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# Small mammal and raptor densities in habitat islands; area effects in a south Swedish agricultural landscape

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## Abstract

There was no significant correlation between the size of habitat islands in cropped fields and the density of field vole, bank vole, and common shrew populations during autumn. Despite this, winter densities of perching raptors were considerably higher in small islands than in large one. Explanations for this, apparently suboptimal, hunting pattern are discussed. The distribution should increase predation mortality for small rodents in small compared to large patches and may have been the cause of the higher winter mortality actually found for field voles in small patches.

## Introduction

A basic ecological question concerns the factors that affect the density and distribution of a species. When the distribution of suitable habitat in a landscape is restricted to patches of limited size this potentially adds several factors. A list of (not necessarily mutually exclusive) factors that have been considered for small mammals in such landscapes include: Chance (Merriam 1984, Lefkovitch and Fahrig 1985), patch isolation (Gottfried 1982), patch size (van Apeldoorn and van der Zee in press), population size, and surrounding habitat (Hansson 1981, Wegner and Merriam 1979).

Here I present data from a study of small mammals in an agricultural landscape where small patches of non cropped land are present. I analyze the relation between autumn density and patch size. If chance extinction combined with low recolonization rate (modelled by Lefkovitch and Fahrig 1985) is an important factor determining small mammal density in these patches, I expect the lowest average densities in small patches. If, on the other hand, mammals resident inside a patch utilize resources in the surrounding fields, (suggested for birds in this landscape by Loman and v. Schantz (in press)) border effects would give the highest densities in the small patches.

I also present data on the winter distribution of raptors in relation to patch size. These birds are important predators on rodents in this landscape. The importance of different factors (including the findings here for small rodents) for their distribution are discussed. I also discuss the importance of raptor distribution for the dynamics of the rodents in this landscape.

## Methods

### *Study area*

The study area is situated 10 km south of the city Lund in southern Sweden (13°12′E, 55°35′N).

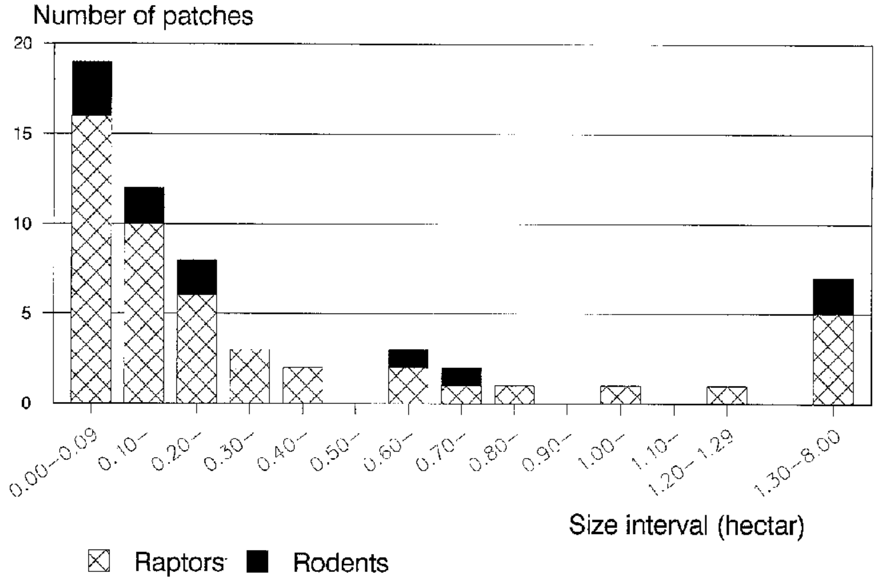



*Fig. 1.* Size distribution of patches used in the study. In the pooled "large" category there were rodent patches 3 and 4 ha, raptor patches 2, 3, 3, 5 and 8 ha large.

This is an agricultural landscape with cereals, rape, and sugar beets as main crops. Patches of uncropped habitat are present. These consist of marl pits, steep slopes, small marshes and groves. The small mammals were studied in eleven and raptors in 48 such patches. The size of the study patches was 0.03 to 4.00 and 0.01 to 8.00 ha respectively (Fig. 1).

### *Small mammal census*

The small mammal community was censused in the autumns of 1983 to 1988 and in the springs of 1984 to 1989. Each census consisted of four days of live trapping (the traps were set on day 1 and checked on days 2, 3, 4, and 5). The traps were multiple catching, baited with rolled oats, and put in a grid system with one trap for every 10 m (thus trap density was 100 traps/ha). The nine smallest patches were completely covered with traps; the number of traps was 3 to 69. The two largest patches, 3 and 4 ha, were sampled on subareas, 0.60 and 0.67 ha respectively, that were covered with the standard 10 m trap grid. Captured small mammals were individually marked. The total number of individuals captured in a patch during a trapping period was used as an index of the number present. The total number captured during a spring period divided by the total number captured during the preceding autumn period was used as an index of winter survival. Bank voles *Clethrionomys glareolus*, field voles *Microtus agrestis*, and common shrews *Sorex araneus* were totally confined to the patches. Loman (in press) gives data on this for the present study area). An unbiased index of density could thus be computed as number caught divided by the area of the patch (or trapped subarea for the two largest patches). Even on patches were only part of the area was trapped, border effects were small because most of the sampled area bordered fields with no voles or shrews. However, the wood mouse *Apodemus sylvaticus* also occurred in the surrounding fields (Loman (in press)). Wood mice are therefore not considered when analysing the relation between patch size and density.

However, to analyse raptor behaviour I need at least a conservative measure of density for all rodents in the patches. I compensate for the wood mouse border effect by estimating density as number trapped divided by the area (or trapped subarea) of the patch plus a surrounding border

(Caughley 1977). The choice of width for this border will affect different patch sizes differently; use of a narrow border increases calculated densities more for small than for large patches. I use a 10 m wide border. This is certainly too little and will thus exaggerate the negative slope found for density over patch area. As my argument below goes, this mean erring on the conservative side.

All correlation analyses are based on one measure for each patch; the six year mean values for each patch.

The four species mentioned above dominated the small mammal community in the area. Other small mammal species present were yellow-necked mouse *Apodemus flavicollis*, Norwegian rat *Rattus rattus, house mouse Mus musculus*, and pygmy shrew *Sorex minutus*. However, these species were much less abundant (Loman, in press).

### *Raptor census*

The distribution of raptors was studied in 48 patches in the same area. Ten patches were part of both studies. For the analysis of raptor densities I divide the patches in three size classes. There were 31 patches that were up to 0.20 ha in size, 11 that were from 0.21 to 1.00 ha, and 6 that were larger than 1.00 ha. The total area covered by patches in the three size classes was 2.33 ha, 5.15 ha, and 22.2 ha respectively. The patches were checked for perching raptors; only patches that offered perching sites were considered. It took about 1 hour to check all patches while driving a 25 km long route. Altogether 19 checks were made during the periods 29/11 1983 to 16/2 1984 and 19/12 1984 to 21/1 1985. Raptors censused were common buzzard *Buteo buteo*, roughlegged buzzard *B. lagopus*, and red kite *Milvus milvus*. A dominating winter food of these species is voles but also wood mice are taken (Wessel 1969; Davis and Davis 1973; Sylvén 1978). Shrews are only taken occasionally. Altogether 66 raptors (37 buzzards, 12 rough-legged buzzards, and 17 red kites) were spotted. The choice of a relevant measure for patch size was a problem with respect to perching raptors. It could be that the raptors directed their hunting effort not only to the patch itself but also to the surrounding field, in particular since wood mice were present there. If so, the actual patch sizes are biased and should actually be larger to encompass the whole hunting area of a perching raptor. To err on the conservative side, I make the following alternative calculations of patch size. I assume that a raptor is always able to find a 10 m high tree on the patch border (this is actually not always possible) and that it is able to detect and catch a rodent within a striking angle of 45° (Sylvén pers. comm.). I therefore include a 10 m wide strip around all patches when calculating their alternative area. With this area measure the total area of the 31 small, 11 medium sized and 6 large patches is 6.61, 8.91, and 26.1 ha, respectively. Note that the choice of 10 m for this measure is independent from the 10 m used in the previous section.

*Table 1.* Results of Spearman rank correlation analysis between patch size and mammal densities. Shrew are not included in the spring analysis because the results could be affected by autumn trap mortality. N = 11 for all tests.

| | Autumn | | Spring | |
|---|---|---|---|---|
| | $R_s$ | P | $R_s$ | P |
| Bank voles | −0.383 | >0.10 | −0.118 | >0.10 |
| Field voles | −0.282 | >0.10 | 0.045 | >0.10 |
| Shrew | 0.547 | <0.10 | | |

## Results

There was no *significant* correlation between autumn density and patch size for any of the three species analyzed (Table 1, Fig. 2) although the regression equations predicted higher densities in smaller patches for all rodent species. The latter includes wood mice, even when a 10 m border was added to the area of the patch. However, there was a tendency for higher shrew densities in larger patches. Spring densities did not show any relation to patch area. Field vole winter survival tended to be higher in large patches than in small ($r_s = 0.73$, d.f. = 10, $P < 0.01$). There was no relation between winter survival and patch size for the bank vole and wood

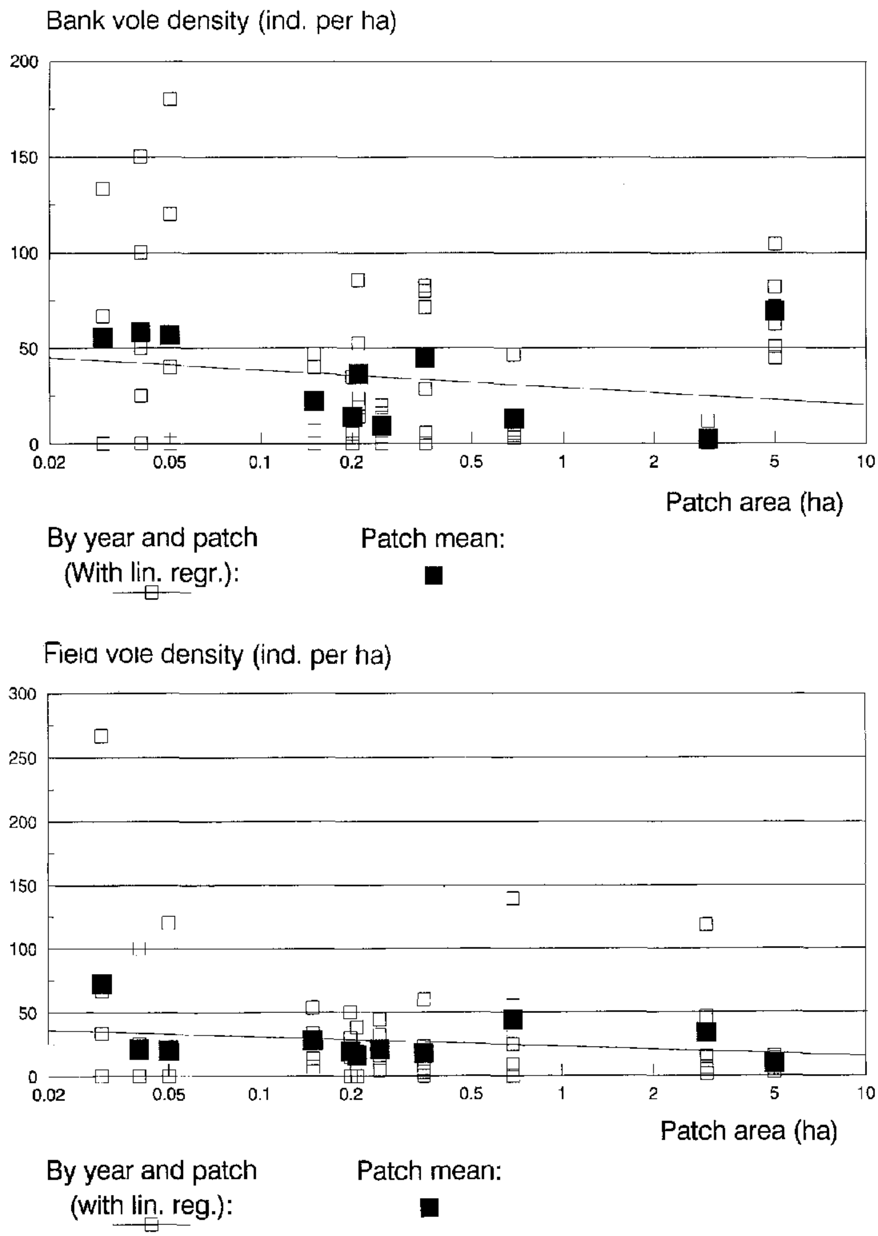
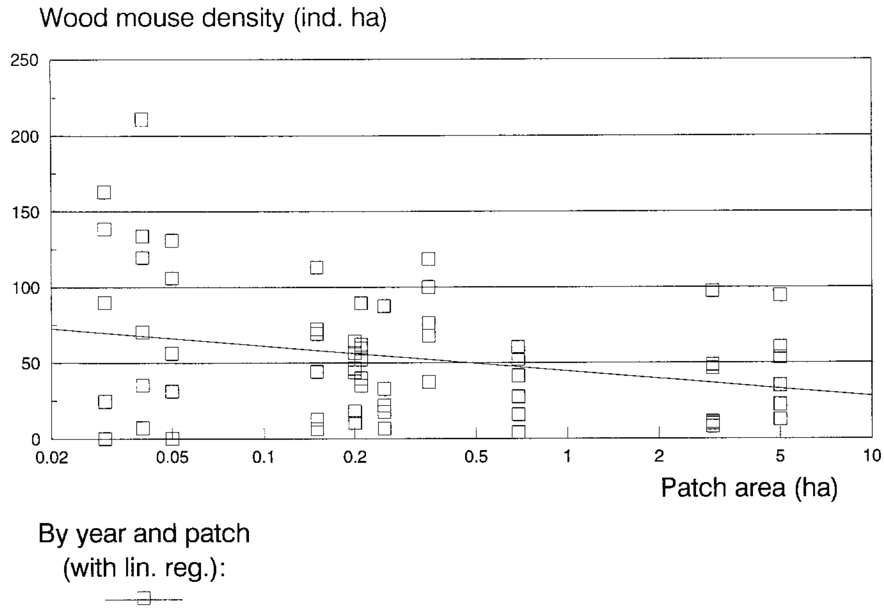



*Fig. 2.* Patch area and mammal densities. There are six data points per patch (i.e. area category). Sometimes fewer are visible because several are stacked on the zero line. Patch means are not given for wood mice; the data shown are based on patch plus border area and are only used for a conservative regression of density on area as explained in the methods section.

mouse, $r_s = -0.06$ and $r_s = 0.25$ respectively (d.f. = 10, $P > 0.10$ for both).

There were altogether 26 raptors spotted in small patches (corresponding to 0.59 ind. per ha), 17 in medium sized (0.17 ind. per ha) and 23 in large patches (0.05 ind. per ha). This should be compared to the expected distribution, considering the total area covered by patches of the different size classes; 5.2, 11.5, and 49.3. The difference is significant ($\chi^2 = 99.9$, d.f. = 2, $P < 0.001$). Based on the alternative area (adding a 10 m border) calculation, the expected number of observed raptors is 10.5, 14.1 and 41,4 individuals. Also this differs significantly from the observed distribution ($\chi^2 = 31.66$, d.f. = 2, $P < 0.001$).



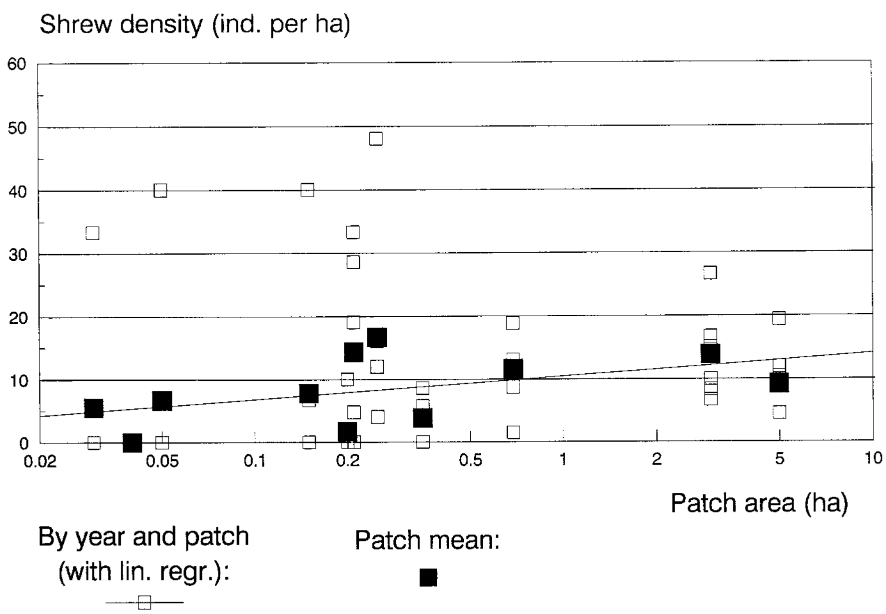




*Fig. 2c* and *d*.

## Discussion

### *The raptor point of view*

Why is raptor density higher in small patches than in large ones? (1) One could imagine that raptors are more easily spotted when perching in small than in large patches. However, the patches were chosen to offer a good possibility of detecting all raptors present. This was probably successful as I observed 22 raptors in patches more than 200 m from the road while the expected number, based on total area, of such observations was the same, 22. (2) Although the difference was not significant, there was still a tendency for higher autumn rodent density in small than in large patches (Fig. 2). Linear regression (Fig. 2) predicts a combined autumn density of the three rodent species of 143, 106, and

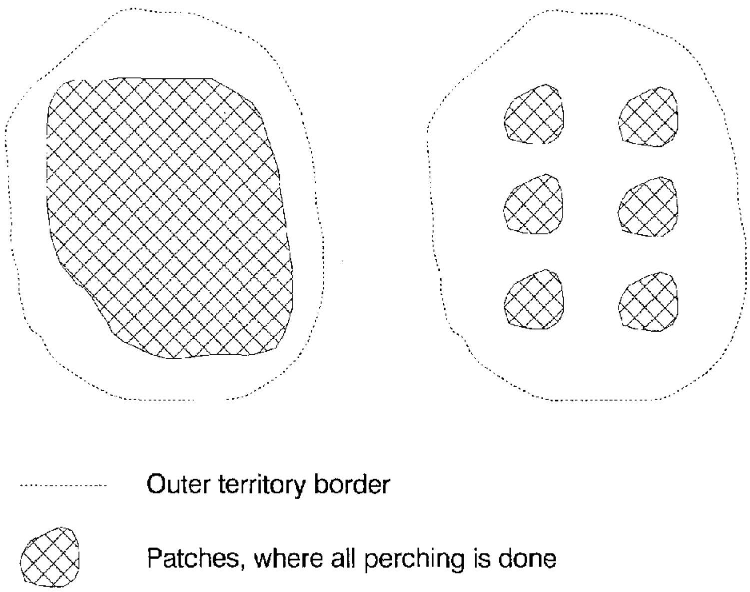



*Fig. 3.* A schematic representation of a raptor territory and patch distribution. This one is assumed for my hypothesis explaining patch size distribution of perching raptors.

86 rodents per ha in the small, medium and large patches respectively. Because of the high field vole mortality during winter in small patches, this difference is partly levelled out by midwinter. I feel reluctant to ascribe the 12-fold difference in raptor density to the maximum 2-fold difference in rodent density. (3) I believe that raptor distribution is due to some behavioural trait that is not immediately linked to rodent distribution. Somewhat exaggerated, when deciding on perch site, the raptors tend to value all patches equally, regardless of size. A more sophisticated explanation for such a decision is based on raptor territoriality. Buzzards, both common and rough-legged, have been shown to be intra- and interspecifically territorial during winter in a nearby study area (Sylvén 1978). Also territory size (all inclusive, patches and fields) is roughly similar for all territory holder. This will mean that some individuals have much larger (and less intensively utilised) patches within their territories than have other less fortunate ones (not to speak about the rodents in their territories!) (Fig. 3). The territories mapped by Sylvén (1978, 97) suggest such a pattern.

*The rodent point of view*

There was no effect of patch area on rodent density. This is in contrast to findings for a bird community in this landscape where population density decreased with patch area (Loman and von Schantz in press) and Gottfried's (1982) finding for *Peromyscus leucopus* where autumn densities were positively correlated with patch area. The lack of a negative correlation here suggests that voles do not utilize resources from the surrounding fields. The habitat islands are thus closed, much like real islands. The lack of a positive correlation on the other hand suggests that total extinction is not common (or at least not area related) and that any empty patches are readily recolonized. This was certainly true for the bank vole, only two patches remained empty for at least two consecutive year, one large and one medium sized. The situation was less clear for the field vole, the two smallest patches were without field voles for 3 and 4 successive years respectively. Unfortunately, without an experimental approach it is impossible to avoid the possibility that two factors with opposing effects are at work simultaneously for field voles.

Though not significant at the 5% level, there was

*Table 2*. Slopes in the regressions of density to log(area) with all patches included and with empty patches excluded. Wood mice densities are based on patch plus 10 m border area. A high decrease in slope value means that most of the empty patches were in the lower area range.

| | All data | | Empty patches excluded | |
|---|---|---|---|---|
| | Slope | N | Slope | N |
| Bank voles | −5.16 | 66 | −8.26 | 51 |
| Field voles | −3.35 | 66 | −11.82 | 48 |
| Shrews | +1.74 | 66 | −3.72 | 36 |
| Wood mice | 6.83 | 66 | −8.49 | 63 |

a clear tendency for higher shrew density in large than in small patches. This was mainly due to a large number of empty patches; in 30 out of 66 occasions there were no shrew captured (Table 2). This was higher than for any of the other three species. If all empty patches were excluded, there was a negative relation between patch size and density for the shrew also. My interpretation is therefore that the shrews are relatively poor colonizers and models emphasing the importance of chance extinction in small patches (Lefkovitch and Fahrig 1985) are particularly applicable for shrews in this landscape.

Whatever the reason for the high density of perching raptors in small habitat islands, this increases the risk of being taken by a raptor for a rodent living in such patches. It is possible that the relatively high winter mortality for field voles in small patches actually was due too this factor.

## Acknowledgments

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