



An estimate of population density of the fat dormouse *Glis glis*, movement and nest cohabitation in two types of forests in the Transylvanian Plain (Romania)

ELIANA SEVIANU & ALIN DAVID

Abstract

Spatially explicit capture-mark-recapture data, obtained by regular nestbox checks during two summer seasons (2006, 2007) were used to estimate population density of the fat dormouse (*Glis glis*) in one oak (*Quercus robur*) and one hornbeam (*Carpinus betulus*) dominated forest in the Transylvanian Plain, Romania. The number of captured dormice was positively correlated with the number of occupied nestboxes, although between 10% and 50% of all nestboxes were shared by 2–6 individuals. The percentage of shared nestboxes and number of individuals found within them varied. Dormice tend to aggregate in nestboxes during the mating season, and almost all shared nestboxes containing more than two individuals (males and females) were encountered during that period. Dormice were more solitary in July and August, when females gave birth, but communal nesting was uncommon in our study sites. The fat dormouse had higher densities in the oak forest than in the hornbeam forest (11.32 ± 1.46 vs. 4.81 ± 0.70 ind./ha), and also the average distance moved was shorter in the oak forest. The maximum distance moved was 150 m in the oak forest and 250 m in the hornbeam forest, but here fewer than 5% of the distances recorded were greater than 150 m, showing high nest site fidelity.

Keywords: nestboxes, communal nesting, habitat requirements

1. Introduction

Density and population size are related population parameters that both have a central role in wildlife conservation and management. Comparative estimates at one point in time for different areas or habitats, or at the same site at different times, allow inferences to be made about population status in relation to other areas or habitats, or other moments in time (Lancia et al. 1994, Buckland et al. 2001, Parmenter et al. 2003, Efford et al. 2005). Estimating the size and/or density of wildlife populations has been one of the most challenging tasks for biologists, especially when it involves rare or elusive species that must be sampled (McDonald 2004), like the fat dormouse (*Glis glis*), a nocturnal, arboreal small mammal (Vietinghoff-Riesch 1960).

One of the most widely used methods to estimate population size of small mammals (including dormice) is capture-mark-recapture (CMR). Setting traps in trees to capture arboreal, nocturnal rodents, such as dormice, could be difficult and time consuming, or sometimes impossible. An alternative method of capturing, by regular nestbox checks, has been widely used to collect data for estimating fat dormouse abundance, population size and density, throughout the species' distributional range (Vietinghoff-Riesch 1960, Gaisler et al. 1977, Juškaitis 2000, Burgess et al. 2003, Kryštufek et al. 2003, Ruf et al. 2006, Pilāts et al. 2009, Seviānu 2009, Lebl et al. 2011).

Capture-mark-recapture method does not estimate the sampled area (Shanker 2000), which is in fact unknown and not easy to define or calculate accurately, so the relationship between population density and data obtained by capturing is still not clear (Efford 2004), and not addressed by conventional capture-recapture methods (Efford et al. 2009b).

A new, spatially explicit CMR method of estimating population density has been recently developed, using the framework of distance sampling (Efford 2004, Efford et al. 2004, Efford et al. 2005, Efford et al. 2009a, b). The method uses CMR data from various arrays of 'passive detectors' that record individuals at a point (where the detector is placed), only when they encounter and interact with a detector (Efford et al. 2004). Passive detectors could be traps (of various types), mist nets, cameras or artificial shelters, and there is no restriction on the layout (Efford et al. 2004). The method provides direct estimates of population density, using 'spatio-temporal' capture histories (Borchers & Efford 2008, Efford et al. 2009b). A spatial model of the population and the detection process is fitted to the spatial detection histories (Efford 2004, Borchers & Efford 2008).

We used spatially explicit capture-mark-recapture method to analyze data obtained by nestbox checks over two years (2006–2007), and to estimate *G. glis* population size and density in two types of deciduous forest. In addition, we analyzed nestbox occupancy and movements by dormice, as revealed by the capture histories.

2. Material and methods

2.1. Study area

The study took place in the Transylvanian Plain (north-western Romania). Although it is named 'plain', it is actually a hilly area, with forests occupying hilltops and north-facing hillsides (Pop 2001). Site A: Ghiris forest (46°47'48" N, 23°58'33" E, 430–460 m altitude, 38 ha, 35 years old, *Aceri tatarico-Quercetum petraeae-roburi*). The forest is an old area of pedunculate oak (*Quercus robur*) with Tatarian maple (*Acer tataricum*) forest that, due to intense exploitation, has had its original structure altered, being now dominated by field maple (*Acer campestre*) and hornbeam (*Carpinus betulus*) and invaded by locust trees (*Robinia pseudacacia*). The shrub layer is moderately developed, formed of various species (hazel *Corylus avellana*, European cornel *Cornus mas*, common dogwood *Cornus sanguinea*, old man's beard *Clematis vitalba*, common privet *Ligustrum vulgare*, bladder nut *Staphylea pinnata*).

Site B: Ciuas forest (46°55'43" N, 24°05'35" E, 280–430 m altitude, 53 ha, *Lathyro hallersteini-Carpinetum*). This forest has also been intensively exploited, and consists of three sections, different in age and composition (40 years old hornbeam, 100 years old sessile oak (*Quercus petraea*), 55 years old hornbeam and sessile oak). It maintains its original, stratified structure only within a three hectare area, where old (125 years) pedunculate oaks still stand. The forest is dominated by sessile oak and hornbeam with some oak, wild cherry (*Prunus avium*) and field maple, and has a well-developed shrub layer (hazel, European cornel, small-leaved lime *Tilia cordata*, elder *Sambucus nigra*).

2.2. Sampling methods

In 2005, at each site, 50 wooden nestboxes (internal size 20 × 20 × 30 cm, entrance diameter 5 cm) were placed at 20 m intervals, in line transects, with entrance holes facing tree trunks, at heights ranging from 2.5 to 4.5 m. At site B, an additional line of smaller nest boxes (internal size 14 × 14 × 21 cm, entrance diameter 3.7 cm) was erected in early spring 2007, parallel with the first one.

The nestboxes were checked once a month, between April and November, for two consecutive years (2006, 2007). Nestboxes were considered occupied only when at least one fat dormouse was found inside. Each captured dormouse was individually marked by ear tattoo and was assigned a unique ID.

2.3. Analysis

We used the capture data from summer months only (June, July and August), 2006 and 2007, when most of the adults were concomitantly active in the area (Sevianu 2009), as the onset and ending of hibernation is correlated with sex and age (Bieber & Ruf 2004). During the study period, the population consisted only of individuals that had hibernated at least once. The data were pooled over years and sites to increase sample size for greater accuracy, but in some cases were analyzed separately for each year, at each site. In the pooled sample, we treated each year separately (as a closed population), meaning we considered only recaptures within the same year. The individuals captured and marked during 2006 were considered unmarked at the first capture in 2007.

Density 4.4 software (<http://www.otago.ac.nz/density>) was used to estimate density and detection parameters from the population size, capture probability and scale of animal movement. The software uses a spatially explicit capture-recapture method, considering the location where each animal was captured, to fit a spatial model of the detection process (Efford 2004, Borchers & Efford 2008). Spatially explicit analysis of CMR data estimates density without having to calculate the effective trapping area (Wilson et al. 2007), being computed directly from the spatial capture history (Efford et al. 2009b). The software uses simulation and inverse prediction, a method that matches values of statistics calculated from field data to values calculated from data simulated with known parameter values (Wilson et al. 2007), and the maximum likelihood method (Efford et al. 2009a). Population size was estimated using the M_0 model, which was selected by CAPTURE program most of the times. In spatial simulation and inverse prediction, model selection for the appropriate closed-population estimator may not be critical (Efford 2004).

Correlation between the number of dormice captured and the number of occupied nestboxes was analyzed using Spearman's rank correlation.

3. Results

3.1. Nestbox occupancy and cohabitation

During the study we captured a total of 283 adult fat dormice in 329 captures (pooled data over two years at both study sites). Out of the 329 cases of dormice found inside nestboxes, 57 cases involved two and more individuals sharing a nestbox (17.33%), and 272 single individuals (82.67%). In June, 39 out of 76 occupied nestboxes were shared by more than one individual, representing 51.31%. In mid and late summer the proportion of shared nestboxes dropped, reaching 5.59% in July (8 out of 143) and 9.09% in August (10 out of 110). The number of individuals that shared one nestbox ranged from two to six (Tab. 1). The number of nestboxes occupied by more than one individual varied significantly between months ($\chi^2 = 31.68$, $df = 2$, $p < 0.001$). The proportion of nestboxes shared by different numbers of individuals also varied between months. In July and August, all except one case of shared nestbox involved only two individuals (with a single case of three males). In June, although the majority of shared nestboxes were still used only by two dormice, there were several cases of up to six occupants (Tab. 1). Capture histories showed that shifting occurs between individuals sharing the nestboxes.

Tab. 1 Percentage of nestboxes shared by different number of individuals out of the total number of shared nestboxes (raw values in parenthesis).

Nr. Ind.	June (39)	July (8)	August (10)
2	61.54 % (24)	100 % (8)	90 % (9)
3	23.08 % (9)	0	10 % (1)
4	2.56 % (1)	0	0
5	7.69 % (3)	0	0
6	5.13 % (2)	0	0

Analyzing data for each month, we found that the correlation of the number of captured dormice inside nestboxes and the number of occupied nestboxes was significant (Spearman's $\rho = 0.88$, $p < 0.001$), although the relationship between the two variables was not straightforward.

A special case of shared nestbox is communal nesting, involving two females with pups. At site B we encountered only two communal nests out of 43 recorded litters, and at site A no communal nests were recorded out of 22 monitored litters. Overall, communal nests rose to 3 % of the total nests found ($N = 65$).

3.2. Population Density

Population densities of dormice at each site did not vary significantly between the two years, but the density at site B was 2.5 times higher than at site A (Tab. 2).

The capture probability for site A was 0.47 per occasion and 0.85 overall in 2006, and 0.38 per occasion and 0.77 overall in 2007. The capture probability for site B was 0.22 per occasion and 0.54 overall in 2006, and 0.48 per occasion and 0.86 overall in 2007.

The mean distance travelled by dormice, as revealed by recapture histories, was 47.2 ± 4.7 m at site A, and over 90 % of travelled distances were less than 150 m, and none more than 250 m (Fig. 1). At site B, mean distance travelled was shorter, 24.8 ± 2.9 m, and none more than 150 m (Fig. 2).

Tab. 2 Density estimates at the two sites. Results are given with standard error (SE). N = estimation of population size, IPD = density estimated by inverse prediction, MLD = density estimated by maximum likelihood.

Capture site Year	Site A Ghiris			Site B Ciugas		
	N \pm SE	IPD \pm SE	MLD \pm SE	N \pm SE	IPD \pm SE	MLD \pm SE
2006	62 \pm 4.20	3.23 \pm 0.67	3.50 \pm 0.71	125 \pm 20.69	10.62 \pm 3.11	11.80 \pm 3.35
2007	82 \pm 6.28	4.78 \pm 0.91	5.09 \pm 0.99	117 \pm 5.88	10.18 \pm 1.45	10.26 \pm 1.42
2006 + 2007 pooled	160 \pm 12.21	4.81 \pm 0.70	4.81 \pm 0.74	251 \pm 17.49	11.32 \pm 1.46	11.71 \pm 1.44

4. Discussion

In our study sites fat dormice used nestboxes during the active season for shelter, daytime rest, rearing young and feeding on stored food.

In the two forests studied, fat dormice shared the nestboxes with conspecific individuals. The number of nestboxes used by dormice, and the actual number of dormice captured

inside nestboxes were positively correlated, thus making either method useful in estimating abundance. Dormice tended to aggregate during the mating season (June), when we found groups of dormice (up to six) of both sexes, in various combinations, but also male groups and female groups, in the same nestbox. The sharing of the same nestbox by several sexually active dormice supports the hypothesis of a promiscuous mating system (Ściński & Borowski 2008). The same study showed that, although home ranges overlap (male-male, female-female, male-female), in July and August fat dormice very rarely shared natural daytime nest sites, only 2–3 % of the cases (Ściński & Borowski 2008). In our study, we found a higher proportion of shared nests, but that could be the result of different study methods, in the radiotracking study fewer individuals being followed.

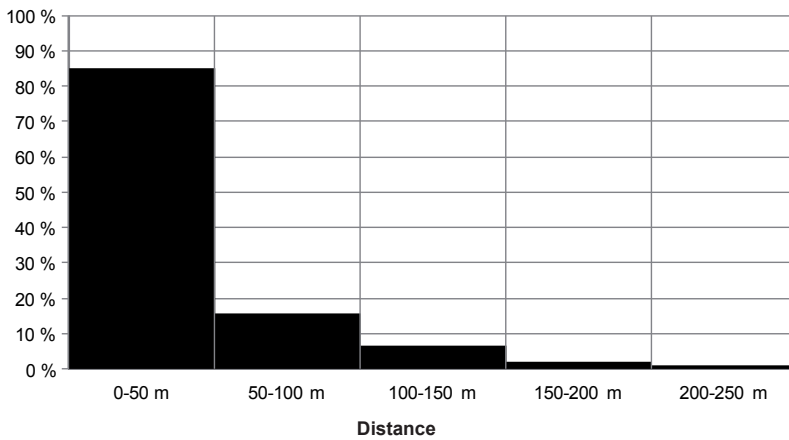


Fig. 1 Histogram of distances between capture and recaptures at site A (N = 65).

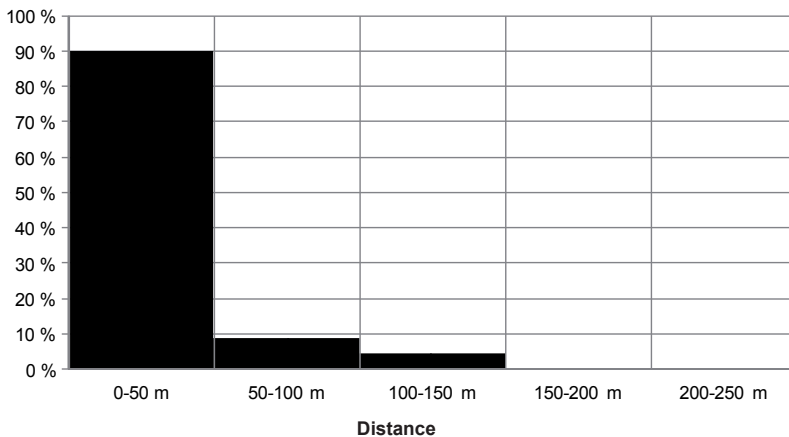


Fig. 2 Histogram of distances between capture and recaptures at site B (N = 86).

Dormice continued to share nestboxes even after the mating season, although to a lesser extent, and only by two, exceptionally three individuals. Communal nesting was uncommon in our study. In August 2006, we found at site B, two females with pups of similar age in one nestbox, and other two females, with pups of different age, sharing another nestbox. In one instance we found a lactating female with six pups sharing a nestbox with a male.

The sharing of nestboxes during the whole reproductive season, and even outside it (pers. obs.), and the shift in individuals that share a nestbox, shows that fat dormice are not solitary, but social animals. The sociality of fat dormice and the lack of hierarchy and ranks were already suggested by Vietinghoff-Riesch (1960).

In a study in Białowieża Forest, no communal natural nests were found (Ściński & Borowski 2008), but in Italy communal nests were found regularly, although the frequency varied greatly between years, ranging from less than 5 % up to 50 % (Pilastro 1992, Pilastro et al. 1994, Pilastro et al. 1996). The variation did not seem to be influenced by the shortage of nestboxes, but the highest frequencies of communal nests were observed in years with high population densities (Pilastro et al. 1996). Due to the very limited number of cases recorded in our study site, we could not make any assumptions about the factors influencing the frequency of communal nesting, but we did encounter them exclusively at the site with high dormice density.

Radiotracking studies showed that dormice can travel more than 500 m by night, but also that the home ranges of individuals overlap (Jurczyszyn & Zgrabczyńska 2007), meaning that the distance between nests could be shorter. The method we used could only show the distance travelled between nest sites used for daytime rest, and not the total distance traveled during the night. The mean distance moved by dormice, as revealed by the capture histories, was therefore much shorter: in over 90 % of cases, they travelled distances of less than 150 m, and none more than 250 m. In a similar study in Germany, the mean distance travelled between nestboxes was slightly higher (57.3–68.6 m) (Ruf et al. 2006), but there too 91 % of all movements were shorter than 150 m. In a study that used bird boxes, much longer distances were recorded: the average distance moved was 272.7 m for males and 201.1 m for females, with a maximum of 1.100 m, but still 70 % of distances did not exceed 200 m (Gaisler et al. 1977). It seems that, although dormice are capable of travelling long distances, most of the recorded distances travelled between nestboxes did not exceed 250 m. The number and the arrangement of the nestboxes, but also the duration of the study, could in fact influence the distances recorded by recapture histories. Dormice changed their nest sites during the reproductive season, but they moved in the vicinity, rarely more than two nestboxes away during one season, showing high nest site fidelity, but not necessarily for the same nest. At higher population density, the distance travelled might be even smaller.

Acorns and beechnuts are the major food source in autumn for the fat dormouse (Bieber 1998, Pilastro et al. 2003, Ruf et al. 2006), and density was found to be dependent on the availability of beechnuts, as significantly higher dormouse density was recorded at sites with high beech (*Fagus sylvatica*) presence (Ruf et al. 2006). Significant year-to-year fluctuations in population densities have been reported in beech forests in northern distribution range, as entire dormouse populations can skip breeding in non-masting years (Bieber 1998, Pilastro et al. 2003, Bieber & Ruf 2004, Ruf et al. 2006, Morris & Morris 2010, Lebl et al. 2011). However, the fluctuations concerned most predominantly the abundance of juveniles, the adult density being not affected by reproductive years (Lebl et al. 2011). There was a significant correlation between the number of dormice found during autumn in nestboxes and the pollen density of beech, but not with the pollen density of oak (Bieber & Ruf, 2004), and the number of breeding females was significantly correlated with the production of beech seeds (Pilastro et al. 2003). In oak and beech forests, in

a three-year study (2006–2008) in Czechia, no years without (or very low) reproduction were recorded (Lebl et al. 2011). Other studies also showed that, in southern distribution range, dormice breed regularly every year (Santini 1978, Pilastro 1992). In our study site, between 2005 and 2007, oak mastling occurred only in 2005, but dormice reproduced each year and there were no significant changes in nestbox occupation rate between 2005–2007 (Sevianu 2009). We suggest that in southern distribution range, in mixed deciduous forests dominated by oak, dormice might not show synchronized breeding with oak mastling and no significant fluctuation in adult population size or density occurs in relation to oak mastling.

We found a significantly higher dormouse density in the oak forest than in the hornbeam forest, showing that in lowland forests the dormouse density is influenced by the presence of oak trees. A study in the northern part of the distribution range showed that the fat dormouse preferred forests with high total cover of oak trees in mature mixed forests, which provided both conditions for arboreal movement in canopies with good interconnectivity, and a good source of food (Juškaitis & Šiožinytė 2008). Previous studies in the deciduous forests of the Transylvanian Plain showed that the presence of a diverse and well-developed shrub layer was also important (Sevianu 2009), confirming the strong dependence on development of undergrowth found in Russia (Ivashkina 2006).

The reported dormouse densities from other parts of Europe vary tremendously, from 0.2 ind./ha (Gaisler et al. 1977) up to 30 ind./ha (Nowak 1994 in Burgess et al. 2003). Vietinghoff-Riesch (1960) found in Germany a density of 4.9 ind./ha, using only September data. In south central Slovenia, in mixed forest of beech and silver fir (*Abies alba*), adult density was estimated at 6 ind./ha (Kryštufek et al. 2003). In deciduous woodlands of Sicily, the densities reported ranged from 4 to 20 ind./ha (Milazzo et al. 2003). In a recent study, densities of 6.237 ind./ha were found in an sessile oak forest in Czechia, and of 6.390 ind./ha and 5.765 ind./ha in beech dominated forests in Germany and Italy (Lebl et al. 2011), but with no details on how the effective trapping area was estimated. The Minimum Number Known to be Alive (MNA) method gave an estimation of 2 ind./ha in mixed woods in Latvia, estimating the sampled area by adding an additional bounding strip to the area ‘covered’ by nestboxes (Pilāts et al. 2009). In a study conducted in Germany in a beech forest using traps, during 7500 trap-nights a total of 196 dormice were captured, and the population density, calculated with MNA-method, ranged between 13 and 22 ind./ha in summer months, but with no details on the area sampled (Bieber 1995).

We could not make valid comparisons of population density with results from similar or different habitats because each study used a different method to estimate density. The methods varied greatly in terms of period of study (entire active period, summer only, autumn), the individuals counted (adults only, adults plus yearling together, adults and yearlings separately or adults, yearlings and juveniles), the area considered to be the sampled area as well as the estimation method.

We compared our findings with the density estimates obtained using call counts. In England, where the species was introduced, densities were lower and varied between 1.7–1.8/ha in mature and pole-stage beech forest, and 0.6/ha in mixed habitat (spruce, pole-stage beech and elder) (Hoodless & Morris 1993). In southeastern Poland, in various types of deciduous and mixed forests, density estimates ranged between 1–11 ind./ha (Jurczyszyn 1995). In mixed forests of north-western Poland, populations were categorized as ‘low density’ (2.7–3.2 ind./ha) and ‘high density’ (8.3–10 ind./ha) (Jurczyszyn, unpubl., in Jurczyszyn & Zgrabczyńska 2007), and density estimates were quite similar to our results in oak and hornbeam forests of the Transylvanian Plain.

Our results suggest that in the lowlands of southeastern Europe, oak-dominated forests are more suitable to sustain high dormouse density than the field maple and hornbeam forests. The fat dormouse prefers mature oak forests and a well-developed shrub layer, conditions that can provide shelter, rich and diverse food sources and allow free canopy movement.

Estimating densities using spatially explicit capture-recapture methods can be very useful in analyzing data from regular nestbox checks, and, as it does not require a specific layout or fixed distances between nestboxes, has the potential of giving estimates of density that can be compared in order to further determine fat dormouse habitat requirements and preferences in different part of the species' range.

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Authors' addresses:

Eliana Sevianu*
Nature Monuments Committee
Romanian Academy of Science
Republicii 44
Cluj-Napoca 400015, Romania

Alin David
Babes-Bolyai University
Faculty of Biology and Geology
Republicii 44
Cluj-Napoca 400015, Romania

*Corresponding author: Eliana Sevianu (e-mail: elianasevianu@gmail.com)

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