile soils with all leaves thread-like (*Koeleria glauca*, *Nardus stricta*, *Festuca ovina* agg.);
[b] Medium-sized loosely tufted or tufted grasses on xero-mesic soils with all or some leaves thread-like (*Deschampsia flexuosa*, *Festuca rubra*);
[c] Mesic grasses with flat leaves (*Festuca pratensis*, *Poa pratensis*, *P. trivialis*, *Dactylis glomerata*, *Bromus arvensis*, etc.);
[d] Tall dune grasses (*Leymus arenarius*, *Ammophila arenaria*);
[e] Tall herbs with large, broad leaves [umbellifers — *Aegopodium podagraria*, *Angelica sylvestris*, *Daucus carota*, etc.; meadowsweet (*Filipendula ulmaria*); thistles (*Cirsium*); nettle (*Urtica dione*)];
[f] Medium-size herbs with simple narrow to elliptical leaves from daisy family (*Taraxacum*, *Crepis*, *Senecio*, *Centaurea*, *Hieracium*, etc.) and scabious (*Jasione montana*, *Knautia arvensis*);
[g] Tall or climbing herbs from the pea family (*Viccia*, *Lathyrus*, *Astragalus*, *Melilotus*);
[h] Small plants on bare places with succulent-like, fleshy leaves (*Sedum acre*, *Honkenya peploides*).