ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LVIII 22 Number 2, 2010

SPRUCE MONOCULTURES OF THE DRAHANSKÁ VRCHOVINA UPLAND (CZECH REPUBLIC) AS THE BIOTOPE OF SMALL TERRESTRIAL MAMMALS (*Rodentia, Soricomorpha*)

J. Suchomel, L. Purchart, J. Urban

Received: January 6, 2010

Abstract

SUCHOMEL, J., PURCHART, L., URBAN, J.: *Spruce monocultures of the Drahanská vrchovina Upland (Czech Republic) as the biotope of small terrestrial mammals (Rodentia, Soricomorpha).* Acta univ. agric. et silvic. Mendel. Brun., 2010, LVIII, No. 2, pp. 185–194

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.

small terrestrial mammals, spruce monoculture, Rodentia, Soricomorpha

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 (49º29′31″ N, 16º43′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 ranked among broken uplands of fold structures and igneous rocks of the Bohemian Highland (KLIMO and MARŠÁLEK, 1992). The area parent rock is acid granodiorite of the Brno massif. The soil profile is created on diluvium layers of various thicknesses with disseminated granodiorite gravel and occasionally also boulders. The soil type is modal oligotrophic Cambisol (MENŠÍK et al., 2009). The research plots are situated at an altitude of 600–660 m, moderately warm climatic region (QUITTE, 1971). Mean annual air temperatures are 6.5 °C and mean annual precipitation 717 mm (HADAŠ, 2002). Potential growth conditions are termed (according to the Institute for Forest Management Planning) as *Abieto-Fagetum* with *Oxalis* (5S1) situated on the upper limit of the beech forest vegetation zone (MENŠÍK et al., 2009).

Four experimental plots were selected in the region. Two spruce monocultures of various age and, for the purpose of comparisons, one planting of beech established within the spruce monoculture transformation to close-to-nature forests and one mixed stand. Both last mentioned plots create isolated refuges in the middle of extensive spruce plantings.

P1 – a spruce monoculture (*Picea abies*) aged 105 years. In the spruce monoculture, no undergrowth occurred. On open areas with gap beech (*Fagus sylvatica*) and silver fir (*Abies alba*) planting aged 8 years, the undergrowth consists of *Rubus* sp., *Calamagrostis* sp., *Avenella flexuosa* and ferns.

P2 – a mixed stand (*Picea abies*, *Fagus sylvatica*, *Abies alba*) aged 125 years. The plot undergrowth consists particularly of *Rubus* sp., *Calamagrostis* sp., *Avenella flexuosa* and intensive natural regeneration of beech.

P3 – a spruce monoculture (*Picea abies*) aged 30 years. It concerns a closed stand without undergrowth; on open places (roads inside and in the vicinity of the stand), undergrowth occurs (particularly *Rubus* sp., *Calamagrostis* sp., *Avenella flexuosa*).

P4 – a beech monoculture (*Fagus sylvatica*) aged 40 years. The stand is free of a herb layer.

MATERIAL AND METHODS

Small mammals were studied on the research plots for the period of three years (2006–2008) and sampled twice a year in the spring (June) and autumn (October) seasons by the traditional method of catching using snap traps (PELIKÁN, 1975). The traps were laid in lines at 3–5 m spacing according to the stand density, namely 100 pcs (P1, P3, P4) and 80 pcs (P2). As bait, a kerosene lamp wick parched on oil and dusted with flour or a peanut butter was used. The traps were exposed for 4 days (i.e. 3 nights) and checked every following day. At trapped individuals, species, body weight and the length of species where confusion could occur (species of the genus *Apodemus* and *Sorex*) were finally determined in a laboratory as well as other length measures. Particular animals were dissected in order to determine sex and sex activities. For species determination, standard keys were used (ZEJDA et al., 2002; ANDĚRA and HORÁČEK, 2005).

The community type was evaluated by means of 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 flavicollis*, *Myodes glareolus*) 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.

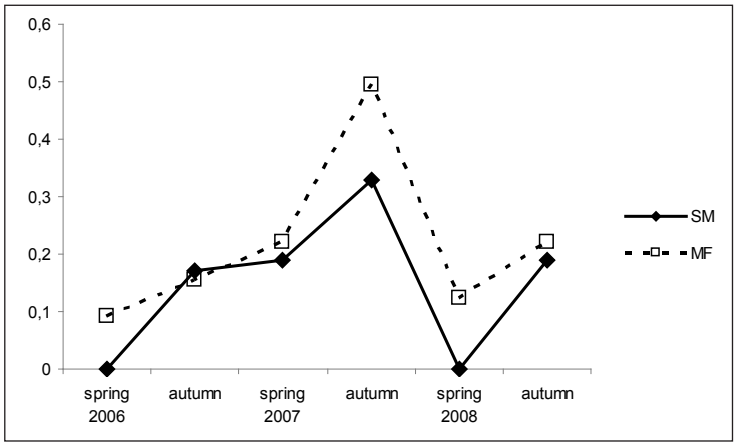
RESULTS AND DISCUSSION

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 flavicollis* 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. sylvaticus* (n = 17; D = 13.3%) and *Myodes glareolus* (n = 34;

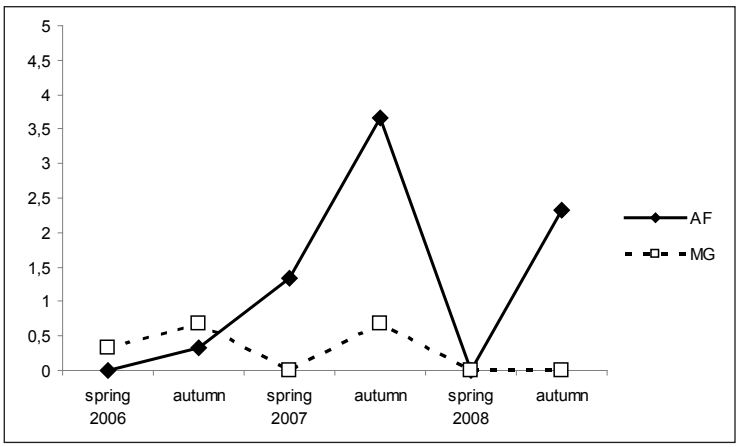
I: *Values of dominance (D), relative abundance (rA), diversity (H´) and equitability (E) of particular mammal species determined in study plots (Σ – mammals total, NTP – number of trap-nights). P1 – spruce monoculture – 105 years, P2 – mixture forest – 125 years, P3 – spruce monoculture – 30 years, P4 – beech monoculture – 40 years*

Species	P1		P2		P3		P4	
	D (%)	rA	D (%)	rA	D (%)	rA	D (%)	rA
Apodemus flavicollis	67.7	1.28	82.1	1.6	22.5	0.5	73.0	1.06
Apodemus sylvaticus	11.8	0.22	3.6	0.07	20.0	0.44	15.4	0.22
Myodes glareolus	14.7	0.28	14.3	0.28	57.5	1.28	7.7	0.11
Microtus arvalis	2.9	0.06	0	0	0	0	0	0
Sorex araneus	2.9	0.06	0	0	0	0	3.8	0.06
Σ	34		28		40		26	
NTP	1800		1440		1800		1800	
H′	1.002		0.559		0.976		0.839	
E	0.623		0.509		0.888		0.605	

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 (ZEJDA et al., 2002) in spruce stands. Also in previous



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

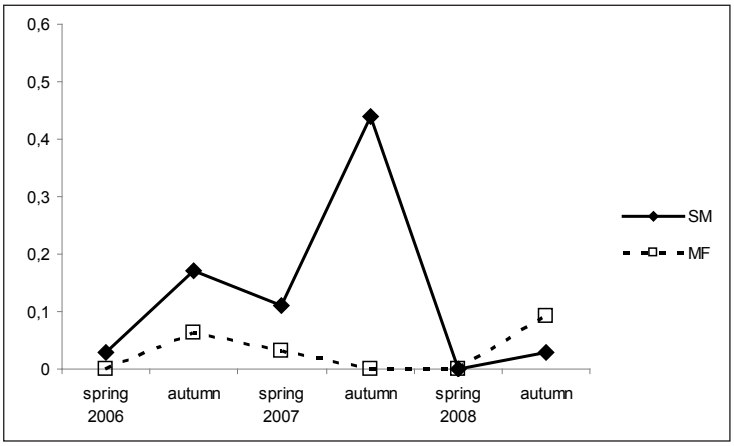


2: *Fluctuation of the abundance of Apodemus flavicollis (AF) and Myodes glareolus (MG) at P1 locality – old spruce stand (105 years)*

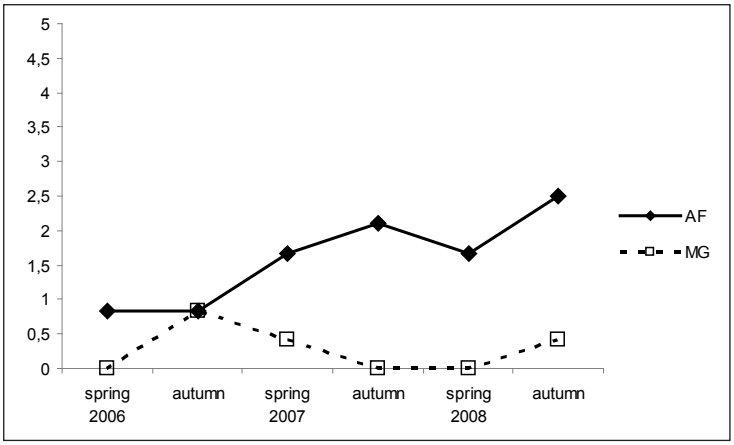
studies carried out in this field research station within MAB and IBP projects, its dominance was higher, namely about 40% to 32% (ZEJDA, 1981). It could be caused by long-term changes in the population dynamics of *A. flavicollis* (FLOWERDEW, 1985) or by changes in site conditions of forest stands in 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; HOLIŠOVÁ and OBRTEL, 1980). However, statistically significant differences were not determined (ANOVA: $p > 0.05$).



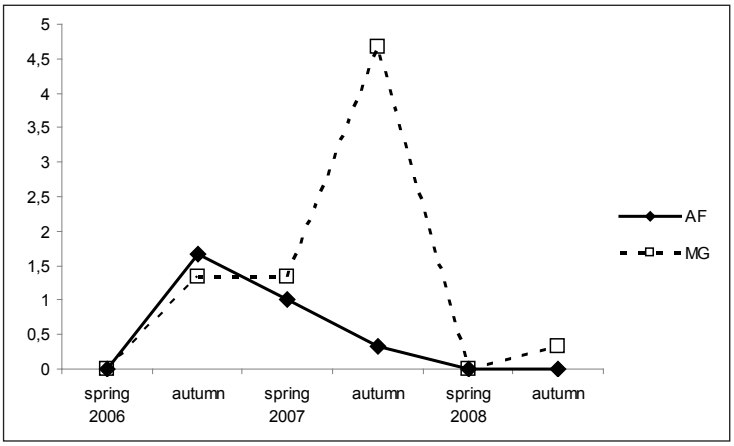
3: *Relative abundance of bank vole (Myodes glareolus); SM – spruce stands, MF – mixed and broadleaved stands*



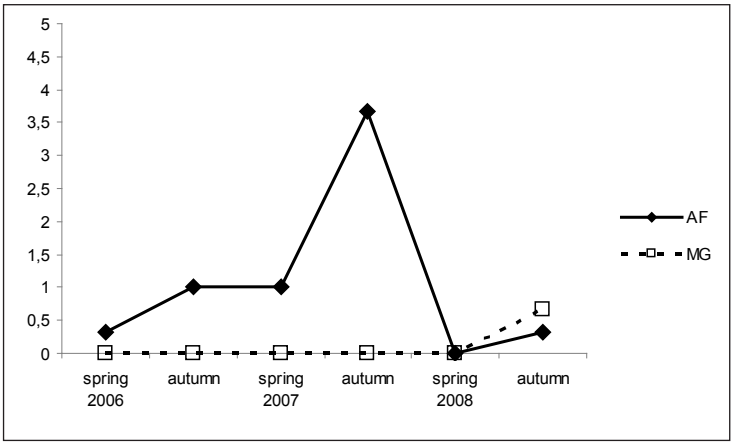
4: *Fluctuation of the abundance of Apodemus flavicollis (AF) and Myodes glareolus (MG) at P2 locality – mixed forest (125 years)*

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).

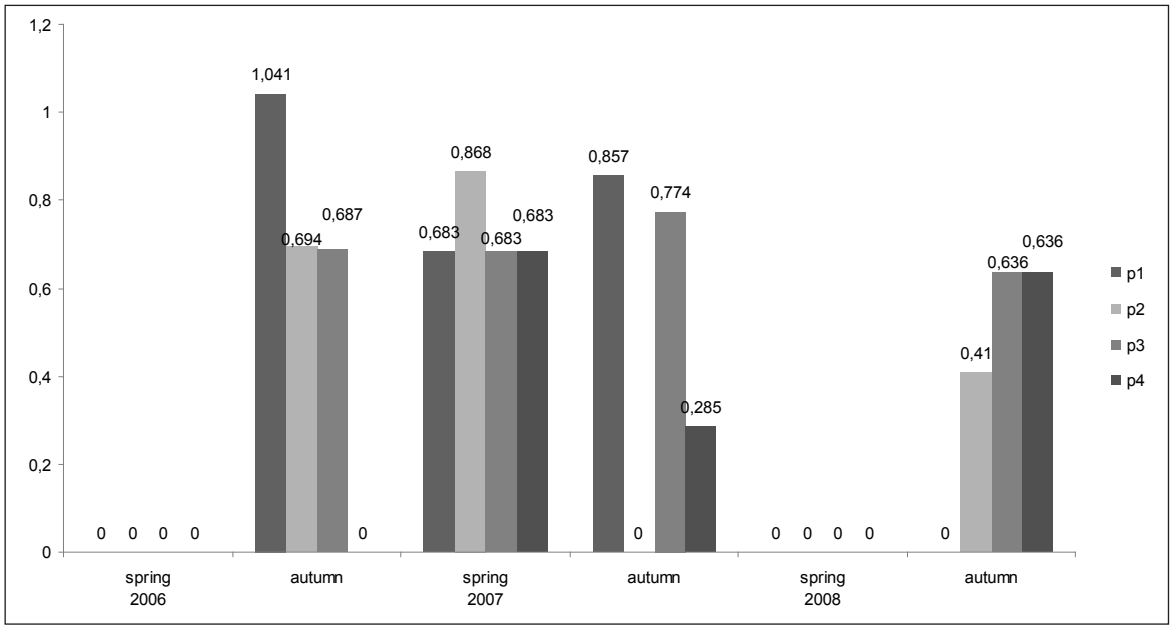


5: *Fluctuation of the abundance of Apodemus flavicollis (AF) and Myodes glareolus (MG) at P3 locality – young spruce stand (30 years)*

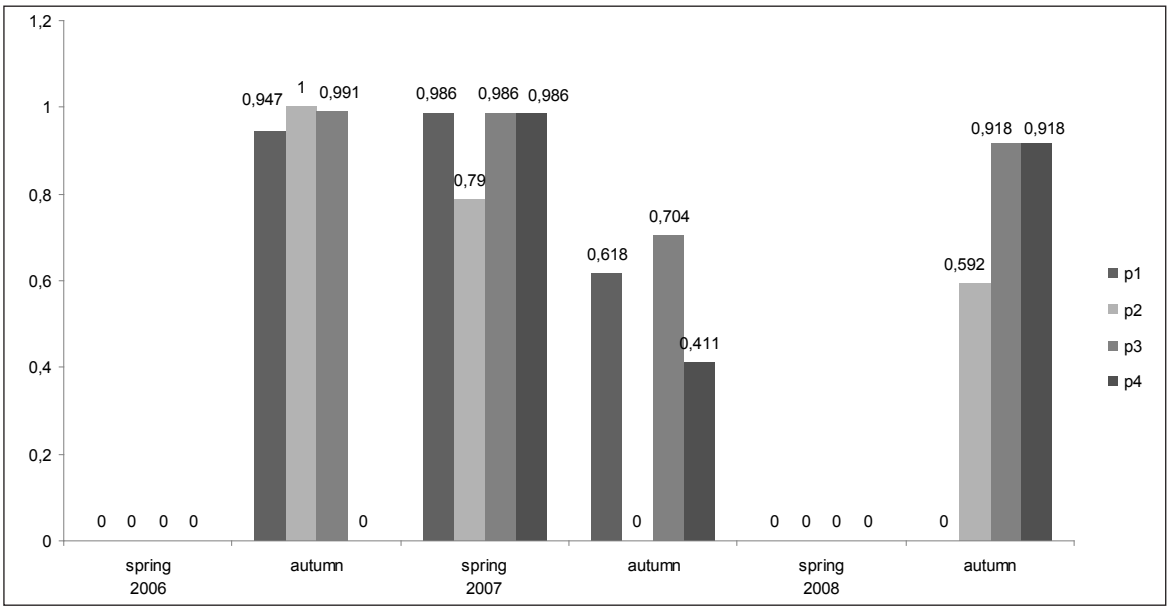


6: *Fluctuation of the abundance of Apodemus flavicollis (AF) and Myodes glareolus (MG) at P4 locality – young beech stand (40 years)*

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 lese – 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 dominancí 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 stanovišti nebyly průkazné ($p > 0,05$). Celkově se studované smrkové porosty jeví jako málo vhodná stanoviště pro drobné zemní savce, přičemž zdejší listnaté a smíšené porosty založené v rámci transformace smrkových monokultur na lesy přírodně blízké umožňují pouze zvýšení dominance adaptabilních druhů žijících v okolních smrčinách.

drobní zemní savci, smrkové monokultury, Rodentia, Soricomorpha

Acknowledgements

The study was supported by financial means of the MSM 6215648902 and VaV SP/2d1/93/07 projects.

REFERENCES

ANDĚRA, M., 1992: The small mammal community of the Hercynian mountain beech and fir forest (Šumava Mts.). *Acta Societa Zoologica Bohemoslovakiae*, 56: 81–91.

ANDĚRA, M., BURGER, P., 1992: The community of small terrestrial mammals in a climax spruce forest (the Sumava Mts.). *Folia Zoologica*, 41, 2: 97–106.

ANDĚRA, M. a HORÁČEK, I., 2005: *Poznáváme naše savce*. 2. přepracované vydání. Jihlava: Sobotales, 327 s.

BRYJA, J., HEROLDOVÁ, M. a ZEJDA, J., 2001: Společenstva drobných savců ve vrcholových partiích Beskyd. *Beskydy*, 14: 201–208.

BRYJA, J., ŘEHÁK, Z., 1998: Community of small terrestrial mammals (Insectivora, Rodentia) in dominant habitats of the Protected Landscape Area of Poodří (Czech Republic). *Folia Zoologica*, 47, 4: 249–260.

BRYJA, J., ŠUGERKOVÁ, M. a HEROLDOVÁ, M., 1999: Drobní zemní savci (Insectivora, Rodentia) nadregionálního biocentra Kněhyně – Čertův mlýn (předběžné výsledky). *Zpravodaj Beskydy*, 12: 151–156.

BÜRGER, P., ANDĚRA, M. a ZBYTOVSKÝ, P., 1987: Savci Blanského lesa (Šumavské podhůří). *Lynx, n. s.*, 23: 5–42.

ČAPEK, M., HEROLDOVÁ, M. and ZEJDA, J., 1998: Birds and small mammal communities in a clearing caused by air pollution. *Folia Zoologica*, 47, 1: 21–28.

ČERMÁK, P. and JEŽEK, J., 2005: Effect of tree seed crop on small mammal populations and communities in oak and beech forests in the Drahany Upland (Czech Republic*). Journal of Forest Science*, 51, 1: 6–14.

FLOWERDEW, J. R., 1985: The population dynamics of wood mice and yellow-necked mice. *Symposia of the Zoological Society of London*, 55: 315–338.

FLOWERDEW, S. R., GURNELL, J. and GIPPS, J. M. W. (EDS.), 1985: The ecology of woodland rodents bank voles and wood mice. *Symposia of the Zoological Society of London*, 55: 89–115.

GAISLER, J., 1983: The community of rodents and insectivores on the ridge of the Orlické hory Mts. in the ten years aspect. *Folia Zoologica*, 32, 3: 241–257.

GAISLER, J. and ŠEBELA, M., 1975: Abundance, diversity and production of small mammals (Rodentia, Insectivora) in two different forest ecosystems. *Scripta fac. Sci. Nat. UJEP Brunensis, Biologia* 2, 5: 99–114.

GILL, R. M. A., 1992: A review of Damage by Mammals in North Temperate forests. 2. Small mammals. *Forestry*, 65: 281–308.

HADAŠ, P., 2002: Temperature and precipitation condition in the high elevation spruce stands of the Drahanská vrchovina Upland. *Ekológia (Bratislava)*, 21, Supplement 1: 69–87.

HEROLDOVÁ, M., 1995: Poškozování lesní výsadby drobnými savci na imisních holinách Malého Smrku (Beskydy). *Zpravodaj Beskydy*, 7: 157–160.

HEROLDOVÁ, M. a ZEJDA, J., 1995: Výsledky výzkumu společenstva drobných zemních savců v oblasti Beskyd s ohledem na poškozování lesních porostů imisemi. *Zpravodaj Beskydy*, 7: 153–156.

HOLIŠOVÁ, V., 1971: The food of *Clethrionomys glareolus* at different population densities. *Acta Scientarium Naturalium Brno*, 5, 11: 1–43.

HOLIŠOVÁ, V. and OBRTEL, R., 1980: Food resource partitioning aminy four myomorph rodent populations coexisting in a spruce forest. *Folia Zoologica*, 29, 3: 193–207.

KLIMO, E. and MARŠÁLEK, J. (eds.), 1992: *Manmade Spruce Ecosystem (Structure, Function, Production, Processes). Report from Project Rájec.* University of Agriculture, Faculty of Forestry, Institute of Forest Ecology, Brno, 178 pp.

KING, C. M., 1985: Interactions between woodland rodents and their predators. In: FLOWERDEW, S. R., GURNELL, J. and GIPPS, J. M.W. (eds.): *The ecology of woodland rodents bank voles and wood mice.* Symposia of the Zoological Society of London, 55: 219–247.

KOLLARS, T. M., 1995: Home range and population densities of shrews (Soricidae) inhabiting a spruce plantation in Bavaria, Germany. *Acta Theriologica*, 40, 2: 219–222.

LOSOS, B., GULIČKA, J., LELLÁK, J. a PELIKÁN, J., 1985: *Ekologie živočichů*. Praha: SPN, 320 s.

MENŠÍK, L., FABIÁNEK, T., TESAŘ, V. and KULHAVÝ, J., 2009: Humus conditions and stand characteristics of artificially established young stands in the process of the transformation of spruce monocultures. *Journal of Forest Science,* 55, 5: 215–223. ISSN 1212-4834.

MONTGOMERY, W. I. and GURNELL, J., 1985: The behaviour of *Apodemus*. In: FLOWERDEW, S. R., GURNELL, J. and GIPPS, J. M. W. (eds): *The ecology of woodland rodents bank voles and wood mice.* Symposia of the Zoological Society of London, 55: 89–115.

OBRTEL, R. a HOLIŠOVÁ, V.: Povaha potravy *Apodemus flavicollis* a *Clethrionomys glareolus* v lužním lese. *Lynx*, 16: 37–45.

PELIKÁN, J., 1975: K ujednocení odchytového kvadrátu a linie pro zjišťování populační hustoty savců v lesích. *Lynx (Praha)*, 17: 58–71.

PELIKÁN, J., ZEJDA, J. and HOLIŠOVÁ, V., 1975: Influence of trap spacing on the catch size of dominant species of small forest mammals. *Zoologické Listy*, 24, 4: 313–324.

PURCHART, L. and SUCHOMEL, J., 2007: The impact of small terrestrial mammals on beech (*Fagus sylvatica)* plantations in spruce monoculture in the area of the Drahany Uplands (preliminary results). *Acta univ. agric. et silvic. Mendel. Brun.*, LV, 5: 131–135.

QUITTE, 1971: *Klimatické oblasti Československa*. Studia Geographica 16, Geografický ústav ČSAV: Brno, 73 s.

SHANNON, C. E. and WEAVER, W., 1963: *The Mathematical Theory of Communication*. Urbana: Univ. Illinois Press, 144 pp.

SHELDON, A. L., 1969: Equitability indices: Dependence on the species count. *Ecology*, 50: 466–467.

SHELFTEL, B. I. and HANSKI, I., 2002: Species richness, relative abundances and habitat use in local assemblages of Sorex shrews in Eurasian boreal forests. *Acta Theriologica*, 47, Suppl. 1: 69–79.

SUCHOMEL, J., 2007: A study of the synusia of small terrestrial mammals (Insectivora, Rodentia) of the Kelečská pahorkatina Upland – Czech Re-

public. *Acta univ. agric. et silvic. Mendel. Brun.* LV, 5: 165–170.

SUCHOMEL, J. and HEROLDOVÁ, M., 2004: Small terrestrial mammals in two types of forest complexes in intensively managed landscape of South Moravia (The Czech Republic). *Ekológia (Bratislava)*, 23, 4: 377–384.

SUCHOMEL, J. and HEROLDOVÁ, M., 2008: Effect of seed crop of trees on the abundance and body parameters of granivorous mammals in isolated forest stands of southern Moravia (Czech Republic). *Polish Journal of Ecology*, 56, 1: 155–160.

SUCHOMEL, J., HEROLDOVÁ, M. and PURCHART, L., 2007: The study of changes in the synusia of small terrestrial mammals (Insectivora, Rodentia) of top parts of the Beskids (preliminary results). *Beskids Bulletin,* 20: 211–216.

ZEJDA, J. and KLÍMA, M., 1958: Drobní savci státní přírodní rezervace Boubínský prales. *Zoologické listy*, 7, 3: 292–305.

ZEJDA, J., 1976: The small mammal community of a lowland forest. *Acta Scientarium Naturalium Brno*, 10, 10: 1–39.

ZEJDA, J., 1981: The small mammal community of a spruce monoculture. *Acta Scientarium Naturalium Brno*, 15: 1–31.

ZEJDA, J., ZAPLETAL, M., PIKULA, J., OBDRŽÁLKOVÁ, D., HEROLDOVÁ, M. and HUBÁLEK, Z., 2002: *Hlodavci v zemědělské a lesnické praxi*. Praha: Agrospoj, 284 s.

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