Ekológia (Bratislava) Vol. 25, No. 4, p. 377–386, 2006

POPULATION OF *Apodemus flavicollis* IN THREE LARGE ISOLATED FORESTS UNDER VARIOUS ENVIRONMENTAL CONDITIONS IN SOUTHERN MORAVIA (THE CZECH REPUBLIC)

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Abstract

Suchomel J., Heroldová M.: Population of *Apodemus flavicollis* in three large isolated forests under various environmental conditions in southern Moravia (the Czech Republic). Ekológia (Bratislava), Vol. 25, No. 4, p. 377–386, 2006.

Population of dominant yellow-necked mouse (*Apodemus flavicollis*) (52–70%) in southern Moravia was studied in three large forest complexes which differed in different degrees of intensity to which they are exploited by people, by defined groups of forest types and food supply. One was old semi-natural forest with dominance of oak (HL), the other was production broad leaved forest with dominant oak and black locust (HA), the third was pheasantry with variable mixture of forest plots of various woody species and age with permanent supplement of food for pheasants and roe deer (RB). During three years of research one of the years was with harvest of oak mast and year after the population abundance of *A. flavicollis* increased in all localities. Due to winter supplementary food in RB the *A. flavicollis* population reached the higher abundance if compared to the HL ($t = 2.37$; $P = 0.03$), but as to HA not significantly. Population in RB also reached a higher winter population abundances if compared to HL ($t = 30.0$; $P = 0.001$) but as to HA again not significantly. Comparing each year minima and maxima, RB all over the time oscillations of population was less pronounced. Tendency to the higher litter size was found in RB (NS) if compared to the other two localities. Sex ratio was balanced in HL (semi-natural forest). In RB and HA was the slight dominance of males. In RB maximal weight (54 g) was found. This can suggest the better body condition due to supplementary food. Population of *A. flavicollis* expressed great flexibility and sensitively reacts on various changes in its environment.

Key words: *Apodemus flavicollis*, large isolated forests, population dynamic, population structure, food supply, seed year

Introduction

Populations of small mammal species were studied in various types of forests as lowland of Moravia and Slovakia (e.g. Zejda, 1976; Dudich, Štollmann 1983; Májsky, 1985; Zejda, 1985; 1991; Krištofík, 1999) and also the other types of low altitude forests (e.g. Zejda, 1973). Our study concentrated on *Apodemus flavicollis* as it is one of the dominant species in all of them and is a good indicator of the changes in food supply (Zejda, 1976).

Population of widely distributed species living in different environments can exhibit different demographic parameters in relation to ecological characteristics of habitats (Gurnell, 1985; Montgomery, Gurnell, 1985) The yellow-necked mouse as one of the most abundant small mammals in the western Palaearctic, due to its broad flexibility utilises a variety of habitats and different environmental conditions throughout its geographical range (Zejda, 1973; 1976; Zejda, Pachinger, 1977; Pachinger, Nabaglo, 1978; Montgomery, 1979; Pachinger, 1982; Montgomery, Gurnell, 1985; Jezdrzejewska et al., 2004). As a woodland rodent prefer mature stages of deciduous forests with an open ground layer. The population dynamic is, like in the other forest species as bank vole and wood mouse, strongly related to the food supply (as mast crops) (Watts, 1969; Flowerdew, 1973, 1987; Zejda, 1976, 1985, 1991; Flowerdew, Gardner, 1978; Jensen, 1982; Pucek et al., 1993; Jedrzejewska et al., 2004). The food supply available to the population is likely to vary in quality and quantity between seasons and habitats. In years with small or failed seed crops rodent numbers are lowest in spring. Then, through the summer they increase due to breeding and reach highest autumn numbers. Reproduction ceases in autumn, and high winter mortality again leads to low numbers of rodents the following spring. Changes in rodent numbers are linked to the biomass of herbaceous vegetation on the forest floor. In years when oak or other trees shed masses of seeds in autumn and winter, the extra food improves winter survival of rodents and can even cause winter breeding (Zejda, 1962; Jezdrzejewska et al., 2004). During the following spring and summer, rodents make use of both stored seeds and also fresh vegetation and populations increase in numbers. As a result, high densities are recorded in autumn, the year after a seed fall. The outbreaks last shortly and usually dramatic decline takes place in winter.

In the present study we compare some demographic parameters (abundance, sex ratio, breeding activity) and body mass among three populations of *A. flavicollis* inhabiting different forest habitats which widely differ in food supply. Special attention was concentrated on the RB locality with permanent supply of food for pheasants and roe deer. The influence of supplementary food was studied on wood mice (Watts, 1969, 1970; Flowerdew, 1972) and voles (Andrzejewski, 1975; Andrzejewski, Mazurkiewicz, 1976; Cole, Batzli, 1978) and we presume the same influence to be on the yellow-necked mouse. Also the development of population under influence of “seed years” was described.

Material and methods

The material was obtained from three study sites in the years 2002 and 2004. They were larger forest complexes, isolated within the intensively managed landscape of South Moravia (Czech Republic). The sites are characterized by different degrees of intensity to which they are exploited by people, and by defined groups of forest types (Zlatník, Raušer, 1970; Randuška et al., 1986).

The location "Horní les" (HL) (120 ha) is a semi-natural forest cover, characterized by a group of forest types *Ulmeto-Fraxinetum carpineum*. It is situated near Lednice, lying at the approximate elevation of 164 m a.s.l. The dominant species are common ash (*Fraxinus excelsior*), English oak (*Quercus robur*), black poplar (*Populus nigra*), broadleaved lime tree (*Tilia platyphyllos*), and common maple (*Acer campestre*). In shrub layer *Cornus sanguinea*, *Euonymus europaeus, Sambucus nigra* and same young specimens of trees as of English oak (*Quercus robur*), lime tree (*Tilia platyphyllos*), and common maple (*Acer campestre*) were present. Rich herb layer was dominated by *Impatients parviflora, Urtica dioica, Ajuga reptans, Glechoma hederacea, Circeum lutetianum, Rubus caesius, Brachypodium sylvaticum, Festuca gigantean, Dactylis glomerata, Deschampsia caespitose* and the others. Four lines were lead in fruit bearing oak forest, one line in connected ash forest. Each line was of 20 snap-traps and on approximately 100 m.

The location "Hájek" (HA) (60 ha) is a typical production forest, characterized by a group of forest types *Carpineto-Quercetum acerosum*. It is situated near Vranovice, lying at the elevation 190 m a.s.l. The dominant woody species are English oak (*Quercus robur*), durmast oak (*Q. petraea*), and black locust (*Robinia pseudoacacia*). In shrub layer *Sambucus nigra* and some young specimens of trees as black locust (*Robinia pseudoacacia*) and English oak (*Quercus robur*) occur. The most frequently occurring species of the herb stratum were the grasses (*Poales)* and some species as *Viola* sp., *Geum urbanum, Alliaria* officinalis, *Pulmonaria officinalis, Galium* sp., *Lamium* sp., *Stachys sylvatica, Stelaria nemorum, Ranunculus* sp., *Ficaria verna, Rumex* sp. Two lines were lead in fruit bearing oak forest, one in mix forest (*Quercus* sp., *Tilia* sp., *Carpinus* sp., *Acer* sp.) one in locust stand and one in oak forest edge. Each line was of 20 snap-traps and on approximately 100 m.

The location "Rumunská" (RB) (280 ha), situated near the town of Židlochovice, is made use of as an intensive pheasantry, lying at the elevation 190 to 200 m a.s.l. With regard to microhabitats, the location Rumunská is the most variable area of the three ones. It includes a number of miscellaneous woody species of various age categories as well as small open areas, such as meadows, small fields, and wetlands. The most prevalent woody species in this location are English oak (*Quercus robur*), durmast oak (*Q. petraea*), Scotch pine (*Pinus sylvestris*), common spruce (*Picea abies*), and black poplar (*Populus nigra*). The following groups of forest types were identified here: *Ulmeto-Fraxinetum carpineum*, *Saliceto-Alnetum* and *Carpineto-Quercetum acerosum*. As to shrub and herb stratum great variety of species occurred. In *Ulmeto-Fraxinetum carpineum* dominance of *Sambucus nigra* and *Crategus laevigata* and also some young specimens trees occurred. In herb stratum *Urtica dioica*, *Galium aparine*, *Symphytum officinale Carex acutiformic*, *Carex riparia*, *Glechoma hederacea*, *Rubus caesius* and *Deschampsia caespitose* were dominant. In *Saliceto-Alnetum* rich shrub layer dominated by *Salix caprea* and *Sambucus nigra* with herb layer with *Aegopodium podagraria*, *Galium aparine*, *Stachys sylvatica*, *Urtica dioica*, *Impatiens noli-tangere*, *Equisetum sylvaticum*, *Deschampsia cespitosa*, *Cardamine amara* in dominance occurred. In *Carpineto-Quercetum acerosum* highest dominance of *Acer campestre* and young specimens of tree stratum occurred with dominant species in herb stratum as *Alliaria officinalis*, *Veronica hederifolia*, *Lapsana communis*, *Urtica dioica* and *Aristolochia clematis*. Two lines were lead in fruit bearing oak forest, one in young oak stand, one in spruce forest, one in pine forest and one in forest edge. Five lines was of 20 snap-traps and on approximately 100 m exception one line of 50 snap-traps in edge of forest. As a supplemented food for pheasants and roe deer corn of wheat, barley and maize was given.

As to sample the individual forests, trapping lines were lead in all characteristic types of stands.

In the year 2001 was a good harvest of lime and hornbeam seeds and in the year 2003 harvest of oak mast in all localities. Differences were stated also in percentage of old oak stands in localities.

In all trial plots, the methodology of traditional line trapping was applied. Snap traps were used and baited with a wick fried in pork fat or spread with peanut butter. The animals were trapped at even intervals five times a year in the years 2002–2004. Each catch took three trap-nights. The trapped individuals were dissected in a laboratory. They were classified according to the species, body size, sex, and sex condition. From this material the population of *Apodemus flavicollis* was evaluated (Table 1). The age of each individual was estimated on the basis of body

Table 1. Numbers of *Apodemus flavicollis* individuals trapped in individual localities (T/N – trap/nights).

	2002					mast harvest 2003					2004					
	II/III	IV/V	VI/VII	VIII/IX	X/XI	II/III	IV/V	VI/VII	VIII/IX	X/XI	II/III	IV/V	VI/VII	VIII/IX	X/XI	T/N
HA	15	10	15	26	14	1	1	8	11	30	1	55	54	65	25	300
HL	1	2	12	48	16	3	1	10	5	10	0	10	35	77	27	300
RB	7	3	5	56	31	13	9	13	28	30	3	39	46	54	34	450

weight according to Gliwicz (1988) and all individuals were divided into adult ($m \geq 25$g) and young (subadult and juvenile; $m \leq 25$ g) age classes.

The relative abundance of *A. flavicollis* ln(rA) was expressed as the number of individuals trapped per the number of trap-nights. Differences between the forests *A. flavicollis* population's parameters were compared and statistically evaluated by t-test. The body weights were compared using Mann-Whitney test (software Statistica for Windows).

Results

During 15 trapping periods (15 750 trap nights) altogether 1585 of small mammal species were captured from which 959 individuals of *Apodemus flavicollis* (60.45%). Beside these, following species were recorded: *A. sylvaticus* (L.) (19.43%), *Clethrionomys glareolus* (S c h r e b.) (14.82%), *Apodemus microps* (K r a t. & R o s.) (0.25%), *Microtus arvalis* (P a l l.) (4.10%), *M. subterraneus* (de S é l y s-L o n g c h a m p s) (0.25%), *Mus musculus* (L.) (0.13 %), *Sorex araneus* (L.) (0.44%), *Crocidura leucodon* (H e r m.) (0.13%).

Apodemus flavicollis was the most numerous species in all forests and dominance of its population was 52.05% in RB, 68.53% in HA and 70.22% in HL. The variability of population was influenced probably by percentage of oak seed bearing trees presence in localities.

The dynamic of *A. flavicollis* abundance differed in each of the forest stand. In RB peasantry, mice population utilized also food supplemented for pheasants and deer and showed higher winter abundances compared to other localities. Its abundance minima differed from the other experimental plots if compared with HL ($t = 30.0$; $P = 0.001$) but not significantly with HA. Locality HA is smallest and more seed bearing species of trees are presented. *Apodemus* sp. is able to go also to the fields around. Comparing each year minima and maxima, RB all over the time oscillation of population was less pronounced. During all three years research RB population of *A. flavicollis* differed in abundance compared to the HL forest (Table 2), but as to HA difference was not significant (Fig. 1). The differences between HA and HL was also not significant (Table 2). The minimum in abundances at the beginning of the year 2004 was probably done by low attractivity of snap traps bait as enough natural food supply was available.

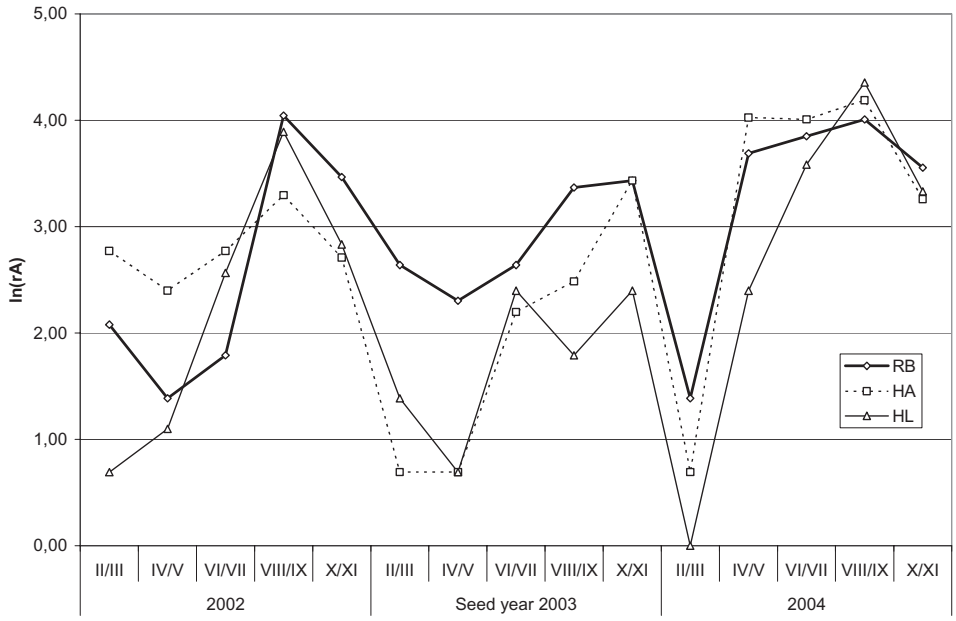

Fig. 1. Abundance (ln) of Apodemus flavicollis in the studied forests (ln(rA) – logarithm of relative abundance).

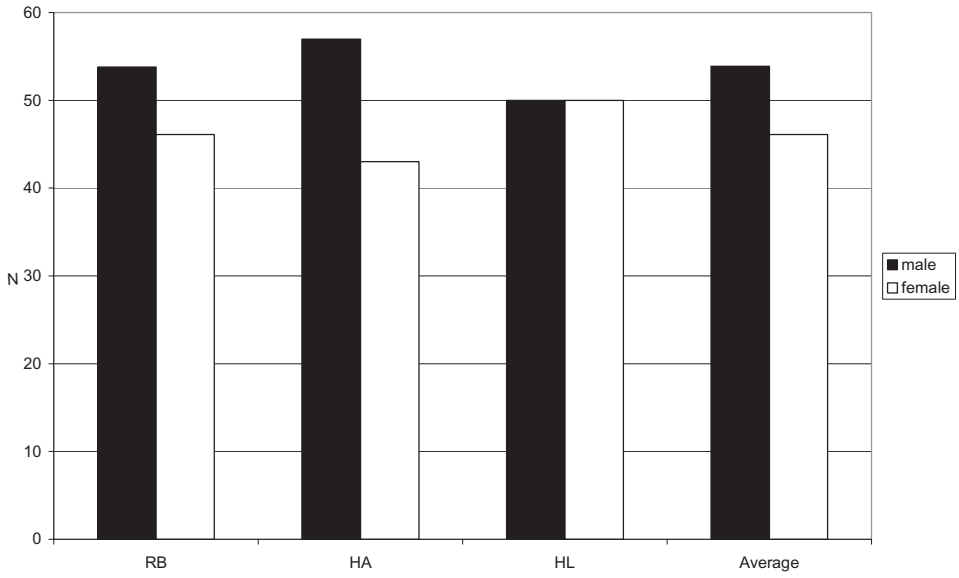

Fig. 2. Sex ratio in three forests localities (N – number of individuals).

The year 2003 was characterised by good crop of oak mast in all localities. The following year population abundance increased in all localities. The slightly higher abundance (NS) was found in HL as forest was dominated by old oaks but in RB peak abundance lasted longer.

Sex ratio was balanced in HL (semi natural forest). In RB and HA slight dominance of males (NS) was recorded (Fig. 2).

T a b l e 2. Differences in relative abundances of the three forests under research.

	t	P
RB : HA	0.798	0.438
RB : HL	2.370	0.033
HA : HL	0.231	0.238

The reproduction period started in March and ended in September in the years 2002 and 2003 in all localities. Only in one case the reproduction was prolonged into the beginning of November in HA (2003 seed year). Shorter duration of breeding season was stated in a peak year 2004 where started in March and ended in the mid of August.

Slight differences (NS) in sexually active females (only with embryos) were found between RB and the other two forests. In HL altogether 32.08% were the active, in HA 39.62 %, but in RB only 28.3%. If also females with placental scars included, the most of sexually active females were found in RB (37.1%), less in HA (33.3%) and least in HL (29.56%). If evaluated in individual years, in spring (peak year 2004) the most sexually active females were in HL (71%) les in RB (67%) and least in HA (60%). As to average litter size differences between the localities were found no significant. Average litter size in the year 2002 was largest in HA but in the years 2003 and 2004 the larger in RB but not significantly (Table 3).

T a b l e 3. Average litter size with minimum and maximum in three experimental forest complexes.

Localities	2002	2003	2004	Average	Min.	Max.
HA	7.17	5.00	4.89	5.69	3	8
RB	4.67	6.00	5.25	5.31	3	9
HL	5.20	5.50	4.80	5.17	4	13

Animals of both sexes were not significantly heavier in any of the localities (Table 4). The maximal individual weight was found in RB (54 g). The mean weight of the whole sample was 29.90 g there. In HL mean weight was 30.04 g and in HA mean weight was 26.24 g. The mean body weight of *A. flavicollis* varied rather little in the various population samples. In the summer ones, the mean body weight was lower than in the autumn. This fact was caused by the relatively higher percentage of juvenile and sub-adult individuals in the population in summer.

T a b l e 4. Variation in body mass (g) in population of *Apodemus flavicollis* on individual localities. SD – standard deviation. Some individuals were eliminated of as the weight was influenced by carnivores.

Locality	HA					HL					RB				
Date	n	Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.
II/III 02	15	33.7	5.99	16	44	1	29	–	29	29	7	31.4	5.68	23	40
IV/V 02	10	37.5	6.02	25	46	2	40	0	40	40	3	38.0	5.89	32	46
VI/VII 02	15	26.5	9.19	11	45	8	25.6	5.83	15	37	5	25.4	6.8	20	38
VIII/IX 02	26	24.8	5.90	17	41.5	48	24.2	8.48	9	41.5	56	24.4	6.83	10.5	39
X/XI 02	14	26.7	5.46	18.5	36	15	25.0	3.28	18.5	30.5	30	27.4	4.5	16.5	38.5
II/III 03	1	33	–	33	33	3	27.3	1.89	26	30	13	31.5	4.91	24.0	40
IV/V 03	0	0	–	–	–	1	35	–	35	35	9	29.9	8.45	13	37
VI/VII 03	8	28.7	4.62	17.5	33	10	30.5	7.85	15	45.5	12	29.7	7.38	12	39
VIII/IX 03	11	28.6	7.48	13	36	5	33.4	3.5	29	38	27	26.9	10.0	10	44
X/XI 03	30	22.4	8.21	10	40	10	28.8	7.0	20.5	42.5	30	24.0	6.0	9	41
II/III 04	1	23.5	–	23.5	23.5	–	–	–	–	–	3	37.5	2.04	35	40
IV/V 04	55	23.1	13.02	6	43.5	10	32.9	13.44	12	51	39	28.2	11.67	9	49
VI/VII 04	54	25.1	10.73	6.5	49	35	26.3	11.29	10	53	46	29.4	9.44	5	54
VIII/IX 04	65	28.8	7.30	14	45	77	28.1	6.57	10	47.5	54	29.6	7.11	15.5	49
X/XI 04	25	32.0	5.33	21	44	27	34.2	6.27	26	48	34	35.2	7.48	21	50

Discussion

During the study of small mammal populations in three large forest complexes in southern Moravia *Apodemus flavicollis* was the dominant species (mean 64%). HL is old, lowland forest with highest biomass of herb stratum and presence of old seed bearing trees which can be most suitable for *A. flavicollis* population. Quite different to this is the RB with mosaic of forests of various age categories as well as small open areas. Dominance of *A. flavicollis* was lowest there. HA is a typical production forest with various tree species dominated by oak with mostly grasses in a herb stratum. Also high abundance of *A. flavicollis* was found there. Zejda (1973) investigated the populations of small mammals in certain forest types groups in southern Moravia. *A. flavicollis* is, by his findings, as oligofagous species and having great spatial activity, able to reach uniform occurrence in various types groups of forests in the oak tier depending on presence of trees bearing seeds.

The *A. flavicollis* has a broad flexibility and utilizes variety of habitats. As woodland rodents its populations prefer forest with seed bearing trees (Zejda, 1973, 1976; Jezdrzejewska et al., 2004). It is known that *A. flavicollis* prefers tree seeds (Obrtel, Holišová, 1974). Its population dynamic is influenced by feasibility of the biotope. As in Pachinger, Nabaglo (1978), influence of various localities resulted in various numbers of *A. flavicollis*.

As to the dynamic of abundance during the 3 years of study it seems the years 2002 and 2004 to be similar. As the harvest of seeds in forests varied in years, it was observed that the year 2001 and 2003 were medium sized seed crops. In the year 2001 was a good harvest of hornbeam and lime seeds and this also positively influenced the abundance and litter size of *A. flavicollis* populations in 2002 especially in HA as hornbeam and lime are highly represented there. In 2003 and 2004 winter abundance and litter size was highest in RB where food was supplied for pheasants and deer. Year 2003 was a good crop of oak mast. The abundance of *A. flavicollis* increased in all localities during the following year 2004. By Watts (1969), Flowerdew (1973), Zejda (1976), Flowerdew, Gardner (1978), Jensen (1982), Zejda (1985), Pucek et al. (1993), Jedrzejewska et al. (2004) and some others, large crop of tree seeds in forest positively influence the dynamic of seed eating small mammals in a year after "seed year".

In RB population of *A. flavicollis* was permanently supplemented by food for pheasants and deer. Under this influence it reached higher winter and spring population abundance compared with other two forests. The all over the time oscillation of this population was less pronounced (yearly maxima and minima). It also showed higher litter sizes in spring and summer. However, populations in all forests declined during the late summer and autumn. By Watts (1969, 1970) and Flowerdew (1972, 1985) food quality appears to influence the amplitude of the fluctuation in numbers but not the decline. It is that both food and behaviour are limiting numbers at the same time. Experiment on Townsend voles (*Microtus townsendii*) in Canada proposed that supplementary food sets the ultimate limit to population growth but that social organization will provide a proximate limitation, and also that this has evolved to maximize individual fitness (e.g. Tamarin, 1983).

Our data are comparable to the findings of Krištofík (1999) with the mean litter size being about 5 in lowland forests. Prolongation of breeding season in a seed year was observed by Zejda (1976). Reproduction was prolonged into the beginning of November in our study only in one case in HA locality.

Sex ratio was in our case balanced in HL. It is characteristic feature of stable population living in optimal habitats (Trubenová et al., 2005). In other two localities it was slightly shifted to the dominance of males.

Number of sexually active female also indicates quality of habitat (Zejda, 1976; Mazurkiewicz, 1991; Mazurkiewicz, Rajska-Jurgiel, 1989). By dominance of this species the most suitable forest type was HL. But not a great differences (NS) were found between the localities. Highest number of females with embryos and placental scars were found in RB as probably due to better overwintering as indicated by higher abundances during the winter. Also higher mean litter size in two year time confirms influence of diet supplementary food (Flowerdew, 1972, 1985; Flowerdew, Gardner, 1978).

Body weight also provides information about the habitat quality (Trubenová et al., 2004). Higher mean and maximal body weight was found in RB. This can be also influence of supplemental food presence at this locality.

Conclusion

In three large forest complexes of southern Moravia the population of *Apodemus flavicollis* as a dominant species of small rodents was studied. Forests differed in different degrees of intensity to which they are exploited by people, by defined groups of forest types and food supply and this influenced the abundance of individual populations. Higher winter abundances were reached under supplementary food in RB pheasantry and also the litter size and body weight was positively influenced by better food condition there. Higher abundance during 2004 was reached in all forests in consequence of a seed year but in HL – old oak forest, was the highest. HL seems to us as the most optimal biotope in spite of higher winter abundance in RB under influence of additional food supply. High winter abundance in HA at the beginning of 2002 was reached after a good hornbeam and lime seed harvest in a previous year and also the mean litter size in that year was the highest. Due to its broad flexibility *A. flavicollis* utilizes variety of habitats and sensitively reacts on changes of its environmental conditions.

Translated by the authors

Acknowledgement

This paper was supported by GAČR 526/03/P051 and GA ČR 206/04/2003.

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Received 2. 5. 2005

Suchomel J., Heroldová M.: **Populace** *Apodemus flavicollis* **ve třech větších lesních porostech lišících se různými podmínkami prostředí.**

Populační dynamika dominantní *Apodemus flavicollis* (52–70%) byla studována na jižní Moravě ve třech větších lesních komplexech které se lišily mírou obhospodařování člověkem, lesními typy a potravní nabídkou pro populace drobných hlodavců. V průběhu tří let výzkumu (2002–2004), rok 2003 byl "rokem semenným" s úrodou žaludů a abundance myšic stoupla na všech lokalitách. Nejvyšších hodnost (NS) dosáhla v Horním Lese (HL) - ve staré bučině. Na lokalitě Rumunská Bažantnice (RB) byli bažanti a srnci celoročně přikrmováni obilím a kukuřicí a důsledkem toho byla zjištěna vyšší abundance *A. flavicollis* populace v zimním období. Pozitivně byla též ovlivněna velikost vrhu a hmotnost zvířat (NS). Na lokalitě Hájek (HA) byla zjištěna rozdílná a vyšší hodnota abundance na začátku roku 2002 jako důsledek úrody semen lípy a habru v předcházejícím roce a také z celého období nejvyšší velikost vrchu. Populace *A. flavicollis* projevila velikou flexibilitu a citlivě reagovala na různé změny v jejím prostředí.