Effect of tree seed crop on small mammal populations and communities in oak and beech forests in the Drahany Upland (Czech Republic)

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ABSTRACT: In 2002 (year with poor seed crop) and 2003 (year with good seed crop), the trapping of small mammals was carried out into standard snap-traps on transects situated in the area of the Křtiny Training Forest Enterprise, U buku locality (the Drahany Upland). The trapping was carried out in both years once a month in the period of September–November, in two types of forest of the community *Querci-fageta*: in a stand dominated by oak and in a stand dominated by beech. In total, 146 individuals were recorded, out of them 142 rodents – *Apodemus flavicollis* (81 individuals), *Apodemus sylvaticus* (32), *Clethrionomys glareolus* (29) and 4 individuals of insectivores – *Sorex araneus*. *Apodemus flavicollis* dominated in both types of stands. In the most numerous *Apodemus flavicollis*, body dimensions were compared between oak and beech stands; the differences were not significant. Species diversity (owing to the presence of *Sorex araneus*) is slightly higher in oak stands (diversity index H‘ = 1.60) as compared with beech stands (H‘ = 1.43). From the aspect of faunistic similarity, it is the case of very similar communities (*Re* = 97.3; I_{BC} = 0.79). In all trapped individuals, basic body parameters were measured. In the oak forest, a higher total abundance was determined in all species as compared with the beech forest. Rodent populations responded to the poor crop of beechnuts and acorns in 2002 by a decline in numbers and to the good seed crop in 2003 by an increase in numbers (*Apodemus* spp.). Another response was the prolongation of reproduction period. In stomachs of the rodents caught in 2003 the percentage of starch granules of consumed food was superior to 2003.

Keywords: small mammals; oak forest; beech forest; seed crop; *Apodemus* spp.; *Clethrionomys glareolus*

A number of authors have studied problems of mammal communities in broadleaved forests of Central Europe. However, only a small part of papers deals with broadleaved forests of the normal hydric series of uplands. Papers concerning floodplain forests where small mammals reach relatively high abundance and species diversity are very numerous. In the floodplain of the Dyje and Morava rivers, detailed repeated studies were carried out by Zejda (1973, 1976, 1985, 1991), Pelikán et al. (1974), Krištofík (1999), in the area of the Odra river by Bryja and Řehák (1998), in Litovelské Pomoraví by Rumler (1988), in the Danube lowland e.g. by Májsky (1985), Brtek (1986) or Krištofík (1999), in the Bialowieza National Park by Rajska-Jurgiel (1992), etc. Some papers aimed at seed consumption by rodents (*Apodemus* species and *Clethrionomys glareolus*) in forests with beech and oak outside of the floodplain were published, but the problem remains interesting for forestry. Feeding habits were researched in papers by Holišová (1960), Drożdż (1966), Abt and Bock (1998), in the north of Europe by Jensen (1985), etc. Part of findings on small mammal communities from these types of forests is then

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summarized in comprehensive papers such as that of Zejda et al. (2002). The objective of the paper was to obtain findings (and to compare them) on small mammals and their responses to good or poor seed crops in two marked types of broadleaved forests on one of the most widespread sites of the 3rd forest vegetation zone of the Drahany Upland, on an oligotrophic-mesotrophic site of a normal hydric series.

STUDY AREA

The locality is situated in the area of the Křtiny Training Forest Enterprise Masaryk Forest between Soběšice and Útěchov, about 10 km north of Brno, in the part of a forest unit called U buku. It refers to two pairs of stands (oak forest and beech forest) belonging to the group of geobiocoenosis types *Querci-fageta* 3AB3 according to Buček and Lacina (1999) or *Melico-Fagetum* Seibert 1954 according to Moravec et al. (2000). In areas of the oak forest, sessile oak *Quercus petraea* predominates being complemented by European beech *Fagus sylvatica*, European hornbeam *Carpinus betulus*, Scots pine *Pinus sylvestris* and small-leaved linden *Tilia cordata*. *Melica nutans* and *Poa nemoralis* predominate as undergrowth species. Total cover of the herb layer exceeds 60%. In plots of the beech forest, *Fagus sylvatica* predominates being complemented by sessile oak *Quercus petraea*, European hornbeam *Carpinus betulus* and small-leaved linden *Tilia cordata*. *Melica nutans, Poa nemoralis, Carex pilosa* and *Galium odoratum* dominate in undergrowth. Total cover of the herb layer amounts to about 30–40%. The age of all stands is over 110 years. In all cases, it refers to slightly open stands (decreased canopy density) with a slightly developed shrub layer (degree of coverage ≤ 10%).

MATERIAL AND METHODS

The trapping was carried out using standard snap-traps. Pieces of a 1cm wide wick impregnated with a mixture of fats and thickened flour were used as universal bait. The traps were arranged in direct lines 100 m long at regular distances 4 m apart. There were some 25 traps on each of the lines and 2 lines were in each of the stands. Two beech and two oak stands were monitored. These pairs of stands were comparable from the aspect of species composition and other characteristics (see above). The trapping was always carried out during two nights once a month in the period of September–November and trap inspection was made always in morning hours. Caught individuals were identified and their sex, basic measures (using a beam calliper measuring to the nearest 0.5 mm) and weight parameters determined: G – weight, LC – body length, LCd – tail length, LTp – hind foot length, LA – auricle height. To verify the rate of seed consumption, simple post mortem analyses of the stomach content were carried out in trapped individuals. Within the dissections possible pregnancy of females was recorded.

For particular species of mammals, dominance and relative abundance were determined in both types of stands as the number of individuals per 100 trap-nights. Diversity index according to Shannon and Weaver (1963) and equitability according to Sheldon (1969) were calculated for both forest types. Faunistic similarity of the community of small mammals of both types of forest was expressed as Renkonen number (Losos et al. 1985) which assesses similarity on the basis of dominance of common species and as Bray-Curtis index (Losos et al. 1992) which assesses the similarity of zoocoenoses by means of differences between abundances of all found species.

Dissection determined: sex, female gravidity, extent of stomach filling, percentage of starch granules in consumed food in stomachs (Table 1).

RESULTS

In total, 146 individuals of small mammals were trapped, out of them 142 individuals of Rodentia – *Apo-*

Table 1. Scales for assessment of stomach filling and of starch granule volume in consumed food in stomach

	Assessment of stomach filling (% of stomach volume)	Assesment of the starch granules (%) in consumed food in stomach
0		None of starch granules
1	1–20	1–20
2	21–40	21–40
3	41–60	41–60
4	61–80	61–80
5	81–100	81–100

Table 2. Basic characteristics of small mammal communities (2002–2003). Number of individuals (*N*), dominance (%), relative abundance (numbers of individuals per 100 trap-nights), diversity index (H‘), equitability (E)

Species	Forest type				Total	
	Oak stand		Beech stand			
	N	(%)	*N*	(%)	*N*	(%)
Apodemus flavicollis	49	55.7	32	55.2	81	55.5
Apodemus sylvaticus	17	19.3	15	25.9	32	21.9
Clethrionomys glareolus	18	20.5	11	19.0	29	19.9
Sorex araneus	4	4.5	–	–	4	2.7
Total	88	100.0	58	100.0	146	100.0
Relative abundance	14.7		9.7		9.7	
No. trap-nights	1,200		1,200		2,400	
No. species	4		3			
Shannon & Weaver diversity (H‘)	1.60		1.43			
Sheldon equitability index (E)	0.80		0.72			

demus flavicollis (81 individuals), *Apodemus sylvaticus* (32), *Clethrionomys glareolus* (29) and 4 individuals of Insectivora – *Sorex araneus*. In both types of forest, *A. flavicollis* was the most numerous species. In the oak forest as compared with the beech forest, higher total numbers of individuals were found in all three species of rodents and moreover, *S. araneus* was also detected there. Thanks to the presence of *S. araneus*,

Table 3. Body parameters and weight of small mammals – minimum, maximum, average

Species	Acronym	Min.–max.	Average	Unit
Apodemus flavicollis	G	20–47	32.7	g
	LC	86–116	101.2	mm
	LCd	90–118	106.7	mm
	LTp	22–25	23.4	mm
	LA	16–22	18.5	mm
Apodemus sylvaticus	G	18–35	25.2	g
	LC	82–111	92.2	mm
	LCd	91–104	97.7	mm
	LTp	20–24	22.6	mm
	LA	14–19	17.2	mm
Clethrionomys glareolus	G	13–21	18.1	g
	LC	75–101	87.3	mm
	LCd	38–51	43.8	mm
	LTp	15–18	16.4	mm
	LA	11–15	13.3	mm

Table 4. Average body parameter differences in male and female *Apodemus flavicollis* from oak and beech stands

Sex	Parameter	Average		Sex	Parameter	Average	
		oak stand	beech stand			oak stand	beech stand
♂	G	31.2	33.8	♀	G	27.3	28.3
	LC	100.3	101.4		LC	97.5	96.9
	LCd	102.3	105.1		LCd	98.6	107.5
	LTp	23.4	23.4		LTp	22.8	22.6
	LA	18.3	18.5		LA	18.5	18.3

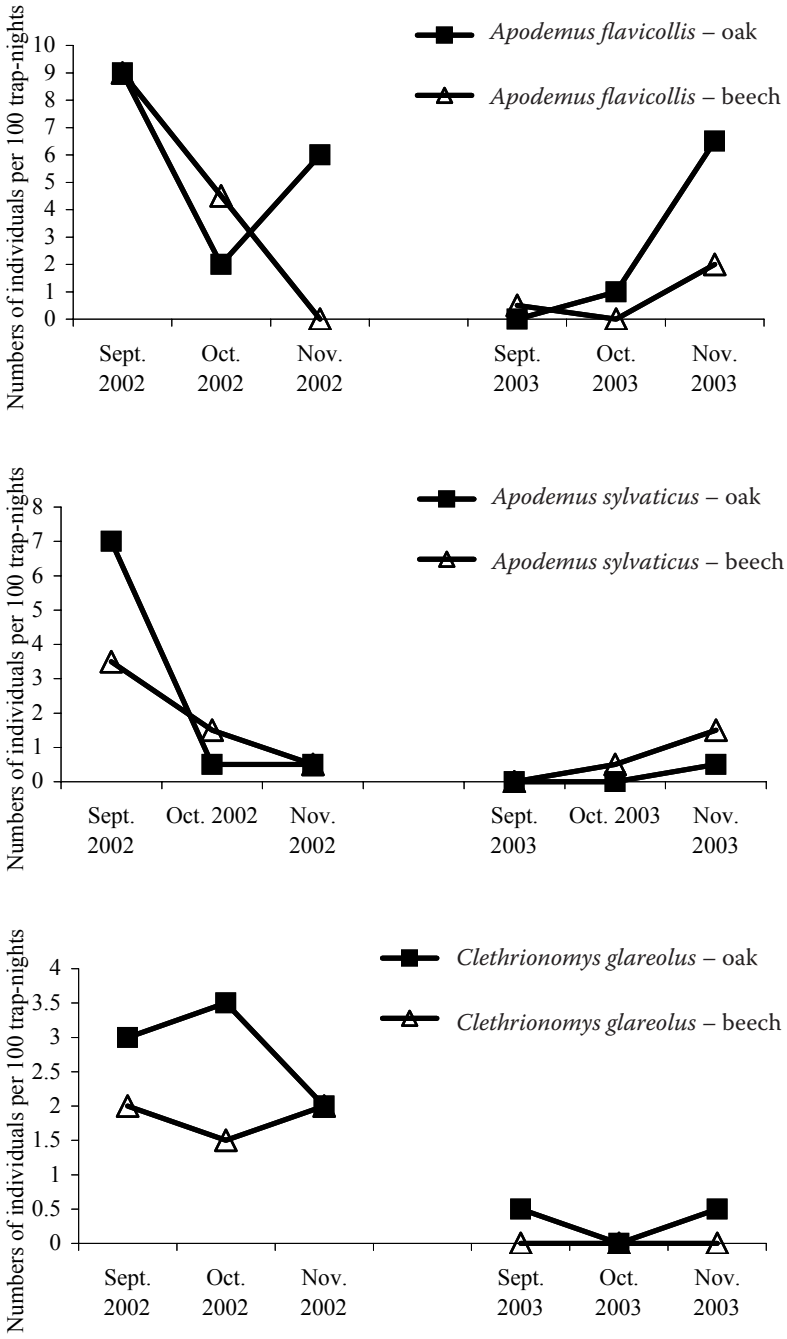


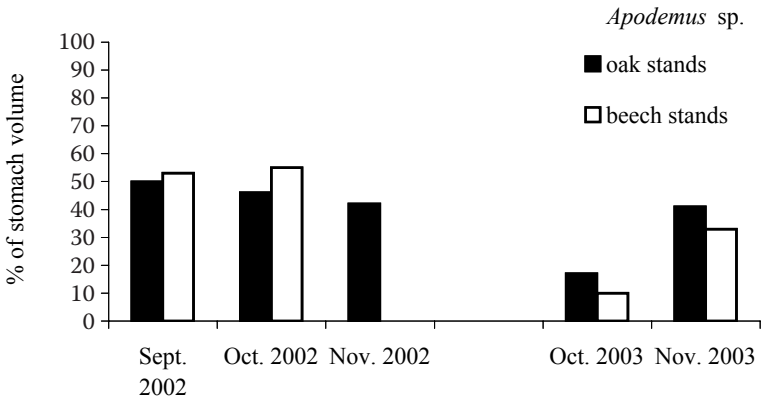
Fig. 1. Changes in relative abundances of *Rodentia* in oak forest and beech forest

species diversity is slightly higher in oak stands as compared with beech stands; oak stands also show slightly higher equitability (Table 2). In 2002, the total abundance of small mammals markedly exceeded the values of the year 2003 (2002 – 116 individuals, 2003 – 30 individuals).

The highest abundance was recorded in *A. flavicollis* in September 2002, both in oak and beech stands – 9 individuals/100 traps per one night (Fig. 1). During autumn 2002, relative abundance mostly decreased and minimum values were reached in September and October 2003. In November 2003, a slight increase in abundance was noticed again above all in *Apodemus* species.

Evidently juvenile individuals (with respect to coloration, body dimensions – e.g. as compared with Pelikán 1967) which occurred particularly on September dates of trapping (in 2003, thanks to the high crop of acorns, however, also in November) were not included in total data on body dimensions of particular species at both localities. Minimum, maximum and average values of particular body parameters and weights are given in Table 3.

In *A. flavicollis*, the number of trapped individuals made it possible to compare body parameters of the field mice from oak and beech stands, however, differences were not statistically significant (Table 4).



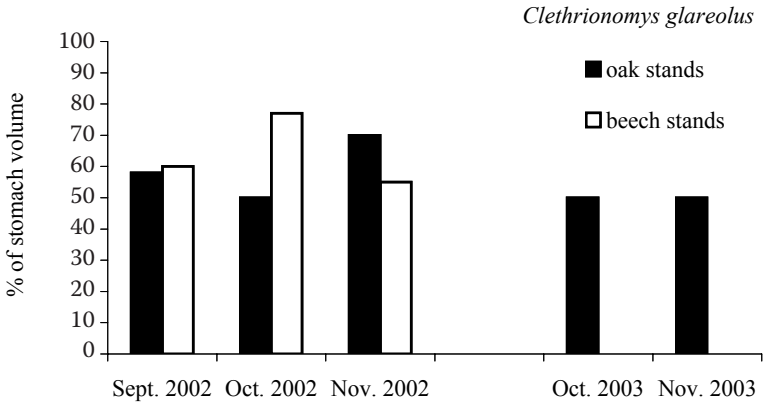
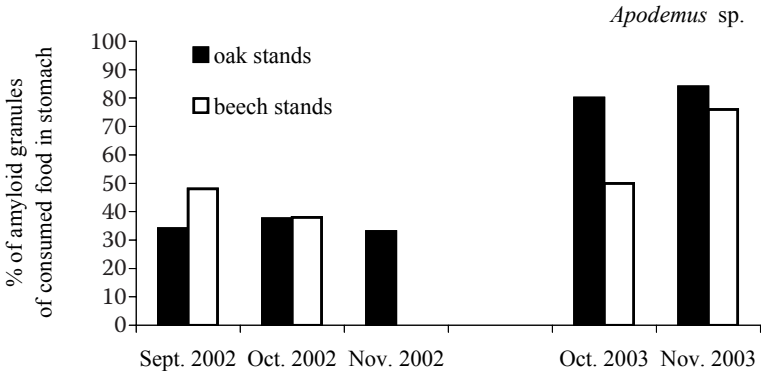


Fig. 2. Extent of stomach filling



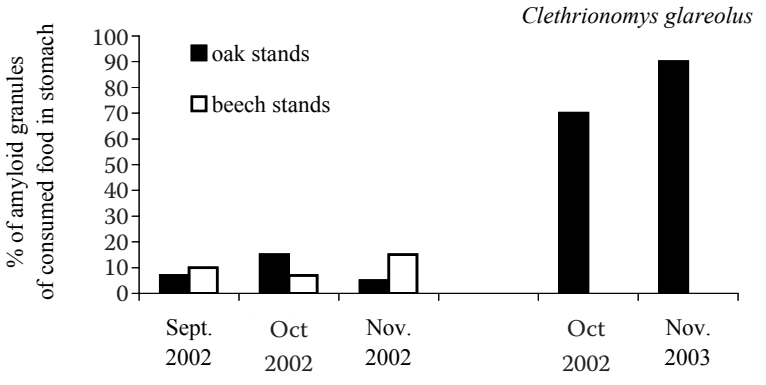


Fig. 3. Proportion of seeds in rodent diet (percentage of starch granules in consumed food in stomach)

Table 5. Numbers of males and females, sex ratio of small mammal populations

Species	2002		2003		Total
	♂	♀	♂	♀	sex ratio
Apodemus flavicollis	29	33	13	6	1.00:0.93
Apodemus sylvaticus	10	17	4	1	1.00:1.29
Clethrionomys glareolus	17	10	1	1	1.00:0.61
Sorex araneus	1	0	1	2	–

Sex ratio in the most numerous *A. flavicollis* was relatively balanced in particular trappings (Table 5), however, it showed a marked difference between 2002 and 2003. While in 2002 females slightly dominated, in 2003 males prevailed. In 2003, however, the number of trapped individuals is insufficient for any decisive conclusions.

In 2002 the average extent of stomach filling of two *Apodemus* species was comparable and lower than the extent of filling in *Clethrionomys glareolus* (Fig. 2). The decline in stomach filling in 2003 with the consumption of seeds higher than in 2002 was found in *Apodemus* spp., but the number of trapped individuals was too small to be assessed exactly. The trend of an increase in seed proportion in diet (or more precisely the percentage of starch granules in consumed food in stomach) is also obvious (Fig. 3).

The structure of the small mammal zoocoenosis in oak stands is very similar to that in beech stands. The high similarity of both communities is supported by the value of Renkonen number (*Re* = 97.3) and Bray-Curtis index (I_{BC} = 0.79). From the aspect of differences between the abundances of found species, the similarity of two zoocoenoses is considered to be significant if $I_{BC} > 0.6$.

DISCUSSION

Eudominance of *A. flavicollis* in broadleaved forests is reported in a number of similar studies. In the majority of cases, however, *A. flavicollis* is only the second most abundant rodent after *C. glareolus* (Pelikán et al. 1974; Krištofík 1999; Zejda et al. 2002). Nevertheless, cases when the field mouse predominated were also noticed, for example in floodplain forests in southern Moravia (Zejda 1976) where dominance of the field mice exceeded 40% or in a floodplain forest in Poodří (Bryja, Řehák 1998) and Litovelské Pomoraví (Wolf 1996) where dominance exceeded 50%.

A marked decrease in the abundance of mammals in 2003 can be explained by the very small crop of beech and oak seeds in 2002. After the relatively good year 2001, beech and oak trees hardly yielded any seeds in the studied localities in 2002. Poor crops manifested themselves by the marked decrease in the number of particularly field mice. Seeds of woody species form a predominating component of food in the mouse in autumn (particularly in October and November) (Drożdż 1966; Abt, Bock 1998). In *A. sylvaticus*, a marked decrease was noticed in both types of forest, in *A. flavicollis* it occurred only in beech stands (Fig. 1). In *A. flavicollis* and *A. sylvaticus*, the consumption of last year's acorns was proved by means of stomach analyses in oak stands. The consumption of the old reserve of seeds together with a large spatial activity of *Apodemus* spp. can explain a marked difference in the relative abundance of *A. flavicollis* in oak and beech stands in November 2002 (Fig. 1). It is possible to expect that, with respect to the shortage of food, individuals of *A. flavicollis* migrated from beech stands to stands more favourable from the aspect of food.

A smaller decrease in relative abundance of *C. glareolus* during autumn 2002 as compared with field mice and a subsequent decrease in abundance in the next year can be explained by the lower mobility of *C. glareolus* together with a trend to replace seed consumption (in the case of their shortage) by the consumption of green parts of plants which, of course, are less calorically valuable being unable to cover energy requirements of the species for a long time (Holišová 1971). The nutritive value difference between seeds and other diet components is also evident in the lower extent of stomach filling with intensive consumption of beech and oak seeds in 2003 compared with the situation in 2002 (Figs. 2 and 3). A difference in the food spectrum of *Apodemus* spp. and *C. glareolus* during autumn (i.e. a higher proportion of green parts of plants, fruits and fungi in *C. glareolus*) and thus also a difference in food dependence on seeds of trees is evident even under conditions of the relative abundance of seeds (Abt, Bock 1998).

Determined body parameters (Table 3) usually correspond to data given for conditions of the CR and if they differ, the differences are not marked. Generally, differences were determined from the existing values of body parameters particularly in minimum dimensions in the food-unfavourable year 2002. In *A. flavicollis*, body weight exceeding 45 g was found in one case (a male of 47 g in weight). The weight is given as maximum in Zejda et al. (2002), Dungel and Gaisler (2002). Zejda et al. (2002), Dungel and Gaisler (2002), Pelikán (1967) or Anděra and Horáček (1982), however, give maximum weight of *Apodemus* spp. amounting to 50 g. The determined minimum body length (LC) – 86 mm (1 female in 2002) was lower (as compared with all three authors cited); Dungel and Gaisler (2002) give 90 mm, Anděra and Horáček (1982) 91 mm and Zejda et al. (2002) 95 mm. The determined minimum of the hind foot length (LTp) – 22 mm is also lower in a number of females and some males mainly in 2002; all three authors give 23 mm. In *C. glareolus*, lower minimum of the body length (as compared with the authors mentioned above) was determined (LC) – 75 mm, viz. in one female trapped in 2002; Dungel and Gaisler (2002) and Zejda et al. (2002) give minimum 80 mm, Anděra and Horáček (1982) 88 mm. Lower minimum was also found in the hind foot length (LTp) – 15 mm, viz. in one male and one female in 2002; Anděra and Horáček (1982) give minimum 15.4 mm, Dungel and Gaisler (2002) 15.5 mm and Zejda et al. (2002) 16 mm.

Determined differences in sex ratio in *A. flavicollis* can be interpreted (in spite of the insufficient number of individuals in 2003, see above) as a consequence of different length of reproduction period in both years.

While in 2002 reproduction was already suppressed in autumn owing to the insufficient food supply, in 2003, thanks to the rich crop of acorns and beech nuts, males were very active in searching rutting females until autumn and thus obviously their more frequent trapping took place. The predominance of males in the *A. flavicollis* population in the period of reproduction is mentioned for example by Pelikán (1966). Effects of seed crops on the reproduction of small mammals can also be demonstrated by trapping one pregnant female of *C. glareolus* on the November date of trapping in 2003 (November 22) although under usual conditions, gravid females are not noticed any longer in populations during that time (Zejda et al. 2002).

The faunistic similarity of micromammal communities inhabiting oak and beech stands is very high (it is a case of virtually identical communities) and exceeds even the level that is reached by using different methods of trapping (transect versus quadrate) in a community (as demonstrated for example by Bryja, Řehák 1998). The species composition of small mammals corresponds to the expectation. Considering the relatively marked opening of the stands and numerous consequential clearcut areas, total absence of representatives of the genus *Microtus* is slightly surprising.

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Vliv úrody semen dřevin na populace a společenstva drobných savců v dubových a bukových porostech Drahanské vrchoviny

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ABSTRAKT: V letech 2002 (slabá úroda semen) a 2003 (silná úroda semen) probíhal odchyt drobných savců do klasických sklopných pastí na transektech situovaných na území Školního lesního podniku Masarykův les Křtiny, lokalita U buku (Drahanská vrchovina). Odchyt byl prováděn v obou letech jednou měsíčně v období září–listopad, a to ve dvou typech lesa společenstva dubových bučin *Querci-fageta*: v porostu s převahou dubu a v porostu s převahou buku. Celkem bylo zaznamenáno 146 jedinců, z toho 142 jedinců hlodavců *Rodentia – Apodemus flavicollis* (81 jedinců), *Apodemus sylvaticus* (32), *Clethrionomys glareolus* (29) a 4 jedinci hmyzožravců *Insectivora – Sorex araneus*. V obou porostních typech dominovala *Apodemus flavicollis*. U nejpočetnější *Apodemus flavicollis* byly srovnávány tělesné rozměry mezi dubovými a bukovými porosty; zjištěné rozdíly nejsou statisticky významné. Druhová diverzita je (díky prevenci *Sorex araneus*) mírně vyšší v dubových porostech (index diverzity H‘ = 1,60) ve srovnání s bukovými porosty (H‘ = 1,43), z hlediska faunistické podobnosti jde o velmi podobná společenstva (*Re* = 97,3; I_{BC} = 0,79). U všech ulovených jedinců byly změřeny základní tělesné parametry. V dubovém lese byla zjištěna u všech druhů vyšší celková početnost než v bukovém lese. Populace hlodavců reagovaly na neúrodu bukvic a žaludů v roce 2002 poklesem početnosti a na úrodu v roce 2003 opětným nárůstem a také prodloužením doby rozmnožování. V obsahu žaludků hlodavců odchycených v roce 2003 byl zjištěn výrazně vyšší podíl škrobových zrn než v roce 2002.

Klíčová slova: drobní savci; dubový les; bukový les; tělesné rozměry; norník; myšice

Lokalita se nachází na území Školního lesního podniku Masarykův les Křtiny mezi obcemi Soběšice a Útěchov, asi 10 km severně od Brna, v části lesního komplexu U buku. Jde o dvě dvojice porostů (dubový les i bukový les) patřící do skupiny typu geobiocénu dubové bučiny *Querci-fageta* 3AB3. Odchyt byl prováděn s využitím tradičních pérových sklapovacích pastí, jako univerzální návnady byly použity kousky 1 cm širokého knotu, napuštěného směsí tuků a zapražené mouky. Pasti byly rozmístěny v přímých liniích o délce 100 m, a to v pravidelných vzdálenostech po 4 m, na každé linii bylo 25 pastí, v každém porostu potom 2 linie. Byly sledovány dva porosty bukové a dva porosty dubové. Tyto dvojice porostů byly srovnatelné z hlediska dřevinné skladby i dalších charakteristik. Odchyt probíhal vždy po dvě odchytové noci, jednou měsíčně v období září–listopad, kontrola pastí byla prováděna vždy v ranních až dopoledních hodinách.

Celkem byl odchyceno 146 jedinců drobných savců, z toho 142 jedinců hlodavců *Rodentia – Apodemus flavicollis* (81 jedinců), *Apodemus sylvaticus* (32), *Clethrionomys glareolus* (29) a 4 jedinci hmyzožravců *Insectivora – Sorex araneus*. V obou typech lesa byla nejpočetnějším druhem *A. flavicollis*. V dubovém lese byly – ve srovnání s bukovým lesem – u všech tří druhů hlodavců zjištěny vyšší celkové počty jedinců, byl zde také navíc zjištěn hmyzožravec *S. araneus.* Druhová diverzita je díky prezenci *S. araneus* mírně vyšší v dubových porostech ve srovnání s bukovými porosty, dubové porosty vykazují také mírně vyšší vyrovnanost.

Největší abundance dosáhla *A. flavicollis* při odchytu v září 2002, a to jak v dubových, tak v bukových porostech – 9 ks/100 pastí za jednu noc. Během podzimu 2002 relativní abundance většinou klesala a minima dosáhla v září a říjnu 2003, v listopadu 2003 byl zaznamenán – především u myšic – opět mírný nárůst abundance.

U *A. flavicollis* umožňoval počet ulovených jedinců srovnání tělesných parametrů myšic z dubových a bukových porostů, rozdíly však nebyly statisticky významné (tab. 3).

Poměr pohlaví u nejpočetnější *A. flavicollis* byl při odchytech poměrně vyrovnaný (tab. 4), vykazoval však výrazný rozdíl mezi rokem 2002 a 2003. Zatímco v roce 2002 mírně dominovaly samice, v roce 2003 převažovali samci, počet ulovených jedinců je však v roce 2003 u všech druhů pro jakékoliv průkazné závěry nedostačující.

Struktura zoocenózy drobných savců v dubových porostech je velmi podobná struktuře zoocenózy bukových porostů. Vysokou podobnost obou společenstev dokládá hodnota Renkonenova čísla (*Re* = 97,3) i Bray-Curtis indexu (I_{BC} = 0,79). Podobnost dvou zoocenóz z hlediska rozdílů mezi abundancemi nalezených druhů je přitom považována za signifikantní v případě hodnot I_{BC} > 0,6.

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