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THE INFLUENCE OF CARPATHIAN LANDSCAPE SCALE ON SPIDER COMMUNITIES

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Abstract - In this study we evaluate the effect of traditional land use and landscape change on the spider communities in the Eastern Carpathians, Romania. Three sampling areas were selected along a gradient of mountain landscape within the boundaries of the Olt river and the mountain zone from the Eastern Carpathian region: forests, semi-natural habitats and extensively used agricultural areas. Spider communities differed according to land use. The highest species diversity was found in clearcut and orchards, whereas forest habitats have less species richness and abundance.

Key words: Traditional land use, habitat, diversity, conservation

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INTRODUCTION

The distribution and abundance of animals is determined by multiple factors, usually acting at various spatial scales (Ricklefs, 1987; Schmidt et al., 2005, 2008; Hartel et al., 2008; Gallé, 2008). It is now accepted that human activity represents a major source of spatial heterogeneity, this being especially obvious in farmlands. A major challenge of today's conservation biology is to understand how land use influences organism distribution. Human impact generally results in landscape fragmentation; the split of formerly continuous land (vegetation) cover in various, more or less isolated fragments (Sala et al., 2000; Coll and Bolger, 2007; Hartel et al., 2008). The spatial ecology of organisms living in fragmented landscapes is actually addressed by landscape and metapopulation ecology (Hanski, 1998, Tischendorf and Fahrig, 2000, 2001). Both approaches assume that the shape, size and isolation of habitat patches are important determinants of population and community dynamics and persistence. The species persistence at a regional level is considered to be threatened if the connectivity and patch sizes decrease, and the habitats assume a matrix-like (i.e. "non-habitat") appearance (Hanski, 1998; Tischendorf and Fahrig, 2001). Recent models and empirical studies challenge the classical patch-fragment-based approach to address organism distribution (e.g. Fischer and Lindenmayer, 2007; Hartel et al., 2008; Price et al., 2009). These studies show that the binary consideration of the ecological space (i.e. polarizing it into habitat and matrix) may be too simplistic and may lead to an underestimation of the important drivers of organism occurrence. This, nevertheless, may have serious conservation implications: protecting certain landscape elements (that are assumed to be critical habitats) while ignoring others (considered as matrix areas) may result in fragmentation and finally biodiversity loss.

Spider communities were investigated following the measures of land-use intensity, landscape structure and habitat diversity in 24 temperate European agricultural landscapes. The total landscape species richness was most significantly affected by an increased proximity of semi-natural habitat patches. Analyzing the total species diversity into components, the loss in total species richness could be attributed primarily to a decrease in species diversity between local communities. The species richness of the local communities of all investigated groups decreased with an increasing land-use intensity and, in the case of spiders, the decreasing proximity of the semi-natural habitat patches (Hendrickx et al., 2007).

At the local scale, plant and litter cover were the two most important variables that significantly affected the communities overall, meaning both the hunting and to some degree the web-building communities. No significant landscape effects were found in the analyses on spider richness and abundance, but community structure was affected by two landscape level factors (grassland patch density and grassland percentage) (Batáry et al., 2008).

The aim of the present study is to investigate the structure of spider communities in a semi-natural and natural mountainous landscape. The specific objectives are to test if spider community assemblages reflect the land use gradient, and to survey the effect of land use on species diversity, richness and abundance.

MATERIAL AND METHODS

Site characterization and sampling design

Data collection was done in 2002 and 2003 from three sampling areas in mountain landscapes within the boundaries of the Olt River and the mountain zone of the Eastern Carpathian region. The sampling sites were situated at a distance of up to 500 m from each other, representing a gradient of the following land use categories: (i) forests, represented by mature natural deciduous mixed (oak and beech) forest with a deficient herbaceous stratum and *Asperula odorata* in sunny patches; the pine (*Pinus silvestris* and *P. nigra*) forest (8 ha) was in continuation of the cleared portion; the herbaceous stratum was rich in species (*Dryopteris filix-mas*, *Hepatica transilvanica, Pulmonaria rubra*, *Asarum europaeum*): (ii) semi-natural open habitats represented by a willow grove near the Olt River and a 10-year-old clearcut, in the neighborhood of the deciduous forest, and finally (iii) extensively used agricultural areas represented by an apple orchard and grassland with semi-extensive cattle pasture during the year of collections. The willow grove and clearcut were sparsely dotted by shrubs and trees, the dominant vegetation being natural weeds and grass.

Ten covered pitfall traps (300 cm^3 in size, 8 cm in diameter, half-filled with ethylene glycol 30% solution) were placed in each land use type in transects from the margin of land use towards the center at 5 m intervals. Samples were collected monthly from May to September. All spiders were sorted and identified up to species level. Species identification was based on the various keys (Roberts, 1985, 1987; Heimer and Nentwig, 1991; Nentwig et al., 2003).

Data analyses

The Shannon-Weiner (H`) and the log series Fisher alpha (ά) diversity index were applied to measure biodiversity. The alpha diversity index is considered to be superior to commonly used indices due to its low sensitivity to sample size and its high discriminate ability (Shah et al., 2003).

Characteristic species of the urban, suburban and rural areas were identified by the IndVal (Indicator Value) procedure (Dufrêne and Legendre, 1997). This method identifies quantitatively the characteristic species of the studied habitat types, and generates a significance value (*p*-value) for the strength of association using a randomized computerized resampling technique. The IndVal of a species is expressed as a product of the specificity and fidelity measures. It receives its maximum (100) when all individuals of a species are found in a single type of site (high specificity) and when the species occurs at all sites of that type (high fidelity) (Dufrêne and Legendre, 1997; Madjdzadeh and Mehrparvar, 2009). The characteristic species is defined as the most representative species of each habitat type, found mostly in that habitat and present in the majority of sites belonging to that habitat. This proved to be a useful method to identify the characteristic species in several habitats (Elek et al., 2001; Magura et al., 2000).

The correlation between the species richness and the number of individuals was assessed using Analysis of Variance. For this analysis the dependent variables (species richness and the number of individuals) were *log* transformed. To assess the significances of the differences between individual groups, the Tukey test was used.

The forming similarity of ground beetles and spider communities were studied with "Principal Coordinates Analysis" (PCoA) methods, and the Jaccard and Horn indices were calculated using the cumulative data from each landscape element and habitat types.

RESULTS

The Shannon and Fisher α diversity values were slightly higher in the clearcut, orchard and grass and generally lower in the willow grove and forest (Table 1).

The species character power for the studied areas indicates the clear habitat preference of the species. We identified quantitative character species by the IndVal procedure for the compared areas. Altogether three groups of species were distinguished by habitat affinity: open habitat species, found mostly in willow and grassland, forest species either recorded in forests and in forest patches of semi natural open habitats. The third group includes the habitat generalists; well represented agricultural lands (Table 2).

The species richness varied between the habitats; forest species were abundant in clearcut and rare in grass. A significantly lower number from the generalist species were captured in pine, beech and grass while open habitat species were frequent in orchard (Fig. 1). The activity-density pattern presented a similar shape, however for open habitat species we found a high abundance in oak forest (Fig. 2).

The PCoA ordination based on the forming structure revealed the dissimilarity between different landscape elements, the spider assemblages showing gradual changes from open toward agricultural lands. The Jaccard index of similarity indicated a clear distinction between forests, semi natural open and agricultural lands, respectively. This was confirmed by computing the forming structure (Horn log10) and forming dominance (Horn) of the spider communities which showed similar shape, and we have therefore presented only the Jaccard (Fig. 3).

DISCUSSION

The landscape effects on the distribution of organisms were demonstrated by many studies (i.e. Thies and Tscharntke, 1999; Waldhardt, 2003; reviewed by Hartel et al., 2008, Batáry et al., 2008; Gallé et al., 2007, Gallé, 2008 for spiders). The clearcut and orchard had high species richness and density compared to the other land use types, possibly because of the higher density of prey (especially in the orchards) that may be attractive for a number of invertebrates, and the structure of these habitats may make them more suitable for spider species with various hunting strategies.

Table 1. The dominance and diversity of the spider assemblages along the studied natural-rural gradient.

	Oak	Beech	Pine	Willow	Clearcut	Orchard	Grass
Taxa	38	18	29	34	71	42	18
Individuals	349	58	208	505	577	149	25
Shannon index (H')	2.17	2.455	2.477	1.778	3.451	3.093	2.789
Fisher alpha (log 10)	1.035	0.951	0.962	0.915	1.328	1.289	1.460

Table 2. Species character power for the studied areas (habitat types), and the habitat preference of the dominant spider species. The IndVal column shows the species character value for the corresponding clustering level. Notations: G - Generalist species, F - Forest species, O - Open-habitat species, ns – not significant, * – $p < 0.05$.

Species	Habitat	IndVal	*p*	Forest habitat	Open habitat	Agricultural land
Alopecosa pulverulenta	O	49	*	6.3/2.7	45/12.8	2.6/1.3
Aulonia albimana	O	44.5	*	0.7/0.3	10/2.9	3.1/1.6
Oedothorax retusus	O	41.5	*	0/0	45/12.8	0/0
Pardosa agrestis	O	45	*	0/0	5/0.1	0.1/0.1
Trochosa ruricola	O	48.5	*	0.3/0.1	10/2.9	3.1/1.6
Callobius claustrarius	F	31	*	48/24	45/12.9	0/0
Pardosa alacris	F	33	*	49.5/24.7	47/13.4	0/0
Pardosa amentata	F	33.3	*	50/25	50/14.3	0/0
Pardosa lugubris	F	31.6	*	48.5/24.2	37.5/10.7	0/0
Xerolycosa nemoralis	F	32	*	49/24.5	48/13.7	1.5/0.4
Pachygnatha degeeri	G	44	*	1.3/0.6	8.5/1.1	50/16.7
Pardosa riparia	G	43	*	0/0	7.0/0.6	49.5/33.0
Phlegra fasciata	G	38	*	0.3/0.1	8.0/0.7	48/24.0
Walckenaeria atrotibialis	G	38.5	*	3.3/1.4	0/0	48.5/48.5
Xerolycosa miniata	G	40	*	0/0	9.5/2.1	49/32.7
Xysticus cristatus	G	37.5	*	1.7/0.7	0.5/0.3	47.5/31.7

Our results show that the most common species assumed to be open habitat specialists (*Alopecosa pulverulenta, Aulonia albimana, Oedothorax retusus, Pardosa agrestis, Trochosa ruricola*) are significantly associated to open areas (clearcuts) (Table 2). Being open habitat specialists, these species are likely to be sensitive to land abandonment, since this promotes vegetation succession that would end up by forest growth. However, Gallé (2008) found that some other species assumed to be open habitat specialists (such are *Alopecosa cuneata, Sitticus zimmer-manni, Steatoda phalerata*) may be well represented in forests. Spider species assumed to be “forest specialists” were common in open habitats as well, suggesting that spider communities from open habitats may not be equally sensitive to forest succession. Finally, spider species regarded as “generalists” were more common in arable lands.

Our study suggests that giving *a priori* ecological attributes to species according to the preferred habitat type (i.e. open-, forested habitat specialists) may not work in all spider species (especially in the case of so called “forest specialists”). A spider community will likely have species that highly differ in their ecological requirements and which possibly react differently to land abandonment or land use intensification. Therefore, researchers should carefully select species when applying spatial models based on patches (fragments) to explore spider occurrence and community structure. For example, considering forest patch characteristics to predict spider occurrence for species that are assumed to be “forest specialists” may have low power. Indeed, Gallé (2008) found no relationship between the spider species richness and forest patch characteristics. Some forest specialist spiders (*Pardosa alacris*) were common in open, grassland habitats as well in his study. It is likely that a

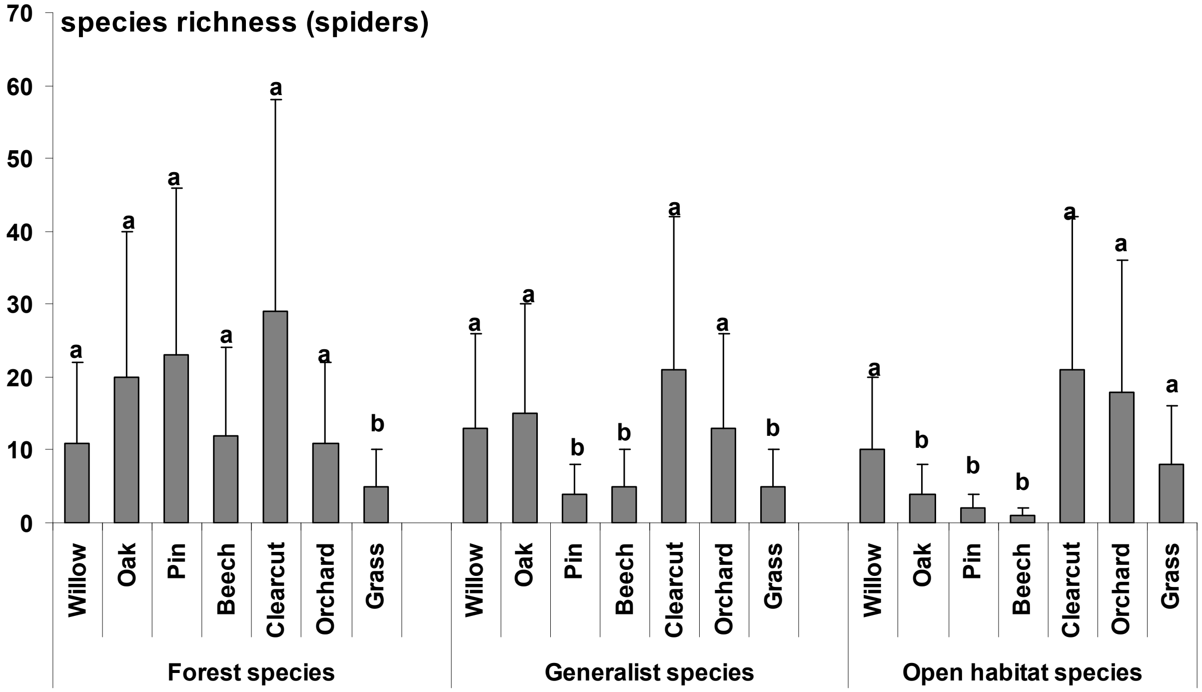

Figure 1. The species richness of spider assemblages along the studied natural-rural landscape gradient (ANOVA). Different letter $p < 0.05$.

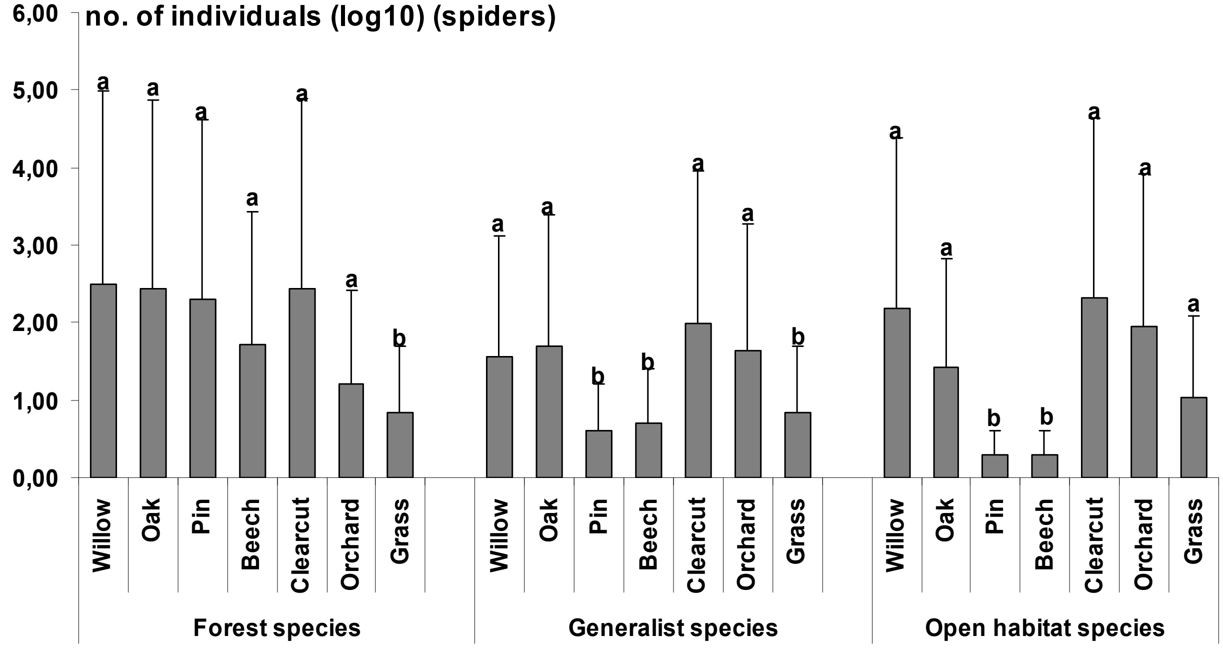

Figure 2. The activity-density of spider assemblages along the studied natural-rural landscape gradient (ANOVA). Different letter $p < 0.05$.

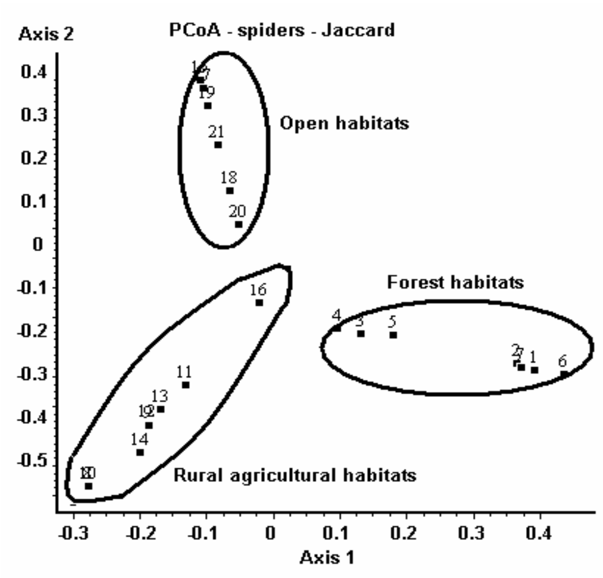

Figure 3. Cluster analysis of the spider assemblages along the studied natural-rural gradient at site level using the Jaccard index of similarity and the group average fusion algorithm (cumulative data from each 7 landscape gradient and3 habitat type).

number of characteristics of the forests (not measured by us) may influence the spider assemblages (Pajunen et al., 1995; Pearce et al., 2004; Varady-Szabo and Buddle, 2006; Okyar et al., 2009). Similar results were reported for other animal groups. For example, Cook et al. (2004) found that small mammals (voles - *Microtus* sp.) may have home ranges that include many patches and the intervening space (i.e. matrix). Tubelis et al. (2004) found that birds may extend their home ranges from native vegetation to a plantation matrix in surroundings.

In conclusion, as expected, we found that spider communities are sensitive to landscape structure and change, the higher diversity of spiders being found in clearcut and agricultural land. Some species were not associated with specific landscape elements; therefore the a priori classification of species as specialists of various habitats may not work.

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