

MICROHABITAT PARTITIONING OF *APODEMUS FLAVICOLLIS* AND *MYODES GLAREOLUS* IN THE SUB-MONTANE ALPS: A PRELIMINARY ASSESSMENT

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ABSTRACT - Interspecific competition can cause partitioning in habitat use by sympatric species. This study gives a preliminary contribution to the understanding of microhabitat partitioning of *Apodemus flavicollis* and *Myodes glareolus* in sub-montane habitats. A total of 1000 trap nights in the subalpine forest in the Austrian Ötztal mountain showed that high- and low-tree cover, high-shrub cover, plot location in or out of the forest, and distance from the forest edge were the variables which discriminated the sites of capture of the two species. *A. flavicollis* seemed to be more associated with the forest edge than *M. glareolus*, which, in contrast, preferred areas well within the forest with high tree and shrub cover. Our results suggest that the two species show some level of partitioning according to microhabitat structure.

Key words: ecology, wood mouse, bank vole, forest, discriminant function analysis

RIASSUNTO - *Uso differenziale dei microambienti da parte di Apodemus flavicollis e Myodes glareolus in ambienti subalpini: primi risultati.* La competizione interspecifica può essere causa di segregazione degli habitat tra specie simpatriche. Questo studio vuole dare un contributo preliminare alla comprensione della segregazione in microhabitat tra *Apodemus flavicollis* e *Myodes glareolus* in ambienti subalpini. Sono state effettuate un totale di 1000 notti trappola in ambiente di foresta subalpina che hanno permesso di evidenziare come la copertura arborea e alto-arbustiva, la posizione interna o esterna al bosco e la distanza dal suo margine fossero le variabili discriminanti i siti di cattura delle due specie. *A. flavicollis* è risultato più associato al bordo-foresta che *M. glareolus*, che, al contrario, preferisce aree interne con elevata copertura arborea e arbustiva. I nostri risultati suggeriscono che le due specie mostrano un certo livello di segregazione spaziale in relazione alla struttura dei micro-ambienti.

Parole chiave: ecologia, topo selvatico, arvicola rossastra, ambienti forestali, analisi discriminante

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INTRODUCTION

Coexisting rodent species often segregate into different microhabitats (Due-

ser and Shugart, 1978), responding to structural components of their environment on a scale of resolution much finer than gross habitat differences

(Seagle, 1985). Microhabitat partitioning is one of the ways by which rodents reduce competitive pressure (Carnes and Slade, 1982). Many studies have focused on microhabitat partitioning, particularly of desert rodents (Wondolleck, 1978), nevertheless few studies have explicitly focused on microhabitat partitioning of European forest species (Canova, 1993; Miklos and Ziak, 2002). The study of microhabitat partitioning is important to fully understand habitat associations within the small mammal community and, being at an ecological scale relevant for these species, it provides a deep insight into the ecology of small mammals.

Habitat preferences of the bank vole *Myodes glareolus* (Schreiber, 1780) and yellow-necked mouse *Apodemus flavicollis* (Melchior, 1834) have been relatively well studied (Niethammer and Krapp, 1978; Niethammer and Krapp, 1982; Mitchell-Jones *et al.*, 1999). Both are typical forest species, but a certain degree of flexibility is possible both at habitat and microhabitat level. Both species are sympatric in most areas of central Europe (Mitchell-Jones *et al.*, 1999). In the central and southern European lowlands, *M. glareolus* prefers beech and deciduous forest edges and glades with high shrub cover. It feeds mainly on the green parts of plants and seeds (Niethammer and Krapp, 1982). *A. flavicollis* prefers old beech and oak forests with little or no shrub vegetation and feeds mainly on seeds (Niethammer and Krapp, 1978). Open meadows are considered to be less suitable habitats for both *A. flavicollis* and *M. glareolus* (Niethammer and Krapp, 1978; Spitzenberger, 2001). Nevertheless, in mountain areas

both species can live above the tree line, with *M. glareolus* being able to live in small patches of blueberries (Corbet, 1966). Moreover, in sub-montane forests of limestone Alps it seems that *M. glareolus* uses open areas in summer, when food is scarce (Muralt, 2006).

Wójcik and Wolk (1985) found that, at high population density, *M. glareolus* adapts its daily activities to avoid *A. flavicollis* because the latter, being bigger and more aggressive, can attack *M. glareolus* and expel it from resources (Andrzejewski and Olszewski, 1963). Thus microhabitat distribution seems to depend also on the presence of competing species (Canova, 1993; Miklòs and Ziak, 2002). The main goal of this study was to provide a preliminary contribution to the understanding of microhabitat partitioning of *A. flavicollis* and *M. glareolus* in sub-montane habitats, identifying the relevant environmental variables associated with their partitioning.

STUDY AREA AND METHODS

The study took place in 2008 on the Northern slope of Ötischer mountain, Austria. After a general survey of all forest patches we selected two most similar NNW-facing sub-montane sites at two different altitudes, one at 900 m a.s.l. (47°52-17' N, 15°11-59E; low site), the other above 1400 m a.s.l. (47°52-01N, 15°12-19E; high site). Both sites included forest stands of European beech *Fagus sylvatica*, Norway spruce *Picea abies*, larch *Larix decidua*, sycamore *Acer pseudoplatanus* and fir *Abies alba*, encompassing treeless areas not grazed by livestock. Forest stands were at least 200 m deep and for the first 100 m not affected by wind breaks or tracks. The forest is about 150 years old and has not been

managed since the beginning of the 20th century. The bedrock is limestone. The two sites differed only in the vegetation cover of the treeless area, the higher site encompassing some little rocky patches with no vegetation.

1. Live-trapping

Small mammals were sampled using “Trip Trap” traps (27,5 x 9 x 8,5 cm). Trapping periods lasted four nights per site (low site: 2-6 September; high site: 20-22 September and 10-12 October). The low site was divided into two parallel strips of fourteen 10 x 10 m squares each and the high site was divided into two parallel strips of 11 squares each. We placed five traps as close as possible within a maximum of 2 m from the centre of each square. Trapping consisted of a total of 560 and 440 trap-nights, respectively. Traps were hay-bedded and baited with 10-20 sunflower seeds, five mealworms, a pea sized dose of peanut butter and a slice of fresh apple. Traps were set in the afternoon and controlled the next morning. Captured animals were identified, aged, sexed and measured after Brohmer (1988) and individually marked by fur clipping. Analyses did not account for dead mice or recaptures.

2. Survey of habitat characteristics

For each of the 50 study squares, seven main habitat parameters potentially relevant for *A. flavicollis* and *M. glareolus* were recorded: (1) percent cover of grass, (2) percent cover of shrubs at 0-0,5 m (low shrubs) and (3) 0,6-3 m height (high shrubs), (4) percent cover of the tree-canopy at 0-2 m (low trees) and (5) >2 m (high trees) height, (6) location: inside (including edges) or outside the forest (in = 1, out = 0) and (7) distance (m) of the centre of each plot from the forest edge (with distance = 0 m for all plots outside the forest). Since the different strata of vegetation may

overlap, each percentage of cover was estimated in relation to the ground, so that the sum of all variables does not result in 100% per plot. Percent cover was classified as: 0% = 1, 0-1% = 2, 1-5% = 3, 6-10% = 4, 11-25% = 5, 26-50% = 6, 51-75% = 7, 76-100% = 8 (Tab. 1). This fine-level subdivision of the first three classes was thought to clearly differentiate stony habitats with no vegetation from those offering at least a minimal plant cover, which may represent a crucial environmental factor for small mammals.

Group separation was performed using SPSS (Version 15) discriminant function analysis, which is commonly used in microhabitat segregation studies (Dueser and Shugart, 1978; Carnes and Slade, 1982). Variables were log-transformed to reduce skewness and introduced simultaneously in the analysis. The significance of the discriminant function was tested by Wilks' Lambda; the degree of group overlap and separation of group centroids were evaluated by the percentage of cases correctly classified and the absolute value of Wilks' Lambda. For all analyses, only the first capture of an individual in each site during each trapping session was included because repeated captures may introduce a bias (Kelt *et al.*, 1994).

RESULTS AND DISCUSSION

Overall we captured a total of 154 individuals (plus 37 recaptures). Species composition and the number of individuals captured differed between sites (Tab. 2).

The function resulting from the discriminant analysis correctly classified 71.8% of cases and retained a relatively low discriminatory power, albeit group means were significantly different. (Wilks' Lambda = 0.79; $\chi^2 = 16.42$; df = 7; $P < 0.05$; Fig. 1).

High- and low-tree cover, high-shrub

Table 1 - Descriptive statistics for the microhabitat variables (all variables describing cover are ordinal variables describing percentage of area covered with: 0% = 1, 0-1% = 2, 1-5% = 3, 6-10% = 4, 11-25% = 5, 26-50% = 6, 51-75% = 7, 76-100% = 8, distance from the forest edge in meters (with patches outside forest = 0), position in/out forest with in = 1 and out = 0) with mean and standard deviation and weight of the variable (correlation within groups between the predictor variable and the standardized canonical discriminant function).

Variables	Mean \pm SD	Weight
High-tree cover	5.48 \pm 2.58	0.823
High-shrub cover	2.28 \pm 1.58	0.593
Distance from forest edge	44.44 \pm 33.29	0.530
Low-shrub cover	1.72 \pm 1.03	0.414
In/Out	45% out; 55% in	0.317
Low-tree cover	2.94 \pm 1.28	0.181
Grass cover	5.16 \pm 1.95	0.180

Table 2 - Number of first captures and relative frequency in parentheses of each species in the low- (900 m) and high (1400 m) sites; *A.a.* = *Apodemus alpicola*; *A.f.* = *A. flavicollis*; *A.s.* = *A. sylvaticus*; *M.g.* = *Myodes glareolus*; *M.a.* = *Microtus arvalis*; *M.s.* = *M. subterraneus*; *S.a.* = *Sorex alpinus*; *S.ar.* = *Sorex araneus*; *S.m.* = *Sorex minutus*.

	<i>A.a.</i>	<i>A.f.</i>	<i>A.s.</i>	<i>M.g.</i>	<i>M.a.</i>	<i>M.s.</i>	<i>S.a.</i>	<i>S.ar.</i>	<i>S.m.</i>
Low site	-	78 (66)	-	21 (17.7)	2 (1.6)	6 (5)	1 (0.8)	5 (4.2)	5 (4.2)
High site	2 (5)	8 (22)	1 (2.7)	6 (16.6)	9 (25.6)	7 (19.4)	-	3 (8.3)	-

Table 3 - Descriptive statistics for the microhabitat variables (mean, standard deviation, F-statistics and p values, sorted by the latter two) for each of the target species of this study. For variable explanation see Table 1.

Variables	<i>A. flavicollis</i>	<i>M. glareolus</i>	F	P
In/Out	0.70 \pm 0.46	0.86 \pm 0.36	6.874	0.010
Distance from forest edge	0.94 \pm 0.77	1.40 \pm 0.74	6.874	0.010
High-tree cover	0.64 \pm 0.27	0.87 \pm 0.20	16.002	0.000
Low-tree cover	0.59 \pm 0.15	0.62 \pm 0.18	4.992	0.027
Grass cover	0.67 \pm 0.12	0.69 \pm 0.12	0.455	0.501
High-shrub cover	0.41 \pm 0.17	0.53 \pm 0.20	13.592	0.000
Low-shrub cover	0.35 \pm 0.12	0.41 \pm 0.16	1.735	0.190

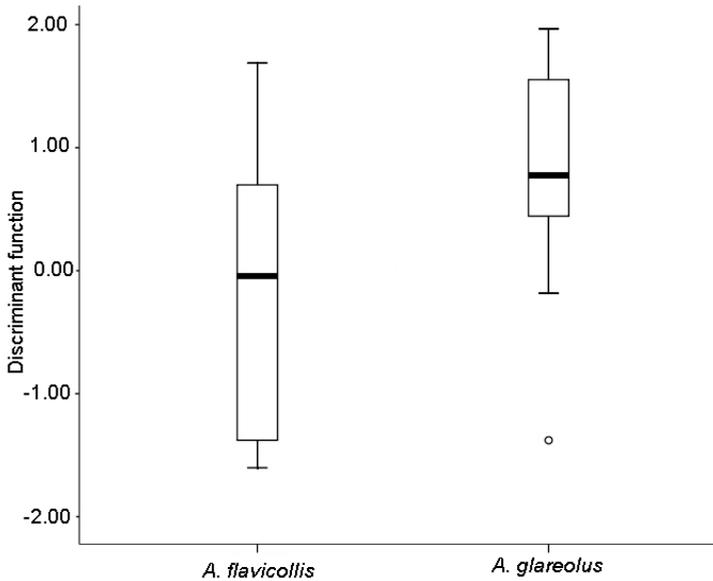


Figure 1 - Box plots showing medians, quartiles and extreme value for the discriminant scores of each group (*A. flavicollis* and *M. glareolus*).

cover, in or out of the forest, and distance from the forest edge were the variables which discriminated the sites of capture of *M. glareolus* from those of *A. flavicollis*, (Tab. 3). The relatively high group overlap is quite common in microhabitat partitioning studies, since the probability of trapping a species outside its preferred microhabitat, depending on its mobility, is often non-negligible.

On the whole, *M. glareolus*, which is known to be more associated to forest edges and high shrub cover (Niethammer and Krapp, 1982), was trapped more often inside the forest with respect to *A. flavicollis*, at places with high canopy cover of old trees and with good cover of high shrubs. In contrast, yellow-necked mice tended to prefer microhabitats outside the forest and stands with little tree- and shrub cover.

This variation in the use of available microhabitats may reflect niche partitioning between the two species when coexisting in sub-montane environments.

Castien and Gosalbez (1994) reported that in spruce forests of the Pyrenees, bank voles preferred forests with high canopy cover but little or no herb/shrub cover in years of good food provisioning, while in medium crop years they were found close to blackberry shrubs, independently from cover.

Our study should be considered as a first assessment of microhabitat partitioning between these two forest species. Although our sample size was adequate for discriminant function analysis (Tabachnick and Fidell, 2001) larger samples (with more spatial and temporal replication) may depict the microhabitat preferences of both spe-

cies more accurately and even allow insights into intra-specific microhabitat partitioning (i.e. between sexes or age classes; Mortelliti and Boitani, 2007). In addition our snapshot study was carried out during only one season, whilst, although Miklos and Ziak (2002) did not find seasonal changes in the microhabitat selection of the two target species, longer studies could take year round variability into account.

A comparative analysis of microhabitat partitioning patterns at the two different altitudes was not possible due to sample size. An exploratory analysis carried out only for the lower altitude site did not result in a substantially different discriminant function. Anyway it is possible that partitioning may change both qualitatively and quantitatively with altitude due to different reproduction timing. Further studies are needed to highlight the influence of altitude, species' density and food availability on microhabitat partitioning between these two rodent species.

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