

Use of space by bank voles (*Clethrionomys glareolus*) in a polish farm landscape

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Abstract

Movements of bank voles (*Clethrionomys glareolus*) were studied in a farmland mosaic in Poland. Distances crossed by animals in short-time periods are significantly longer in heterogenous than in homogenous habitats. In long-time and large-spatial scales, a significant portion of the animals in a population travel among habitat elements of the mosaic, reducing the degree of isolation of patch populations and decreasing the probability of local extinction.

Introduction

In many farm landscapes in Poland woods are fragmented and small woodland mammal species find their habitat scattered in separated and usually small patches. These changed patterns force animals to adapt behaviourally to survive. Adaptive changes in the use of space by individuals seem to be of highest importance for metapopulation existence. For this reason studies of movements by animals in mosaic landscapes are gaining in importance (e.g. Merriam 1984, 1991; Liro and Szacki 1987).

Here we present data on movements of bank voles (*Clethrionomys glareolus*) in a farm landscape. We examine short-time scale movements in both homogenous and heterogenous environments and long-time and long-distance movements in a farmland mosaic. We interpret our results in terms of metapopulation processes.

Methods

Studies were carried out in north-eastern Poland in a partly wooded, mosaic farm landscape. Marked bait and snap-trapping were used in all study areas. Bait was margarine and flour mixed with selected chemical markers. All chemicals used as markers were stereoisomers of the well known and toxic pesticide – gamma-HCH (benzene hexachloride). All of them are chlorinated hydrocarbons. None of them, however, has ever been used in Poland as pesticides in agriculture or forestry practice because of their low toxicity (Worthing 1983), so they were totally undetectable (absent) in the environment. Extremely low, even trace amounts of markers were enough to mark animals eating the bait, and to be detectable in their body tissues for as long as four months. The concentration of each marker was 0.1 g of pure chemical compound per 1 kg of bait. To protect the bait against rain and to avoid contamination of the environment, bait was exposed inside plastic tubes 30 cm long and about 3,5 cm in dia-

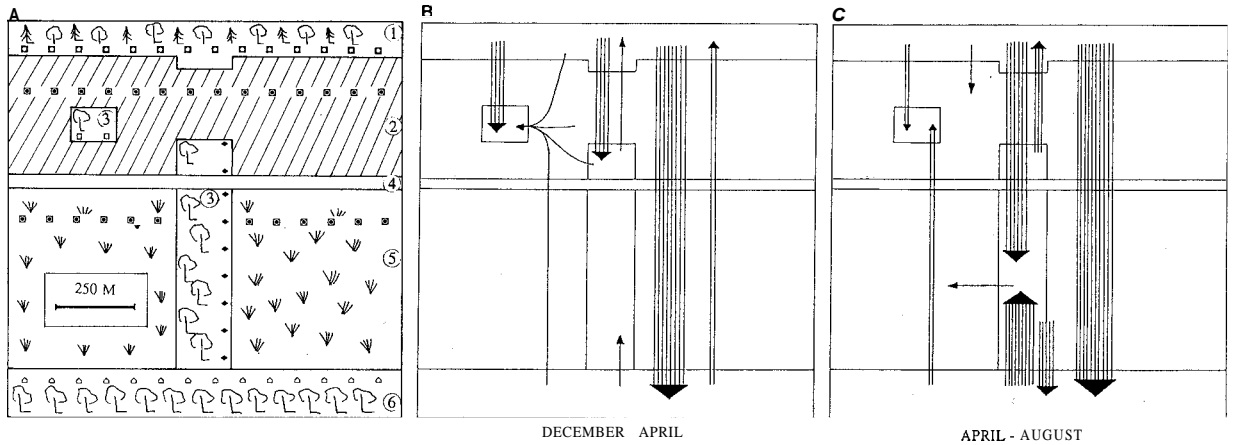


Fig. 1. Study area map (A) and movements of bank voles between different habitats at two different seasons (B, C). (A): 1 – mixed forest; 2 – crop field; 3 – alder woods; 4 – gravel road; 5 – pasture; 6 – lake-shore habitat; The various symbols indicate various markers added to the bait; One arrow indicates movement of one individual.

meter (PCV waterpipe cut in 30 cm lengths). These tubes also made the bait inaccessible to bigger mammals and all birds. Trapped bank voles were examined for the presence of residues of chemical markers in their body tissues using gas chromatography. The whole dried body of each individual was taken as a sample.

Samples were homogenized separately with anhydrous sodium sulfate in a porcelain mortar. Samples were extracted 24 h in the Soxhlet apparatus with 90 ml of n-hexane. Organic extract was evaporated under a stream of nitrogen and the residue was dissolved in 1 ml of n-hexane. Samples were then washed with concentrated sulphuric acid. The purified extract was again evaporated and dissolved in 1 ml of n-hexane (Worthing 1983). Five μ l portions of prepared samples were chromatographed on Pye Unicam 104 gas chromatograph with Ni⁶³ detector. Glass columns of 4 mm diameter, 5 feet in length packed with 1.5% OV 17 + 1.95% OV 210 on 80–100 mesh WHP Chromosorb were 260" and 210", respectively. Argon was applied as carrying gas with flow rate of 60 ml/min. Chromatograms of chlorinated hydrocarbons present in the samples were compared with chromatograms of authentic standard compounds to quantitate CHs.

Short-term movements of bank voles were studied using two straight lines of snap-traps, each 1000 m long. Trap lines were set in both heterogeneous and homogeneous environments. Trap-line

A was placed inside a large and relatively homogeneous, mixed-wood forest (*Pinieta-Vaccinium myrtilli* community with some elements of *Quercus-Fagetea* class). Trap-line B was placed in a mosaic of habitats consisting of mixed-wood forest, alder wood (*Circeo-Alnetum* community) and a crop field adjoining the forest. A station with marked bait was placed in the middle of each trap line. The bait was offered for five days preceding trapping. Pairs of snap traps were placed at 20 m intervals along each line (100 traps arranged in 50 trapping stations) and were inspected once daily over five days of trapping. Bank voles caught at each distance from the bait station were examined for the presence of the chemical marker in their body tissues. Overall, 118 bank voles were trapped.

Seasonal, wide-range movements of bank voles among different habitat patches within a farmland mosaic were studied on another area of approximately 2 square kilometers. The study area was a mosaic of various habitats: mixed forest (mixed elements of *Quercus-Fagetea* and *Vaccinio-Piceetea* classes), crop fields, pasture, alder woods (*Alnetea glutinosae* class), and woody lake-shore habitat (zonally arranged *Circeo Alnetum*, *Salicetum pentandro-cinereae* and *Phragmitetum* communities), and was bisected by a narrow, gravel road (Fig. 1A). Bait/trap stations in mixed forest, crop field, pasture and lake-shore habitats were arranged in lines perpendicular to the assumed direc-

tion of animal movements (forest – lake-shore – forest), while those situated along a narrow strip of wood were parallel to this direction (Fig. 1A). Bait marked with 5 different markers was used to mark individuals that had fed in each habitat unit of the study area. Bait was available for about one month before trapping at the bait stations, placed at 50 m intervals along straight lines (Fig. 1A). The bait was placed inside plastic tubes, as described above. At least 0.5 kg of each kind of marked bait was used. Four months later pairs of snap-traps were set at each station instead of baiting tubes for a 5-day trapping period. All trapped individuals were examined for the presence in their body tissues of all 5 types of markers used in the experiment. The experiment was carried out in two different years to collect data for different seasons. In the first year bait was exposed from late November 1988 and animals were trapped in early April 1989, while in the second year bait was exposed in April 1990 and bank voles were trapped in late August 1990. Overall, 95 bank voles were trapped: 42 individuals in the first year of the experiment and 53 individuals in the second.

Results

Bait stations were in the middle of each 1000 m trap line, so the longest possible animal movement in a straight line (longest possible ranges of movements) was 500 m. Among 118 trapped bank voles, 66 individuals (56%) were marked with a bait. The mean distance between bait station and the trapping point was almost twice as long on the transect in heterogenous as on the transect in homogenous habitat (t-Student's test, $t = 3.66$; $df = 64$; $p < 0.05$). However, the maximum distances moved were close to 500 m in both habitats (Table 1).

In April, 22 marked individuals were found among 42 trapped bank voles (52%). Of the marked bank voles, 17 individuals (77%) were marked with bait types from outside the habitat in which they were trapped. One bank vole caught in a woodlot contained residues of all types of markers used in all habitat units (Fig. 1B). This individual had visited all “marked” habitats within

Table 1. Mean distances (\pm S.E.) and longest recorded distances moved by bank voles in homogenous (A) and heterogenous (B) habitats.

Distance (m)	A	B
Mean \pm S.E.	135 \pm 116	243 \pm 133
Longest recorded	440	480

the whole study area at least once between December and April. Most movements of bank voles (12 of 17) were from mixed forest to other habitats in the mosaic (Fig. 1B).

In August, 45 of 53 trapped bank voles (84%) were marked with a bait. Thirty-nine voles (87%) contained markers from outside the habitat unit in which the vole was trapped. There was much less directionality of movement (Fig. 1C).

The proportion of voles moving among habitat units (individuals marked with “foreign” bait) was distinctly higher in August than in April (Chi-square test, $\chi^2 = 12.042$, $p < 0.05$) (Fig. 2).

Discussion

It is widely known that small mammals can travel much longer distances than one might predict from the average size of their home range. For example, Robinson and Falls (1965) found that the greatest dimension of home range of *Microtus pennsylvanicus* usually does not exceed 30 m on the average, while individuals can easily move up to 200 m. Recent literature contains many records of long distances crossed in short time periods by small mammals (Andrzejewski and Babinska-Werka 1986; Liro and Szacki 1987; Wegner and Merriam 1990; Szacki and Liro 1991). Therefore, the movements of approximately 500 m, recorded in this experiment, are not surprising. However, our results give clear evidence that distances between marked and trapped animals are significantly longer in heterogenous habitats compared to homogenous ones.

Extremely long distances – more than 1000 m – travelled by striped-field mice (*Apodemus agrarius*) and bank voles (Liro and Szacki 1987; Szacki and

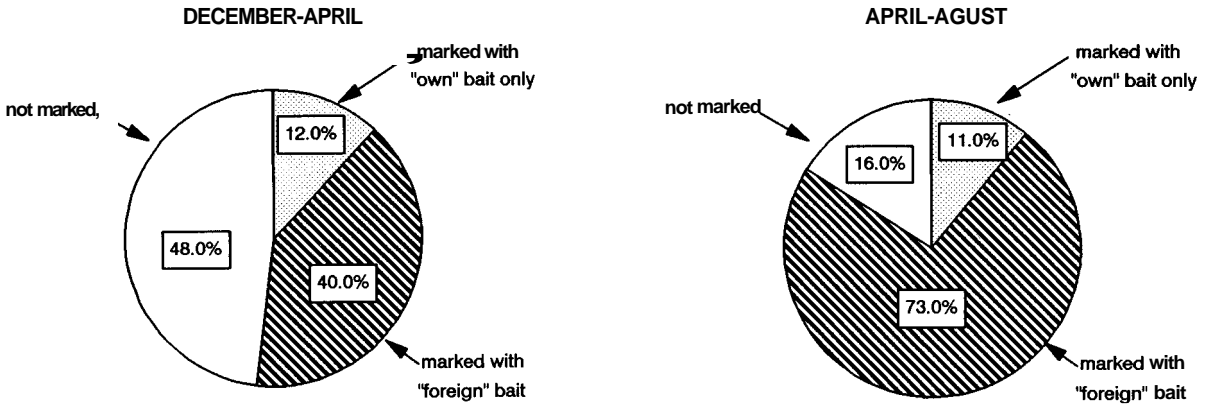


Fig. 2. Percentage of individuals marked with "own" and "foreign" bait.

Liro 1990) were recorded only in a very heterogeneous suburban mosaics. Also Merriam (1990) and Wegner and Merriam (1990) give examples of distances longer than 1000 m moved by white-footed mice (*Peromyscus leucopus*) in a mosaic farm landscape. These data suggest that increased movement range might be a common behavioural response of small mammals to increased habitat heterogeneity.

The increased movement in heterogeneous space may be caused by the wider distribution of habitat resources which animals must find (shelter, food etc). There also may be some alternate explanations. However, discussing this problem and the possible benefits to "wide-range movers" in a heterogeneous habitats is not our intention here. Whatever the causes and benefits, the ability of individuals to move relatively long distances in a heterogeneous, patchy habitat can influence markedly the functioning of a whole metapopulation.

According to Levins (1970), a metapopulation consists of a group of small subpopulations inhabiting patches of suitable habitat. Each subpopulation is restricted to the habitat patch and, therefore, is spatially isolated from other subpopulations inhabiting other suitable patches. Spatial isolation and the relatively small size of subpopulations can cause their local extinctions. Local extinctions are recolonized by transfer of individuals between patches. The dynamic demographic equilibrium of the whole metapopulation is thus supported by balanced processes of extinction and recolonization.

Result of our study of movements of bank voles in a mosaic landscape seem not to be fully consistent with Levins' (1970) concept of metapopulation. The observed relatively low percentage of marked bank voles caught in spring suggests that many of those individuals arrived from outside the study area. The dominant direction of movements from mixed forest to other habitats of the mosaic indicates that bank voles use mixed forest as a preferred habitat for wintering, spreading throughout the landscape searching for suitable summer habitats to occupy. The relatively high percentage of marked bank voles in the autumn catch (including very high percentages of animals marked with "foreign" bait) suggests that animals are very mobile during the reproductive season; a large portion of the population was travelling among habitat elements of the mosaic at this time.

According to our bank vole data, a possible scenario of a year-round metapopulation cycle is: [1] In spring voles disperse from the best patches of overwintering habitat. Animals colonize empty habitat patches and start to breed there; [2] during the whole reproductive season animals move frequently among occupied habitat patches and possibly a large proportion of individuals use more than one habitat patch. These dispersers may range over the whole mosaic area; [3] In autumn, at the end of the breeding season, a large number of highly mobile individuals choose the best habitats for wintering, thus decreasing the probability of local winter extinction (Fig. 3).

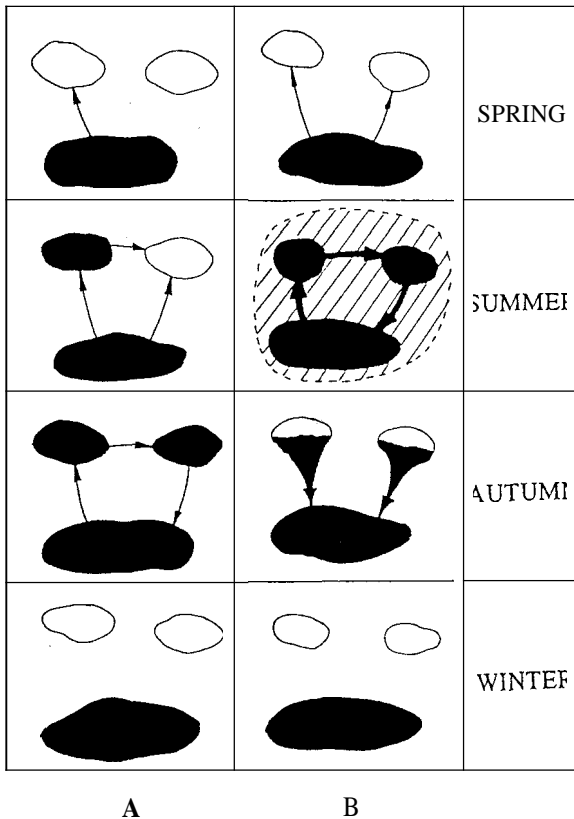


Fig. 3. The schematic picture of year-round cycle of Levins' (1970) metapopulation (A) and according to our bank vole data (B).

Black spots – patches of habitat actually occupied; white spots – patches of habitat not occupied actually; arrows show possible directions of animals' movements; lined area – region covered by spatial activity of dispersers.

While contrary to the assumptions of Levins' theoretical stochastic model of metapopulation, this "nomadic" type of metapopulation existence seems to be fully consistent with the findings of Wegner and Merriam (1990). Despite the isolation of habitat patches, a "nomadic" metapopulation does not consist of strongly isolated subpopulations (at least during some phases, such as reproduction) as Levins' metapopulation does. Subpopulations do not fluctuate independently, because they are strongly interconnected by frequent inter-patch movements of individuals during each generation. Habitat patches can be selected by mobile animals according to their changing habitat quality. Low quality habitat patches can be emptied by emigra-

tion of highly mobile individuals; not only by seasonally high local mortality. Local extinction by deaths is less frequent, therefore increasing the probability of metapopulation survival.

In contrast to our results, Bauchau and Le Boulengé (1991) found bank voles to have low mobility. In a mosaic landscape in central Belgium, bank voles were found only in forests and woodlots and showed no tendency to move between them frequently. It seems that even different populations of the same species can exhibit different spatial behaviour. It is not only the species' ability to move which varies, but also different aspects of the spatial composition of the landscape (corridors, barriers, quality of patches etc.) can play an important role in determining metapopulation processes in patchy environments.

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