JOURNAL OF FOREST SCIENCE, *53*, 2007 (7): 340–344

Contribution to the knowledge of *Clethrionomys glareolus* populations in forests of managed landscape in Southern Moravia (Czech Republic)

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ABSTRACT: In intensively managed landscape, the dynamics of the bank vole (*Clethrionomys glareolus, Cg*) populations was studied in three types of forest complexes which differed in food supply. The first type was an old semi-natural forest with dominance of oak (HL), the second was a production broad-leaved forest with dominant oak and black locust (HA), and the third was a pheasantry with a variable mixture of forest stands of various woody species and age with a permanent supply of food for pheasants and roe deer (RB). The population fluctuations in four years of research were influenced by the seed year (2003, oak mast harvest), so higher population densities remained for the next two years. The influence of mast crop on the weight of individuals was statistically significant ($\alpha = 0.05$, $P = 0.0484$). Probable niche vacation (*Apodemus flavicollis, Af* densities lowered) was the reason for another high abundance year (2005). There were no significant differences in abundance between the localities as the *Cg* population was influenced comparably by the seed crop. There was only a tendency to prefer the most variable biotope in RB. There was a strong impact on the forest regeneration in tree plantings during the winter 2004/2005. The importance of abundance prediction by abundance monitoring was stressed as needed for impact prevention.

Keywords: bank vole; forests in managed landscape; population dynamic; food supply

The species with widespread distribution and inhabiting a broad range of environments can show different demographic parameters in relation to the ecological characteristics of inhabited biotopes (Montgomery, Gurnell 1985). Due to its broad flexibility the bank vole as one of the most abundant small mammals in the western Palearctic utilizes a variety of habitats and different environmental conditions throughout its geographical range (Zejda 1973, 1976; Montgomery 1979; Petrusewicz 1983; Jedrzejewska et al. 2004). The species is found in all forest habitats with preferences for the ground cover (Gurnell 1985). Like in the other forest species such as wood mouse the population dynamics is strongly related to the food supply (as mast crops) (Flowerdew 1973; Zejda 1976; Flowerdew, Gardner 1978; Jensen 1982; Zejda 1985, 1991; 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, during summer they increase due to breeding and reach the highest autumn numbers. Reproduction ceases in autumn, and high winter mortality leads again to low numbers of rodents in the subsequent 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 the winter survival of rodents and can even cause winter breeding (Zejda 1962; Jedrzejewska et al. 2004). During the next spring and summer, rodents make use of both the stored seeds and fresh vegetation and populations increase in numbers. As a result, high densities are recorded in autumn, a year after the

Supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6215648902.

seed fall. In the present study we compare some demographic parameters (abundance, sex ratio, breeding activity and body mass) in three populations of Cg inhabiting different forest habitats which widely differ in food supply. Special attention was concentrated on the RB locality with a permanent supply of food to pheasants and roe deer. The development of populations under the influence of seed years was also described.

MATERIAL AND METHODS

The material was obtained from three study sites in the years 2002 and 2005. These were larger forest complexes, isolated in the intensively managed landscape of South Moravia (Czech Republic). The sites are characterized by different intensity of the exploitation by people, and by defined groups of forest types (Randuška et al. 1986).

The location Horní les (HL) (120 ha) is a seminatural forest stand, characterized by the group of forest types *Ulmeto-Fraxinetum carpineum*. It is situated near Lednice in Moravia. 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*).

The location Hájek (HA) (60 ha) is a typical production forest, characterized by the group of forest types *Carpineto-Quercetum acerosum*. It is situated near Vranovice. The dominant woody species are English oak (*Quercus robur*), durmast oak (*Q. petraea*), and black locust (*Robinia pseudoacacia*). The shrub stratum was little developed and mosaic-like. It consisted of shrubs of *Crategus oxyacantha* and *Eonymus europaea* beside scattered bushes of *Carpinus betulus*.

The location Rumunská (RB) (280 ha), situated near the town of Židlochovice, is used as an intensive pheasantry. With regard to microhabitats, the location Rumunská is the most variable area of the three locations. 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 silvestris*), common spruce (*Picea abies*), and black poplar (*Populus nigra*). The following groups of forest types were identified there: *Ulmeto-Fraxinetum carpineum*, *Saliceto-Alnetum* and *Carpineto-Quercetum acerosum*.

The annual mean air temperature in the studied area was 9.5°C; the total annual precipitation was 545 mm.

In each locality under study the immediate supply of mast diet was evaluated on ten plots 0.5 m^2 in size, and the mean amount of mast was determined.

In all trial plots, the methodology of traditional line trapping was applied (Pelikán 1975). 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 2000–2005. 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 *Cg* was evaluated.

The relative abundance of *Cg rA* was expressed as the number of individuals trapped per number of trap-nights. Data on the bank vole impact were collected by Forestry control. The changes in the localities and yearly abundances of the *Cg* population were compared by Wilcoxon's matched pair test. The differences between body masses were compared by HDS test (ANOVA). All statistical tests were computed using the program Statistica for Windows 6.1 (Statsoft 2000).

RESULTS

During 20 trapping periods (20,150 trap nights) 2,112 individuals of small mammals were recorded. As to the individual species *Apodemus flavicollis*, *A. sylvaticus*, *Clethrionomys glareolus*, *A. microps*, *Microtus arvalis*, *Microtus subterraneus*, *Mus musculus*, *Sorex araneus*, *Crocidura leucodon* and *C. suaveolens* were trapped. Of these 442 (20.9%) were *Cg* individuals.

Population fluctuations of *Cg* during the four years of study varied and a strong influence was exerted by the seed year (2003, oak mast harvest; Fig. 1). In the HL forest the amount of food supply in the form of oak mast was the highest (208 g/m^2) in contrast to RB (69 g/m^2), but in RB additional food was given to pheasants and roe deer during the whole year. There were no significant differences in abundance between the localities as the *Cg* population was comparably influenced by the seed crop. There was only a tendency to prefer the most variable biotope in RB (*rA* = 2.58). Lower abundance was found in HL (2.21) and the lowest in HA (1.64), which was influenced by food supply and also probably by competition with *Af.*

Differences in the body weight of *Cg* (if the years 2003 and 2004 were compared – influenced by the seed crop) were statistically significant ($\alpha = 0.05$; $P = 0.0484$).

Autumn prolonged breeding (progradation phase) in the year influenced by mast crop (2004), and prob-

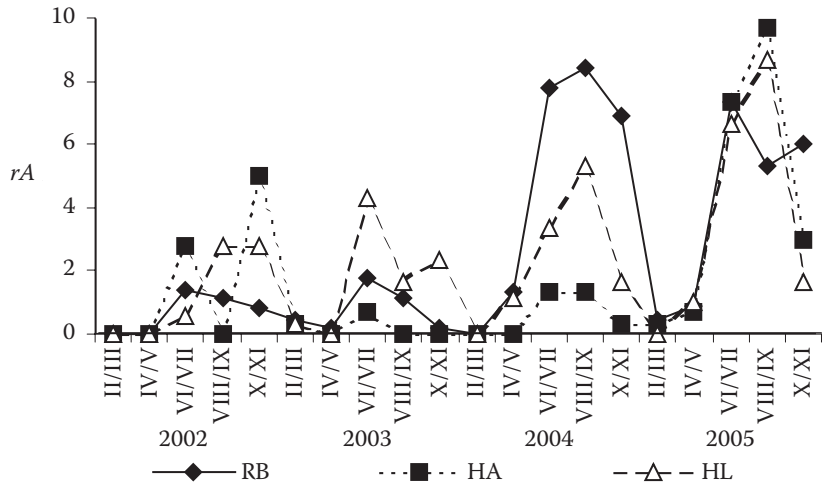

Fig. 1. Four-year monitoring of the relative abundance (*rA*) of *Clethrionomys glareolus* in three forest complexes under various environmental conditions in rural landscape

able niche vacation (*Af* densities lowered) was the reason for another high abundance year (gradation phase 2005) (Fig. 1).

Comparing the sexual activity in the particular localities it was the highest in HL (57% of active females) and the lowest in RB (48%). The sex ratio was almost balanced in RB and HL but slightly shifted to the male dominance (59%) in HA.

Body mass and length were compared and the tendency to be highest was in RB (weight: max. 38 g, min. 9 g, mean 21.36 g; length 90.7 mm) and lowest in HA (weight: max. 35 g, min. 12 g, mean 20.2 g; length 90.4 mm) the differences not being significant.

A strong impact on forest regeneration was found in southern Moravian forests as exerted by the bank vole gnawing the stems of young trees. In controlled forests 40% of young oak plantings were damaged to some extent after winter 2004–2005 but no impact was observed in winter 2005–2006.

The only effective prevention against damage seems to be the reliable prediction of population densities by pest species monitoring and early plantation protection.

DISCUSSION

During the study of small mammal populations in three large forest complexes in southern Moravia *Cg* was one of the most dominant species. The lowland forest was characterized by the highest biomass of the herb stratum which is the most suitable food supply for this species (Gurnell 1985). Quite different is RB with the mosaic of forests of various age categories as well as small open areas. This was the locality with the highest abundance after the seed year. We presume that the variety of biotopes supplied more space and lower competition for other species than the most dominant *Af* (Suchomel, Heroldová 2006). HA is a typical production forest with different tree species and mostly grasses in the herb stratum. The preference of dicotyledonous herb species can influence its abundance there (Holišová 1971) in the time of its progradation phase.

Populations of small mammal species were studied in various types of forests such as lowland ones of Moravia and Slovakia (e.g. Zejda 1976; Dudich, Štollman 1983; Májsky 1985; Zejda 1985, 1991; Krištofík 1999) and also in the other types of low altitude forests (e.g. Zejda 1973). In all of them *Cg* is one of the dominant species. In our study we concentrated on the study of the population of this species as also some other authors did (Alibhai, Gipps 1985; Mazurkiewicz 1991).

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

In RB the population of *Cg* was permanently supplemented by food for pheasants and deer. Under this influence it reached the higher winter population abundance than in the other two forests. It also showed higher litter sizes in spring and summer.

However, populations in all forests declined during the late summer and autumn. According to Wats (1969, 1970) and Flowerdew (1972, 1985) food quality appears to influence the amplitude of the fluctuation in numbers but not the decline. It is so that both food and behaviour are limiting numbers at the same time. An experiment on Townsend voles in Canada indicated that supplementary food sets the ultimate limit to population growth but the 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 with 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 RB locality.

The sex ratio was balanced in our case in HL and RB. It is characteristic feature of stable population living in optimal habitats (Alibhai, Gipps 1985). In HL it was slightly shifted to the dominance of males.

The number of sexually active females indicates the quality of the habitat (Zejda 1976; Mazurkiewicz, Rajska-Jurgiel 1989; Mazurkiewicz 1991). According to the dominance of this species the most suitable forest type was HL (26.8%). But no large differences were found between the localities. The highest number of females with embryos and placental scars was found in RB, probably due to better overwintering as indicated by higher abundances during winter. The higher mean litter size in a two-year period also confirms the influence of supplementary food (Andrzejewski 1975; Cole, Batzli 1978; Flowerdew 1972, 1985, 1987).

Body weight also provides information about the habitat quality (Suchomel, Heroldová 2006). In our case the animals of both sexes were not significantly heavier in any of the localities. But higher mean body weight and maximal body weight were found in RB. This can also be influenced by the presence of supplemental food at this locality.

All the year round a high concentration of birds of prey was observed in RB locality. Their influence on the population of small mammal species is a question to be answered. According to Flowerdew (1987) predators may exert a strong pressure on a decrease in mammalian populations but, equally, they may have a low effect on their numbers. It is a difficult factor to consider in relation to the mammalian population regulation without taking into account its interactions with the behaviour and abundance of the prey population. As the *Cg* is mostly active in night, predation would be possible only by the owl species.

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Received for publication March 1, 2007
Accepted after corrections April 20, 2007

Příspěvek k poznání populací norníka rudého (*Clethrionomys glareolus*) z lesů kulturní krajiny jižní Moravy

ABSTRAKT: Ve třech lesních komplexech lišících se potravní nabídkou v intenzivně obhospodařované krajině jižní Moravy byla studována populační dynamika norníka rudého. Šlo jednak o starý polopřirozený les s dominancí dubu (HL), dále o produkční listnatý les s převahou dubu a trnovníku akátu (HA) a bažantnici s rozmanitostí lesních porostů tvořených rozličnými druhy a věkovými kategoriemi dřevin a s množstvím doplňkové potravy pro přikrmování bažantů a srnčí zvěře (RB). Kolísání populace v průběhu čtyřletého sledování bylo ovlivněno semenným rokem (2003, úroda žaludů), což mělo za následek zvýšení populační hustoty v následujících dvou letech. Byl zjištěn statisticky průkazný vliv úrody žaludů na tělesnou hmotnost sledovaných zvířat ($\alpha = 0{,}05$, $P = 0{,}0484$). Nárůst početnosti v roce 2005 byl pravděpodobně ovlivněn i nízkou abundancí myšice lesní (*Apodemus flavicollis*), která může při vyšších počtech výrazně omezit populaci norníků obsazením jejich ekologické niky. Mezi jednotlivými lokalitami nebyly zjištěny průkazné rozdíly v abundanci, což svědčí o srovnatelném vlivu úrody semen. Byla zaznamenána pouze tendence preferovat nejvariabilnější biotop v RB. Byl zjištěn i silný impakt na výsadbu lesních dřevin během zimy 2004/2005, což podtrhuje význam predikce početnosti norníka rudého monitorováním jeho populace z hlediska potřeby prevence škod.

Klíčová slova: norník rudý; lesy v kulturní krajině; populační dynamika; potravní nabídka

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