The community of small terrestrial mammals of spruce monocultures of the Drahanská vrchovina Upland was studied on small experimental plots, namely in spruce plantations aged 30 and 105 years and on comparative plots in a 40-year beech stand and in a 125-year mixed stand occurring apart in the middle of spruce stands. In total, 128 small mammals of five species were trapped in the period 2006–2008. There were the marked dominance and abundance of *Apodemus flavicollis* at all plots (*D* = 67.7–82.1%; *rA* = 1.0–1.6) with the exception of a young spruce stand where *Myodes glareolus* (*D* = 57.5%; *rA* = 1.28) dominated. The community diversity was low (*H*′ = 0.6–1.0) and rather balanced (*E* = 0.51–0.89) showing the highest diversity index in a mature spruce monoculture, which, through its age (105 years), made possible the occurrence of a herb layer. With plantings of *Abies alba* and *Fagus sylvatica* (age 8 years), it provided the highest diversity of sites. The mixed and beech stands showed the lowest diversity (*H*′ = 0.6–0.8), which was also affected by the extreme dominance of *Apodemus flavicollis* (73–82%). These biotopes represented optimum sites for this mouse. Differences in diversity, equitability and relative abundance between particular species and sites were not significant (*p* > 0.05).

In general, the studied spruce stands appear to be little suitable sites for small terrestrial mammals. The local broadleaved and mixed stands established within the spruce monoculture transformation to close-to nature forests enable only increasing the dominance of adaptable species living in neighbouring spruce stands.

Spruce monocultures, particularly of younger age classes with insufficiently developed undergrowth, are generally unsuitable sites for the majority of small mammals (ZEJDA, 1981). The low biodiversity, low population density and the limited production of biomass of dietary-attractive species of plants and long intervals of the seed crop of the only predominating tree species – Norway spruce (*Picea abies*) result in nearly the absence of the family of Arvicolidae and low population densities of typical forest Muridae, genus *Apodemus* (ZEJDA, 1981). In communities of forest trees of other composition, higher species and age structure, the species diversity, population density and production of particular representatives of the community of small terrestrial mammals are markedly higher in the same vegetation zone (PELIKÁN et al., 1975; GAISLER and ŠEBELA, 1975; ANDĚRA, 1992; SUCHOMEL, 2007 etc.).

Studies of communities of small terrestrial mammals of spruce monocultures are rather rare. It refers either to synecological and production studies (ZEJDA, 1981; GAISLER, 1983; BÜRGER et al., 1987) or studies of the impact on woody species (GILL, 1992; PURCHART and SUCHOMEL, 2007). More frequently, there are studies of communities of small mammals of climax natural mountain spruce stands in various stages of succession (e.g. ANDĚRA and BÜRGER, 1992; BRYJA et al., 1999; 2001; SUCHO-
MEL et al., 2007) while cultivated spruce stands are not too attractive for the studies being substantially less abundant (e.g. ZEJDA, 1981; KOLLARS, 1995). With respect to the marked proportion of Soricidae in largely mountain or Scandinavian spruce stands, a number of studies is focused on these insectivores (KOLLARS, 1995; SHELFTEL and HANSKI, 2002 etc.).

The aim of the paper is to present preliminary results of research into communities of small terrestrial mammals of cultivated spruce stands from the Drahanská vrchovina Upland including their character in neighbouring mixed and beech stands established in this region within the process of the transformation of spruce monocultures to close-to-nature forests.

STUDY AREA

The study was carried out in the Rájec-Němčice field research station of the Institute of Forest Ecology, Mendel University in Brno, about 3 km west of the village of Němčice (49°29′31″ N, 16°43′30″ E) and in research areas of MP Lesy Benešov near Boskovice, roughly 2.5 km N of the field research in the central part of the Drahanská vrchovina Upland. From the aspect of the topography type the area ranks among broken uplands of deformed border slopes of a vault megastructure. From the point of view of the relief typological classification the area is finally determined in a laboratory as well as other basic ecological characteristics such as dominance (D) and relative abundance (rA) of selected species (in terms of LOSOS et al., 1985) as well as diversity (H’) (SHANNON and WEAVER, 1963) and equitability (E) (SHELDON, 1969). The significance of differences in indices of diversity and equitability and relative abundance between dominant species of small mammals (Apodemus flavi col lis, Myodes glareol us) and particular studied plots was tested by t-test and analysis of variance (ANOVA) in the Statistics Cz 7.1 program. Numbers of realized trap-nights and trapped animals on particular experimental plots are given in Tab. I.

RESULTS AND DISCUSSION

In the studied region, in total 128 small terrestrial mammals of five species were trapped within the period of monitoring, namely four species of rodents (Rodentia) and one species of insectivores from the order of shrews (Soricomorpha). Apodemus flavi col lis with the total dominance of 57.8% (n = 74) was the most abundant species which was more than half of sampled small mammals. It showed evidence of the high adaptability and vitality of this euryvalent species. Nevertheless, also A. sylvest ris (n = 17; D = 13.3%) and Myodes glareol us (n = 34;
D = 26.6%) showed high total dominance. All these species represent typical eudominant representatives (D > 10%) of high adaptability. Other two species of small mammals were determined quite sporadically, viz. subrecedent (D < 1%) Microtus arvalis (D = 0.8%; n = 1) and recedent (D = 1–2%) Sorex araneus (D = 1.6%; n = 2). The present predominance of A. flavicollis in an old spruce stand (P1) as against A. sylvaticus (Tab. I) is of interest. It became evident there by its high relative abundance (Fig. 3). Otherwise, wood mouse (A. sylvaticus) is generally more frequent (ZE-JDA et al., 2002) in spruce stands. Also in previous

<table>
<thead>
<tr>
<th>Species</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
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<tr>
<td></td>
<td>D (%)</td>
<td>rA</td>
<td>D (%)</td>
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<tr>
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<td>82.1</td>
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<td>0.28</td>
<td>14.3</td>
<td>0.28</td>
</tr>
<tr>
<td>Microtus arvalis</td>
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<td>0.06</td>
<td>0</td>
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<tr>
<td>Sorex araneus</td>
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<td>0</td>
</tr>
<tr>
<td>Σ</td>
<td>34</td>
<td>28</td>
<td>40</td>
<td>26</td>
</tr>
</tbody>
</table>

1: Relative abundance of yellow-necked mouse (Apodemus flavicollis); SM – spruce stands, MF – mixed and broadleaved stands

2: Fluctuation of the abundance of Apodemus flavicollis (AF) and Myodes glareolus (MG) at P1 locality – old spruce stand (105 years)
studies carried out in this field research station within MAB and IBP projects, its dominance was higher, namely about 40% to 32% (ZEJDA, 1981). It could be caused by long-term changes in the population dynamics of *A. flavicollis* (FLOWERDEW, 1985) or by changes in site conditions of forest stands in the given region due to processes of the spruce monoculture transformation to close-to-nature forests (KLIMO and MARŠÁLEK, 1992). *A. flavicollis* is an absolutely dominant species at sites dominated by *Fagus sylvatica* (P2, P4) where it reaches more than 70% occurrence (Tab. I), which highly exceeds values determined in various types of forest stands by other authors, namely both in lowlands (ZEJDA, 1976; BRYJA and ŘEHÁK, 1998; SUCHOMEL and HEROLDOVÁ, 2004) and highlands (ČERMÁK and JEŽEK, 2005; SUCHOMEL, 2007), and in mountain regions (HEROLDOVÁ and ZEJDA, 1995; BRYJA et al., 1999; 2001; SUCHOMEL et al., 2007). The dominance of *Myodes glareolus* is also significant. In spite of present low populations of the species it represents an important potential as a species markedly affecting regeneration of local forest ecosystems and their tree component because it is able to increase its abundance from the stage of pessimum within a relatively short period (ČAPEK et al., 1998). Particularly at present when important changes in forest management happen and coniferous stands are replaced by increasing areas of broadleaves representing the main food of this species in the winter season (HOLIŠOVÁ, 1971; HEROLDOVÁ, 1995) the higher proportion and increasing the abundance of *Myodes glareolus* in the community of small mammals can occur. Values of the dominance of other species of small mammals are given in Tab. I.

Only at *A. flavicollis* and *Myodes glareolus*, sufficient amounts of individuals were obtained population dynamics to be evaluated. The relative abundance of *A. flavicollis* was higher on areas of broadleaved and mixed stands (Fig. 1), which represents to biotope preferences of the species (ZEJDA et al., 2002; ANDĚRA and HORÁČEK, 2005) and the different quality of biotopes when stands with the proportion of bearing beech trees (P2) provide food offer of higher quality in the form of beech nuts (OBRTEL and HOLIŠOVÁ, 1974; HOSÍSOVA and OBRTEL, 1980). However, statistically significant differences were not determined (ANOVA: $p > 0.05$).
Marked fluctuations of the population dynamics of *Myodes glareolus* in spruce stands as against areas with the predominance of broadleaves is of interest (Fig. 2). It became evident particularly in a young spruce stand (P3, Fig. 5) where the relative abundance of the species was markedly higher than in a 100-year spruce stand (P1, Fig. 3). It can be caused by the dense crown canopy of the young stand in Plot P3, which limits the activity of predators, particularly of owls and birds of prey (KING, 1985) as well as the developed herb layer at margins and gaps of the experimental plot, which is the inevitable condition for the occurrence of *Myodes glareolus* (ZEJDA et al., 2002). On plots with the dominant proportion of broadleaved species (Figs. 4 and 6), particularly in stand P2 with bearing beech trees, low population densities of *Myodes glareolus* could be also significantly affected by the high abundance of *A. flavicollis* showing the highest dominance throughout the region (82.1%, Tab. I), which, as a more aggressive species, often inhibits the occurrence of *Myodes glareolus* (MONTGOMERY and GURNELL, 1985). On the contrary, quite minimum competition pressure showed the population of *A. flavicollis* from a young spruce stand (P3) where its dominance and (Tab. I) and abundance (Fig. 5) were very low due to an unsuitable site, particularly the absence of food in the form of seeds of woody species (OBRTEL and HOLIŠOVÁ, 1974; HOLIŠOVÁ and OBRTEL, 1980). However, statistically significant differences in the relative abundance between both species and particular sites were not determined (ANOVA: *p* > 0.05).

The peak of population abundance of *A. flavicollis* is significant virtually at all monitored plots (with the exception of P3) in 2007. It could be caused by the increased supply of food in the form of seeds of bearing trees (OBRTEL and HOLIŠOVÁ, 1974; HOLIŠOVÁ and OBRTEL, 1980), mainly beech nuts, which was proved both by the highest relative abundance at a site with bearing beech trees (P2) and the seed harvest of broadleaved species noted in Moravia in 2006 (SUCHOMEL and HEROLDOVÁ, 2008) responded by rodents by their reproduction with a certain (even one year) delay (FLOWERDEW et al., 1985). The increased abundance of *A. flavicollis* can result in important losses of tree seeds (SUCHOMEL and HEROLDOVÁ, 2008).

5: Fluctuation of the abundance of *Apodemus flavicollis (AF)* and *Myodes glareolus (MG)* at P3 locality – young spruce stand (30 years)

6: Fluctuation of the abundance of *Apodemus flavicollis (AF)* and *Myodes glareolus (MG)* at P4 locality – young beech stand (40 years)
The studied community was also characterized by the relatively low index of diversity $H'$ (about 0.6–1.0; Tab. I) being rather balanced (Fig. 8) at a number of localities in the course of monitored years. The highest diversity was found in a 100-year spruce stand ($H' = 1.002; E = 0.623$). It could be caused by its age (over 100 years) enabling the initial creation of a herb layer, which is an inevitable condition for the occurrence of small mammals, particularly of Arvicolidae (HEROLDOVÁ, 1995; HEROLDOVÁ and ZEJDA, 1995), further through opening and enriching the stand by the gap planting of beech and silver fir, which also represents suitable conditions for the development of a herb layer creating new site types and obviously also lower dominance of *A. flavicollis* (as compared with P2 and P4) with respect to the smaller suitability of spruce stands for this species (ZEJDA, 1981; ZEJDA et al., 2002). The lowest index of diversity was determined in a mixed stand (P2; $H' = 0.559; E = 0.509$), which can be attributed to the very high dominance of *A. flavicollis* occupying all suitable ecological niches. Values of the diversity and equitability of all plots are given in Tab. I and their fluctuation at particular sites in the course of monitored years in Figs. 7 and 8. However, statistically significant differences in diversity and equitability among particular plots were not detected (ANOVA: $p > 0.05$).

7: Fluctuation of diversity ($H'$) in the monitored region. P1 – old spruce stand, P2 – mixed stand, P3 – young spruce stand, P4 – beech stand

8: Fluctuation of equitability (E) in the monitored region. P1 – old spruce stand, P2 – mixed stand, P3 – young spruce stand, P4 – beech stand
The total diversity of a monitored synusia is substantially lower than in other types of forest stands. For example, SUCHOMEL (2007) determined diversity $H'$ = 1.26 in mixed forest stands at the borderland of the Hostýnské and Oderské Hills. ČERMÁK and JEŽEK (2005) mention diversity $H'$ = 1.43–1.6 in monitored communities at the Drahanská vrchovina Upland, SUCHOMEL and HEROLDOVÁ (2004) 1.5 in large forest complexes of southern Moravia. ZEJDA (1976) noted diversity fluctuating from 0.97 to 1.04 in floodplain forests. Higher diversity was noted in mountain forest ecosystems. For example, BRYJA et. al. (1999, 2001) determined values 1.27–1.67 based on research carried out in the region of the Moravian-Silesian Beskids.

In addition to the increase of abundance and dominance of some species of rodents at the monitored locality the decrease of Sorex spp. was noted as compared with other authors (BRYJA and ŘEHÁK, 1998; BRYJA et al., 1999; 2001). Theoretically, it is possible to relate this decline with the general decrease of shrew insectivores (Soricidae) in Moravia after 2000 (SUCHOMEL and HEROLDOVÁ, 2004).

CONCLUSION

Although it refers only to the preliminary evaluation of given problems it is evident that species richness of the synusia of small mammals of local forest stands is low and the community reaches there only low population densities both in spruce stands and in a beech monoculture and a mixed stand. The community is nearly unified at all sites containing universally only three more abundant species ($A. flavicollis$, $A. sylvaticus$ and $Myodes glareolus$) with the marked dominance of $A. flavicollis$. It can be caused by the local isolation of mixed stands in the middle of extensive tracts of spruce monocultures, which (as site-poor ecosystems) disable the occurrence of the higher number of species and thus, they cannot serve as reservoirs of the small mammal biodiversity. Thus, islands of mixed and age-differentiated stands can be colonized only by adaptable dominant species from surrounding spruce stands (in our case Apodemus flavicollis), which respond (in the quality environment of the close-to-nature forest) by a population boom with the marked increase of dominance at the expense of other species of small mammals.

SOUHRN

Smrkové monokultury Drahanské vrchoviny (Česká republika) jako biotop drobných terestrických savců ($Rodentia$, Soricomorpha)

Bylo studováno společenstvo drobných zemních savců smrkových monokultur Drahanské vrchoviny na čtyřech experimentálních plochách, a to ve smrkových výsadbách o stáří 30 a 105 let a na srovnávacích plochách v bukovém porostu – 40 let, a smíšeném lesu – 125 let, které se nacházejí izolovaně uprostřed smrkových porostů.Celkem bylo v letech 2006–2008 odchyceno 128 ks drobných savců v pěti druzích, s výraznou dominanci i abundancí $Apodemus flavicollis$ na všech plochách ($D = 67,7–82,1$ %; $rA = 1,0–1,6$), s výjimkou mladé smrčiny, kde dominoval $Myodes glareolus$ ($D = 57,5$ %; $rA = 1,28$). Diverzita společenstva byla nízká ($H' = 0,6–1,0$) a poměrně vyrovnaná ($E = 0,51–0,89$), s nejvyšším indexem diverzity v dospělé smrkové monokultuře, která svým stářím (105 let) umožňujícím nástup bylinného patra a s podsadbami $Abies alba$ a $Fagus sylvatica$ (věk 8 let) poskytovala nejvyšší rozmanitost stanovišť. Smíšený a bukový porost měly diverzitu nejnižší ($H' = 0,6–0,8$), což ovlivnila i extrémní dominance $Apodemus flavicollis$ (73–82 %), pro kterou představují tyto biotopy optimální stanoviště. Rozdíly v diverzitě, ekvitabilitě i relativní abundanci mezi jednotlivými druhy a stanoviště nebyly průkazné ($p > 0,05$). Celkově se studované smrkové porosty jeví jako málo vhodné stanoviště pro drobné zemní savce, přičemž zdejší listnaté a smíšené porosty založené v rámci transformace smrkových monokultur na lesy přirozeno blízké umožňují pouze zvýšení dominance adaptabilních substrátů žijících v okolních smrčinách.

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Address
doc. Ing. Josef Suchomel, Ph.D., Ing. Luboš Purchart, Ph.D., Ing. Jakub Urban, Ústav ekologie lesa, Mendelova univerzita v Brně, Zemědělská 3, 613 00 Brno, Česká republika