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Original investigation

Spatial distribution of the yellow-necked mouse (*Apodemus flavicollis*) in large forest areas and its relation with seed crop of forest trees

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Abstract

The checking of nestboxes put up in a grid system gives a chance to estimate both relative abundance and spatial distribution of yellow-necked mice (*Apodemus flavicollis*) in large forest areas. This is difficult to achieve using traps due to manpower that would be required. Long term investigations carried out in Lithuania at two study sites with an area of 60 and 85 ha respectively, showed that there was no relation between relative abundance of *A. flavicollis* in autumn and the pattern of their spatial distribution. When relative abundance of *A. flavicollis* was the same in different years, spatial distribution of mice could be both random and aggregated, as well as regular. The pattern of spatial distribution shown by *A. flavicollis* in large forest areas with a high diversity of tree-stands was related to the productivity and spatial distribution of forest trees with heavy seeds (mainly oak and hazel). In separate years mice used to occupy nestboxes at those places where a heavy seed crop was present. When crops of oak and hazel failed completely, spatial distribution patterns of *A. flavicollis* tended to be regular. The data obtained suggest one practical conclusion: long-term *A. flavicollis* population studies in small plots of forest, with a high diversity of forest stands, may only reflect the situation in these specific places and not necessarily the state of the entire *A. flavicollis* population.

Key words: *Apodemus flavicollis*, spatial distribution, seed crop, Lithuania

Introduction

The range of the yellow-necked mouse (*Apodemus flavicollis*) in Europe is restricted to deciduous and mixed forest zones (PUCEK et al. 1993). *A. flavicollis* is regarded as primarily a species of mature deciduous woodland although also known from other habitats including other deciduous woodland types and coniferous forest (MONTGOMERY 1999). In eastern Europe it also occurs in open habitats (NIETHAMMER 1978). Nevertheless, in its habitat selection *A. flavicollis* prefers deciduous forests with heavy seed producing species and avoids coniferous stands (AULAK 1970, cit. after PUCEK et al. 1993).

A. flavicollis frequently uses nestboxes for birds (LÖHRL 1960; LIKHACHEV 1962; JUŠKAITIS 1997, 1999, 2000) or dormice (MARSH

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and Morris 2000). *A. flavicollis* seldom occupies nestboxes in spring but in September–October they can occupy as much as 50% of all nestboxes over different years, especially in oak-woods (Juškaitis 2000). According to Likhachev (1962), occupation of nestboxes by *A. flavicollis* in different years clearly coincided with abundance estimated by trapping, and hence the results of nestbox checks can be used to indicate *A. flavicollis* abundance. The checking of nestboxes put up in a grid system in large forest areas enabled to estimate both the relative abundance and the spatial distribution of this rodent, which is difficult to do using traps because of the work that this would entail.

The aim of this study is to assess the dynamics of *A. flavicollis* spatial distribution in large forest areas in separate years and its relation to the seed crop of forest trees.

Material and methods

Data on relative abundance and spatial distribution of *A. flavicollis* were collected during investigations of two common dormouse (*Muscardinus avellanarius*) populations carried out in Lithuania at two locations: study site A from 1984 to 1989 and again from 1999 to 2000 and study site B from 1984 to 1992.

Site A (south-west Lithuania, Šakiai district) occupied an area of 60 ha, and 262 nestboxes were located here. The forest contained a great variety of 30–80 year-old forest stands. Birch (*Betula pendula*) stands with Norway spruce (*Picea abies*) and black alder (*Alnus glutinosa*), ash (*Fraxinus excelsior*) stands with aspen (*Populus tremula*), and pure Norway spruce stands prevailed. A Norway spruce stand with oak (*Quercus robur*) was located on the southern outskirts of the site. Solitary oak-trees also grew in other places of site A. Within the understorey, hazel (*Corylus avellana*) grew abundantly, with buckthorn (*Frangula alnus*) located in some places. The renewed study site A (1999–2000) incorporated 272 nestboxes in the same area. Anthropogenic activity became more intensive at this site: approximately 10 year-old coppice occupied an area of 5 ha and all of the understorey had been cut down in some places.

Site B (east Lithuania, Moletai district) occupied an area of 85 ha, and 341 nestboxes were located here. Most of site B contained 100–130 year-old oak stands with Norway spruce, in some places with maple (*Acer platanoides*) and aspen. The eastern part of the site was covered by 40–60 year-old aspen stands with Norway spruce and oak. Within the understorey, hazel grew in all of the site B area.

At both study sites, wooden nestboxes for small hole nesting birds were placed in a grid system every 50 meters, at a height of 1.5–2.0 meters. The density was four nestboxes per ha. The nestboxes were checked nine times during each season from April to October. However, only the data from September (two controls) and October (one control) were used to estimate relative abundance and spatial distribution of *A. flavicollis* in autumn.

Relative abundance of *A. flavicollis* was estimated according to the percentage of nestboxes occupied by these animals in autumn (September–October). Spatial distribution of *A. flavicollis* was determined by the distribution of occupied nestboxes at the study sites in autumn. Nestboxes were considered occupied by *A. flavicollis* if the animals themselves were found or signs of their activity (nests, food supplies or remains, excrement). Oak and hazel seed crops were estimated visually in the study site areas using three categories: abundant, slight or absent.

Hopkins's method of detecting non-randomness (Hopkins 1954, cit. after Greig-Smith 1964) was used to estimate the pattern of the spatial distribution. Coefficient of aggregation A was calculated – the ratio of the square of the mean distance between a random point and its nearest nestbox occupied by *A. flavicollis* (P) to the square of the mean distance between this nestbox and its nearest neighbouring occupied nestbox (I): $A = \sum P^2/\sum I^2$. The distances were measured on maps (1 : 10 000), and the same 40 random points were used for each year analysed. The coefficient of aggregation A is a unity for random distributions, greater than 1 for aggregated distributions, and less than 1 for regular distributions. The deviation of A from unity was tested for significance using corresponding diagram (Hopkins 1954, cit. after Greig-Smith 1964). Coefficients of aggregation are listed in table 1.

Results and discussion

Relative abundance of *A. flavicollis* was fairly constant at site A during the years of investigation: usually mice occupied about 10% of all nestboxes (Tab. 1). Increases in *A. flavicollis* abundance were only observed

Table 1. Seed crop of oak and hazel, relative abundance (as % of nestboxes occupied) and spatial distribution of *A. flavicollis* at two study sites in Lithuania during autumn (September–October)

Year	Seed crop of oak	Seed crop of hazel	% of nestboxes occupied	Coefficient of aggregation A	Significance of deviation from 1	Pattern of spatial distribution
			Site A			
1984	abundant	–	11.8	0.81	NS	random
1985	–	–	9.9	0.61	P < 0.05	regular
1986	slight	–	11.5	4.02	p < 0.001	aggregated
1987	–	abundant	19.8	1.74	P < 0.01	aggregated
1988	slight	slight	11.5	0.82	NS	random
1989	abundant	–	13.4	0.92	NS	random
1999	abundant	–	9.9	1.43	P < 0.05	aggregated
2000	abundant	abundant	11.0	0.95	NS	random
			Site B			
1984	slight	–	14.9	1.22	NS	random
1985	abundant	–	9.7	1.57	P < 0.05	aggregated
1986	abundant	–	32.3	0.91	NS	random
1987	–	–	15.0	0.72	NS	random
1988	slight	–	10.6	0.62	P < 0.05	regular
1989	abundant	–	43.7	0.95	NS	random
1990	slight	abundant	29.3	0.88	NS	random
1991	–	slight	4.7	0.55	P < 0.01	regular
1992	abundant	–	27.9	0.99	NS	random

in 1987, when mice occupied about 20% of all nestboxes. Thus, population abundance was fairly stable during the years investigated. However, spatial distribution of *A. flavicollis* was essentially different in separate years. When relative abundance of mice was practically the same (about 10% of nestboxes occupied), the pattern of the spatial distribution changed from almost regular in 1985 (A = 0.61) to evidently aggregated in 1986 (A = 4.02) (Fig. 1). There was no relation between relative abundance of *A. flavicollis* and the coefficient of aggregation A (coefficient of correlation r = 0.12; p = 0.77).

At site B, relative abundance of *A. flavicollis* fluctuated considerably more widely than at site A with 5% to 44% of nestboxes occupied (Tab. 1). These fluctuations of abundance could be related with the oak acorn crop in different years (JUŠKAITIS 2000). The pattern of spatial distribution changed from regular (A = 0.55) to aggregated (A = 1.57) at site B as well as at site A and was also not connected with relative abundance of *A. flavicollis* (r = 0.06; p = 0.88).

Analysis of data collected showed that the spatial distribution of *A. flavicollis* was related to the productivity and spatial distribution of forest trees with heavy seed crops (primarily oak and hazel). This was more obvious at site A, which was distinguished by the greater diversity of forest stands and in the small area of stands containing oak-trees. In general, the concentration of mice within the southern outskirts of the site with oak-trees was a characteristic feature of *A. flavicollis* spatial distribution at site A during all the years of study (Fig. 1).

During the eight years of the study oak acorn crop only failed in 1985 and 1987, and in other years the crop was estimated as abundant or slight (Tab. 1). Abundant hazelnut crops were recorded in 1987 and 2000. Examples presented below show that spatial distribution of *A. flavicollis* was related mainly to oak and hazel crop patterns. A clearly aggregated distribution of nestboxes occupied by *A. flavicollis* (A = 4.02) was recorded in 1986, when mice were highly concentrated in the southern part of site A where fruiting oak-trees were present (Fig. 1 c). In 1987, distribution of mice was aggregated again, but its pattern was different in comparison with the previous year (Fig. 1 d). The oak crop failed in 1987, but hazelnuts were abundant in this year. *A. flavicollis* occupied nestboxes in those parts of site A where fruiting hazel was present, although they were not found there in other years (particularly in the north-east of site A). A very similar pattern of *A. flavicollis* spatial distribution was observed in 2000 when a good hazelnut crop was once again present.

Regular spatial distribution, occurring rather seldom, was recorded in 1985, when

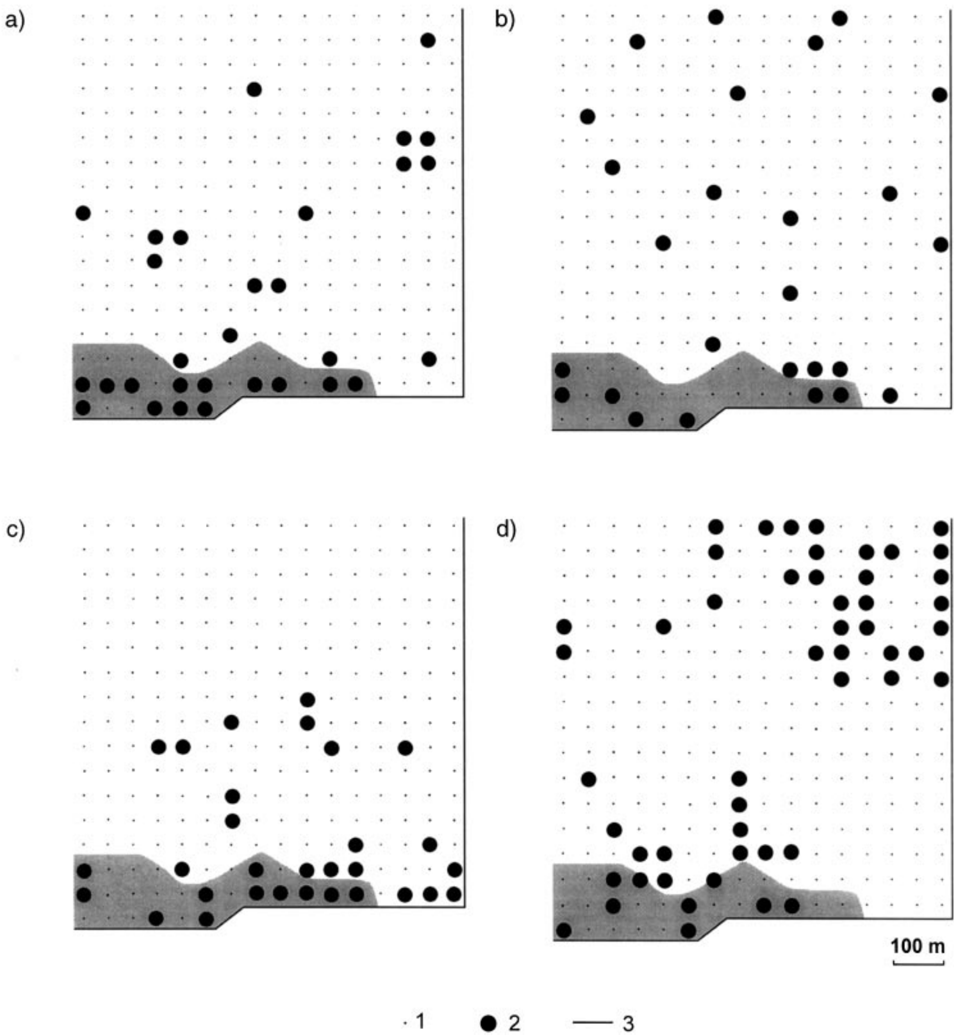

Fig. 1. Spatial distribution of nestboxes occupied by *A. flavicollis* at site A: a) in 1984, b) in 1985, c) in 1986, d) in 1987. Forest stands with oak are grey-shaded. 1 – nestboxes, 2 – nestboxes occupied by *A. flavicollis*, 3 – forest edge.

there were crop failures of both oak and hazel. Nestboxes occupied by *A. flavicollis* were distributed almost evenly in all parts of site A (Fig. 1 b). Probably such distribution was related to *A. flavicollis* searching for other food sources. In spring 1986, remains of ash seeds gathered by *A. flavicollis* were found in some nestboxes. Such a phenomena was not observed in years with a good oak or hazel seed crop.

Although relative abundance of *A. flavicollis* fluctuated in wider limits at site B in comparison with site A, spatial distribution patterns were more constant (Fig. 2). At site B, the spatial distribution of occupied nestboxes was random in six out of nine years studied (Tab. 1). Also the spatial distribution pattern was almost unrelated to oak and hazel seed crop, probably because site B was characterised by a considerably more homogenous composition of forest stands. Both oak and hazel grew in almost all regions of site B (Fig. 2).

Thus, *A. flavicollis* spatial distribution in large forest areas with diverse forest stands did not depend on the abundance of mice population, rather it was related to the spatial distribution of fruiting trees with a heavy seed crop (primarily oak and hazel). In Sweden, the local distribution of *A. flavicollis* also correlated with the number of plants with a heavy seed crop (shrub and tree species; ANGELSTAM et al. 1987). In forest with a more homogeneous composition of forest stands and more equal distribution of oak and hazel, spatial distribution of *A. flavicollis* was more constant.

The data obtained may result in one key conclusion: long-term *A. flavicollis* population studies in small plots of forest with diverse forest stands may only reflect the situation at these specific places but not the state of the entire *A. flavicollis* population.

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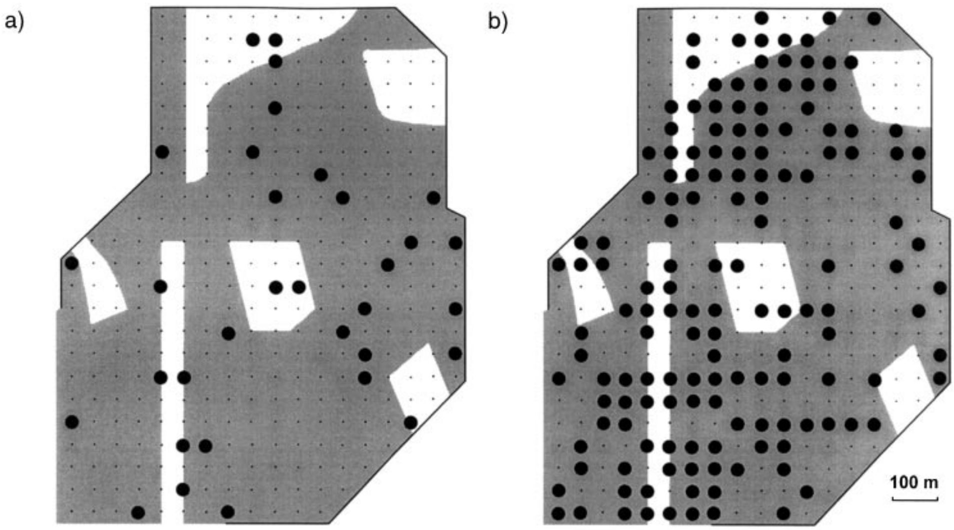

Fig. 2. Spatial distribution of nestboxes occupied by *A. flavicollis* at site B: a) in 1985, when relative abundance was low, b) in 1989, when relative abundance was the highest. Symbols description as in Fig. 1.

Zusammenfassung

Zur räumlichen Verteilung der Gelbhalsmaus (*Apodemus flavicollis*) in großen Waldgebieten in Abhängigkeit von der Samenproduktion der Waldbäume

Regelmäßige Nistkastenkontrollen, mit Kästen die in einer regelmäßigen Verteilung auf der Fläche angebracht sind, geben die Möglichkeit einerseits die relative Abundanz und andererseits die räumliche Verteilung von Gelbhalsmäusen (*A. flavicollis*) in großen Waldgebieten abzuschätzen. Dies ist mit Fallenfängen wegen des enormen Arbeitsaufwandes kaum zu leisten. Langzeituntersuchungen in Litauen auf zwei Untersuchungsflächen mit 60 bzw. 85 ha Fläche zeigten, daß es keinen Zusammenhang zwischen der relativen Abundanz von *A. flavicollis* und dem Charakter ihrer räumlichen Verteilung gibt. In verschiedenen Jahren mit gleicher relativer Abundanz von *A. flavicollis* konnte deren räumliche Verteilung sowohl zufällig als auch regelmäßig oder aggregiert sein.

Der Charakter der räumlichen Verteilung von *A. flavicollis* in großen Waldgebieten mit einer hohen Diversität von Waldbeständen war abhängig von der Verteilung von Gehölzen mit großen Samen (vor allem Eiche und Hasel). Gelbhalsmäuse besetzten in verschiedenen Jahren vornehmlich Nistkästen, in deren Nähe große Samen vorhanden waren. Die räumliche Verteilung von *A. flavicollis* tendierte in Jahren, in denen eine Fruktifikation von Hasel und Eiche ausfielen, zur Regelmäßigkeit. Die ermittelten Daten lassen als praktische Schlußfolgerung zu, daß Langzeituntersuchungen an *A. flavicollis* auf kleineren Flächen in Waldgebieten mit unterschiedlichen Waldbeständen nur die Situation an dieser konkreten Stellen reflektieren, nicht aber den Status der Gesamtpopulation.

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