# AN INDEX METHOD OF ESTIMATING RELATIVE POPULATION DENSITIES OF THE COMMON VOLE (*MICROTUS ARVALIS*) AT LANDSCAPE SCALE

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## RÉSUMÉ

De nombreuses questions d'écologie fondamentale ou appliquée imposent l'application de protocoles d'échantillonnage à des échelles sectorielles, voire régionales, auxquelles se réalisent de nombreux mécanismes écologiques importants. L'absence de méthodes d'échantillonnage utilisables à ces échelles représente un obstacle majeur à l'analyse et à la compréhension de ces mécanismes. Pour une population de Campagnols des champs (*Microtus arvalis*) nous avons testé la validité d'une méthode d'estimation indiciaire en densité relative applicable le long de transects plurikilométriques. Les résultats obtenus montrent que cette méthode d'estimation indiciaire en densité relative est bien adaptée au suivi des variations d'abondance et de distribution des populations du Campagnol des champs et autorise des études pour une grande diversité d'objectifs et d'échelles spatiales.

## SUMMARY

Many issues in fundamental and applied ecology require the use of sampling protocols at the sectoral or even regional scales at which many important ecological mechanisms occur. The lack of workable sampling methods at these scales is a major obstacle to the analysis and understanding of these mechanisms. We test the validity of an index method of estimating relative population densities, applicable along transects of several kilometers in length, for a population of Common Voles (*Microtus arvalis*). The results show that the index method of estimating relative density is well adapted for monitoring variations in the abundance and spatial distribution of Common Vole populations and authorizes studies for a wide range of objectives and spatial scales.

## INTRODUCTION

The upsurge in problems posed by rodents for agriculture (crop damage) and public health (transmission of disease to humans) results in most instances from a change in the demographic pattern of these species (Myllymäki, 1979; Spitz, 1989;

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*Rev. Ecol. (Terre Vie),* vol. 55, 2000.

Delattre *et al.*, 1996, 1998). The transition from stable to unstable patterns (outbreak systems) regularly occurs subsequent to environmental changes at sectoral or even regional scale (Delattre *et al.*, 1992, 1999; Giraudoux *et al.*, 1997). It is therefore at the sectoral or landscape scale (*sensu* Blondel, 1995) that the explanatory mechanisms must be sought for these changing patterns of rodent populations over space and time.

Most of the available methods of estimating abundance involve capture techniques which are unsuitable at these scales. An initial advance was made by the development of index techniques based on the observation of traces or damage related to rodent activity. Index techniques for investigating variations in population abundance were used by Emlen *et al.* (1957) for the Meadow Vole (*Microtus pennsylvanicus*), Lidicker & Anderson (1962) for the California Vole (*Microtus californicus*), Myllymäki (1970) and Hansson (1986) for the Field Vole (*Microtus agrestis*), and Buker (1984) for the Common Vole (*Microtus arvalis*). However, in the absence of any means of comparing the results of these index techiques with a standard reference technique (e.g. capture), it was impossible to validate the index techniques for these different examples.

More recently Giraudoux *et al.* (1995) for the Water Vole (*Arvicola terrestris*), Krohne (1982) for *M. californicus,* and Liro (1974), Mackin-Rogalska *et al.* (1986) and Delattre *et al.* (1990a) for *M. arvalis* have sought to validate the use of presence indices. Close correlations were established in these studies between population densities measured on the one hand by capture techniques (capture - marking - recapture or line capture) and on the other hand by presence indices recorded at the same time and the same site as capture (occurrence of earth mounds, number of runways, burrow closure-reopening rate, number of burrows and presence of droppings). However, the techniques were not validated beyond the scale of habitats or parcels at which capture took place. Yet it is at landscape scale that most of the current ecological problems arise testing new hypothesis (e.g. "source and sink" dispersal) or designing strategies for rodent control.

The purpose of this work is to evaluate a new sampling method for estimating abundance based on presence indices that provides information on temporal and spatial variations of population abundance and that is operational at landscape scale.

## MATERIAL AND METHODS

### STUDY SITE

The study was conducted in the commune of Septfontaines (46° 58' N, 6° 11' E, Doubs department) in a medium mountain agro-ecosystem at an elevation of 700-800 m, where former studies (Delattre *et al.*, 1990a, 1990b, 1992, 1996) have been carried out. The study site is composed mainly of mowing meadows and pastureland which exceeds 95 % of farmland. It exhibits two different landscape structures: hedgerow networks over about 600 ha and openfields covering about 300 ha (Fig. 1).

### SAMPLING METHODS

Population dynamics were compared over a six year period (Fall, 1990; Fall, 1996) encompassing one complete multi-annual fluctuation of *M. arvalis* in this

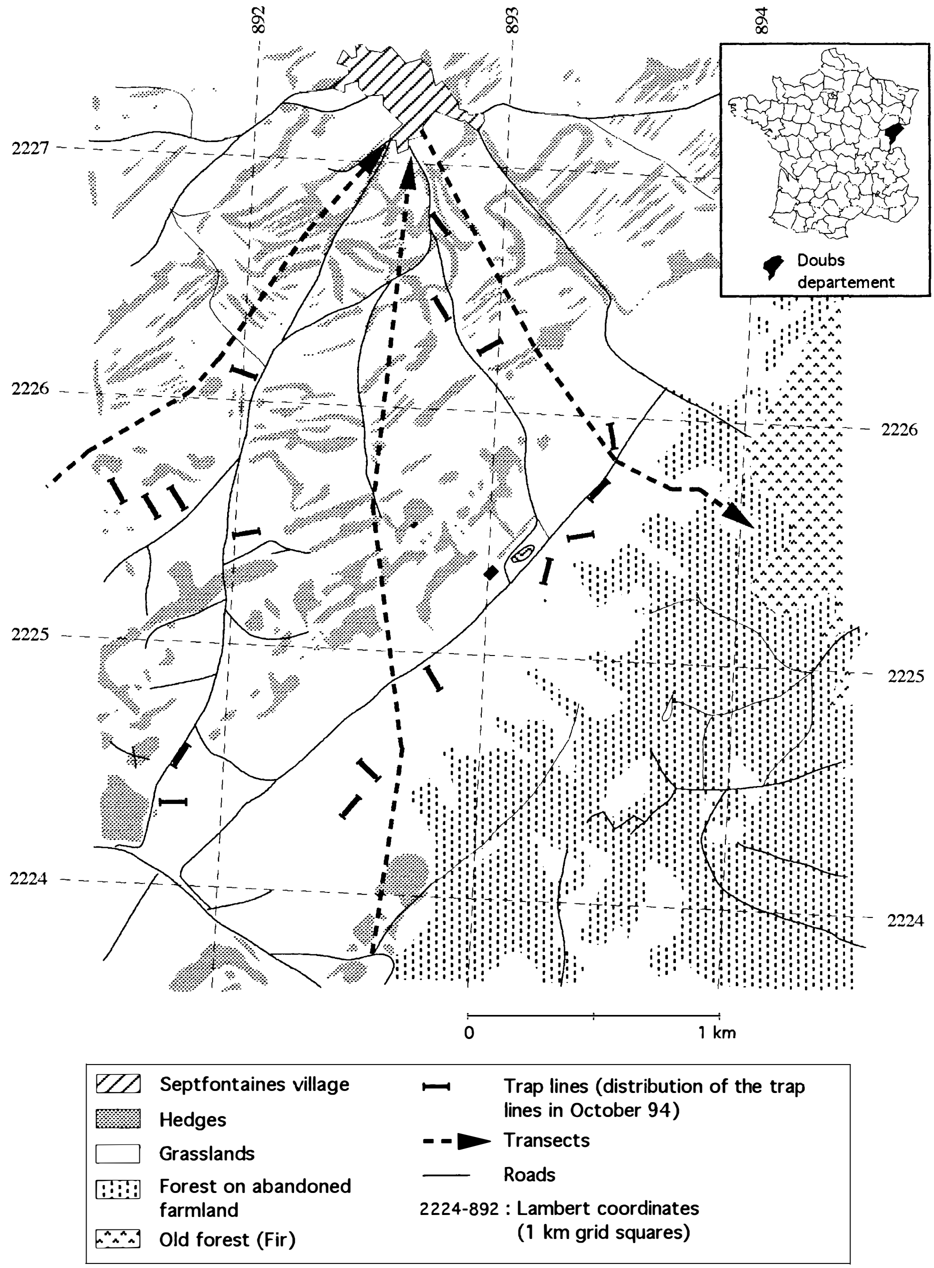


Figure 1. — Study area and localization of transects and traplines.

region at this time by means of (i) a capture protocol and stratified sampling method at the site scale, (ii) an index sampling protocol along transects of several kilometers in length.

*Capture protocol*

Rodents were captured with INRA traps (Aubry, 1950) laid in lines. Each line comprised 34 traps set at three meter intervals and was visited daily for three days (Spitz, 1974a, 1974b). Rodents were weighed and dissected for determination of sex, reproductive status and parasitological examination. All the grassland habitats (mowing meadows, pastureland, followland and cropland) frequented by Common Voles were sampled in a stratified manner and by a minimum of four lines for each type of habitat. Captures were made at two seasons, in the spring before the reproduction period and in the fall after the end of reproduction. An average of 17 trap lines (15-26) were set up each season (Fig. 1). The trap line locations used once a season were identical for each season but changed from one season to another in order to avoid overtrapping (for more details, see Giraudoux *et al.*, 1994).

*Transects*

Three transects of 2.4, 3.2 and 2.2 km, making a total of 7.8 km, were walked at the same time as the capture operations were conducted (Fig. 1). For comparison, this represents a sampling pressure of 1 km per square kilometer *versus* an average of 0.2 km of trap lines per square kilometer in the other method. The presence or absence of feces, used as a presence index, was recorded along each transect for intervals of 10 paces. Only the transect lengths crossing grassland habitats favorable to *M. arvalis* were retained.

### DATA ANALYSIS

The capture results were expressed as a "Capture abundance index", corresponding to the number of captures for 100 trap-nights. The number of trap-nights is obtained by multiplying the number of trap lines set each season by the number of traps per line (= 34) and by the number of nights (= 3).

Results for the three transects were aggregated as a "Transect abundance index" equal to the number of 10-pace intervals with positive sightings (containing at least one feces) as a percentage of the number of intervals sampled. These results were collated for each of the 13 seasons of the study (for further details see Delattre *et al.*, 1996 and Giraudoux *et al.*, 1994). A linear regression was looked for and a Pearson's correlation coefficient calculated between the Capture abundance index and the Transect abundance index together (Sherrer, 1984).

## RESULTS

Over the period 1990-1996, a total of 1 246 Common Voles were captured for 233 trap lines, corresponding to a trapping effort of 23 766 trap-nights. Over the same period, 98 km of transect were walked.

### POPULATION KINETICS

Common Vole populations underwent marked variations in abundance over the study period (Fig. 2). The start of observations coincided with a growth phase

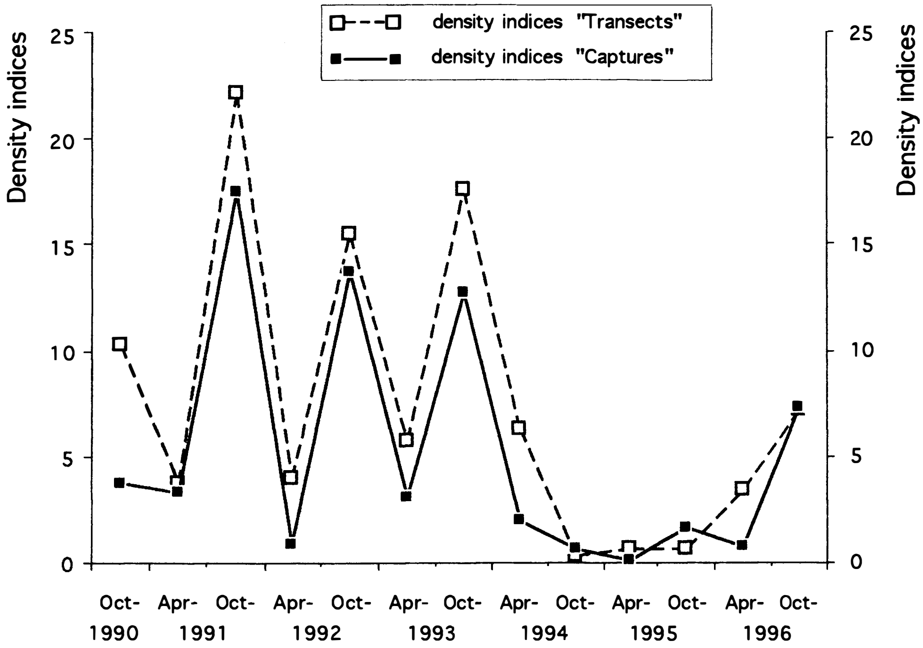


Figure 2. — Time variations of the Transect density indices (% intervals with feces/total intervals) and Capture density indices (N voles/100 trap. nights) respectively based on index record and trapping.

(Fall, 1990; Fall, 1991), followed by a long abundance phase (Fall, 1991; Fall, 1993). The subsequent phases of decline and low density were short (12 and 18 months, respectively: Fall, 1993; Fall, 1994 and Fall, 1994; Spring, 1996). A new growth phase occurred in 1996 at the end of the study period.

### Comparison of the two sampling methods

Comparative analysis of the Capture and Transect abundance indices show a close correlation between the two variables: $r = 0.949$ ($p < 0.001$) (Fig. 3).

## DISCUSSION

The abundance indices recorded by the index method correlate excellently with the values obtained by the capture method used as a reference standard. The rare distortions observed in the kinetics plotted by the two methods can be ascribed in each case to biases related to the capture method. They can be explained: (i) by particular weather conditions, especially rainy conditions, which have a positive effect on rodent dispersion and are reflected by an over-evaluation of numbers (in April 1991 more captures were made on the 2nd and 3rd days than on the 1st day), a phenomenon which has already been reported for rodents (Saucy & Schneiter,

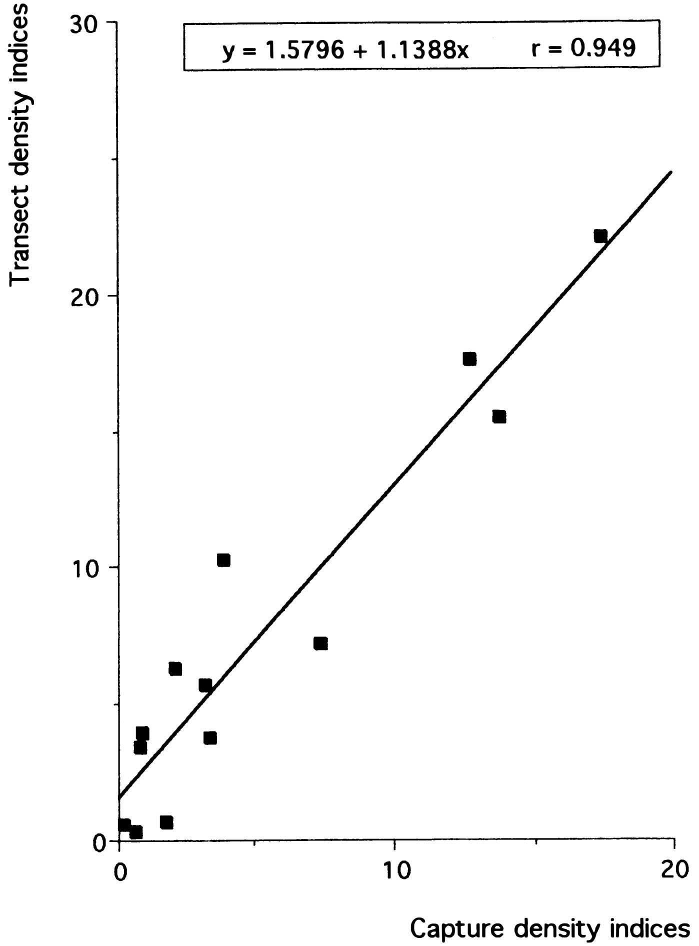


Figure 3. — Linear regression of the Transects density indices (ratio of intervals where feces were recorded to the total number of intervals) against the Capture density indices (number of animals captured per 100 trap. nights).

1997); (ii) by substantial changes in the spatial distribution of rodents over the multi-annual cycle giving rise to marked biases when, for example, too large a proportion of the environments sampled by the capture protocol have become refuge zones.

Observation of presence indices for the study of abundance variations and spatial distribution of Common Vole populations can therefore make a valid contribution to the development of sampling protocols. Because they are easy to use, effective and save time, index techniques are particularly useful for:

(i) landscape ecology studies, for which spatialized information provided by the transect technique is particularly valuable. Variations in abundance and spatial distribution can then be analysed in terms of remoteness from fixed landscape features of the influence of respective areas on the different environments or habitats (Delattre *et al.*, 1996). The role and importance of particular habitats (ecotones, corridors, refuge zones, etc.) can also be evaluated (Delattre *et al.*, 1999);

(ii) prey-predator or host-parasite studies for which precise knowledge of reciprocal variations in abundance of the species under study (numerical responses) or behavior patterns (functional responses) can be obtained (for such protocols see Henttonen, 1987; Korpimäki, 1993);

(iii) comparative studies designed to define the different operational modes of populations (Delattre *et al.*, 1992) and test hypotheses about the regulatory factors underlying each mode.

Finally, in practical terms, index techniques find immediate application in the establishment of agricultural early-warning systems intended to warn about the occurrence and diffusion of outbreaks at different spatial scales (including regional) and defining ways to combat those outbreaks (e.g. by targeting source zones for early action).

## CONCLUSION

Provided the conditions for using the technique already set out are complied with (Delattre *et al.*, 1990b), the index sampling method is suitable for monitoring variations in the abundance and population distribution of Common Voles and authorizes studies for a wide range of objectives and spatial scales.

## ACKNOWLEDGEMENTS

This work received financial support from the *Département Hydrobiologie et Faune Sauvage* of the *Institut National de la Recherche Agronomique* ("*Rongeurs et Paysage*", 1996) and the objectives contract of the *Franche-Comté Région* "*Rongeurs et Gestion de l'espace rural*", 1992-1996.

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