Dynamics and reproduction of small rodents in Germany

Jacob, J.
Julius Kuehn Institute, Federal Research Centre for Cultivated Plants, Institute for Plant Protection in Horticulture and Forestry, Vertebrate Research, Toppheideweg 88, 48161 Muenster, Germany, jens.jacob@jki.bund.de

DOI: 10.5073/jka.2011.432.048

Abstract

Analyses of time series of population dynamics and reproduction of small rodent species in Germany show that 1) first order effects prevail and higher order effects occur, 2) that within and across species abundance can fluctuate synchronously and 3) that part of the density dependence may be explained by intra-specific mechanisms related to reproduction.

Keywords: *Microtus arvalis*, *Microtus agrestis*, *Myodes glareolus*, population dynamics, reproduction

Introduction

The size of populations of small rodents such as common voles (*Microtus arvalis*), field voles (*M. agrestis*) and bank voles (*Myodes glareolus*) fluctuates with a period of about 2-5 years in Germany and in other parts of Europe (e.g., Jedrzejewski and Jedrzejewska, 1996; Luque-Larena et al., this volume; Tkadlec and Stenseth, 2001). During population peaks, these species can cause considerable damage to agricultural crops and forest trees. Crop losses can exceed several 100 million € in Europe per year (Jacob and Tkadlec, 2011). In addition, they can carry and transmit disease to humans and livestock. One recent example is an outbreak of human hantavirus infections in Germany in 2010, when more than 2,000 people were infected (Faber et al., 2010). A thorough understanding of biological and ecological features of fluctuating small rodent populations is vital to improve early warning systems be it for the protection of crops or for the protection of human health. Timely forecasts of rodent outbreaks can raise awareness by stakeholders and aid farmers, foresters as well as health care staff to engage in early management actions.

Methods

The multi-annual nature of the population dynamics of the rodents involved makes it necessary to use time-series to study patterns and mechanisms of abundance fluctuations and associated phenomena including damage to plants and transmission of zoonotic diseases. Therefore, the hard work of the States' plant protection staff and of the forest workers in obtaining abundance estimates during many decades is highly relevant and highly appreciated.

Data were collected in several locations and pooled by Federal State. For common voles, counts of reopened tunnel entrances were available that were collected by State Plant Protection Institutions in the Federal States of Mecklenburg-Western Pomerania (1990-2008), Saxony-Anhalt (1956-1995) and Thuringia (1971-1998). For bank voles and field voles, data were available from snap-trapping in Bavaria (1980-1989; data kindly provided by W. Bäumler) and trapping conducted by forestry administration in Lower Saxony (1971-2010). In addition, a data set was used that combined snap trap data of common voles and field voles from forestry administration in North-Rhine Westphalia (1972-2005). Information about reproductive performance in spring and autumn (%pregnant, %lactating, number of embryos) was limited to common voles in Saxony-Anhalt (1977-1994). Partial autocorrelations (time series), pair-wise correlations (synchrony of fluctuations) and REML multiple correlations were calculated using JMP 8.0 (SAS Institute 2008).

Results

In all areas and species concerned, small rodent populations fluctuated considerably. The *s*-index was 0.41 ±0.05 for common voles, 0.34 ±0.01 for bank voles and 0.29 ±0.02 for field voles. Auto-correlation patterns for common voles suggested 3-4 year outbreak periods in Saxony-Anhalt and in combined common vole/field vole abundance from North-Rhine Westphalia but not in Mecklenburg-Western Pomerania. There was also a tendency for bank voles and field voles in Lower Saxony for outbreaks with a 3-4 year period. Time series from Bavaria were too short to extract reliable information.

The rate of increase of vole populations of the same species fluctuated synchronously in adjacent states but there was also synchrony in field vole and bank vole populations that were several hundred km apart. Also, the rate of increase of bank vole and field vole populations fluctuated synchronously within and between states and there was also clear correlation of the rate of increase of field vole and common vole populations across states. The only negative correlation found was between growth rates of *Microtus* voles (no separation of species) in the northwest of Germany and common vole populations in the northeast and in central Germany.

Reproductive parameters within autumn or spring were positively correlated in common voles in the central German state of Saxony-Anhalt where high pregnancy rate was related to high lactation rate and high numbers of embryos. High reproductive activity in spring was negatively correlated to abundance and reproductive performance in the following autumn and the same was true for the relation of reproductive activity in the previous autumn and abundance in the current autumn. The negative relation of reproductive activity and future breeding and dynamics seemed to be more pronounced between previous and current autumn than between spring and autumn and there was a negative correlation between abundance in the previous autumn and population growth to the following autumn.

Discussion

In the time-series analyzed, examples for first order effects in the population dynamics of common voles, field voles and bank voles in Germany are common. In addition, in some time-series, higher order effects occurred such as in common voles in Saxony-Anhalt and *Microtus* voles in Lower Saxony. This is in concord with other studies of the population dynamics of small rodents in Europe (Luque-Larena et al., this volume; Tkadlec and Stenseth, 2001). Delayed effects did not occur in all time-series of bank vole or field vole abundance. Despite the differences in the cycle pattern, there was generally synchronous fluctuation within and among some species indicating that similar ecological processes govern changes in abundance. These may include several extrinsic and extrinsic factors.

The analyses of breeding and abundance in common voles in Saxony-Anhalt suggest that high breeding performance is negatively correlated to future breeding and abundance. This indicates that at least part of the density dependence may be explained by intra-specific mechanisms related to reproduction. Interestingly, delayed density dependence in fluctuating bank vole populations is related to reproductive phenomena including senescence (Tkadlec and Zejda, 1998) that might also explain the pattern found for common voles in this study.

The results may aid the development of predictive models for forecasting the outbreak risk of small mammal species based on climate (Imholt et al., in press) and weather (Blank et al., in press) by including biological predictors. Such models are relevant for crop protection and/or the protection of human and livestock health.

References

Blank BF, Jacob J, Petri A, Esther A 2011 Topography and soil properties contribute to regional outbreak risk variability of common voles (*Microtus arvalis*). Wildlife Research, in press

Faber MS, Ulrich RG, Frank C, Brockmann SO, Pfaff GM, Jacob J, Krüger DH, Stark K 2010 Steep rise in notified hantavirus infections in Germany. Euro Surveill 15(20): pii=19574

Imholt C, Esther A, Perner J, Jacob J 2011 Identification of weather parameters related to regional population outbreak risk of common voles (*Microtus arvalis*) in Eastern Germany. Wildlife Research, in press

Jacob J, Tkadlec E 2010 Rodent outbreaks in Europe: dynamics and damage. In: Singleton, GR Belmain S, Brown PR, Hardy B (eds.) Rodent outbreaks - ecology and impacts. p. 207-223, International Rice Research Institute, Los Baños, Philippines

Jedrzejewski W, Jedrzejewska B 1996 Rodent cycles in relation to biomass and productivity of ground vegetation and predation in the Palearctic. Acta Theriologica 41: 1-34

Luque-Larena JJ, Mougeot F, Arroyo BE, Viñuela J, Jareño D, Arroyo L, Lambin X 2011 Large-scale range expansion and eruption of common vole (*Microtus arvalis*) outbreaks in agricultural plains of NW Spain: historical reconstruction and novel impacts. (this volume)

Tkadlec E, Stenseth NC 2001 A new geographical gradient in vole population dynamics. Proceedings of the Royal Society of London Series B-Biological Sciences 268: 1547-1552

Tkadlec E, Zejda J 1998 Density-dependent life histories in female bank voles from fluctuating populations. Journal of Animal Ecology 67: 863-873