

## Long-term Population Fluctuations of the Field Vole (*Microtus arvalis*)

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### Abstract

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On the field vole (*Microtus arvalis* Pall.) there are long-term data of its occurrence and population levels in individual districts of the Czech Republic. That makes it possible to determine the length of these periods and thus predict the future population development in individual areas. Quantitative data on the field vole population from all districts of the Czech Republic from the years 1955 to 1998 were analysed using the time series methods. In none of the districts were hidden periods of population development found, and therefore it may be stated that the field vole population was acyclic. The acyclic population development was probably caused by the temperate climatic conditions without great extremes. Because the acyclic population development was found in all districts, we selected for closer study only two districts (i.e., Vyškov and Kolín) which were regular and most affected by the field vole. In addition, one of the districts is in the eastern part of the Czech Republic and influenced by continental climate, while the other lies in the western part that is influenced by maritime climatic conditions.

**Key words:** field vole; population fluctuations; ecological conditions; Czech Republic

On the territory of former Czechoslovakia, HORÁČEK (1944) examined data from Telč and Olomouc (i.e., from the Lichtenstein Demesne) and found periodic population cycles in a number of game animals. Periodic population changes in game animals were also described by PIKULA and BEKLOVÁ (1988) in the Czech Republic. BEKLOVÁ and PIKULA (1993) BEKLOVÁ *et al.* (1983, 1993, 1994) evaluated the relationship between numbers of game animals and climatic influences.

HENTTONEN *et al.* (1985) compared populations of *Clethrionomys* sp. using spectral analysis (quantitative index of periodicity) and found differences based on geographic origin of populations.

In this paper we deal with population fluctuations of the field vole (*Microtus arvalis* Pallas 1788) in the Czech Republic during the years 1955–1998. Changes in the population level of the field vole vary in different areas of the Czech Republic according to their specific conditions. They are influenced by ecological conditions (e.g., elevation above sea-level, climatic conditions, pedological conditions etc.). It is supposed that the study of long-term population fluctuations might be used in predicting the development of the field vole population in individual areas of the Czech Republic.

### MATERIAL AND METHODS

Data on the density of the field vole population originate in the State Phytosanitary Administration of the Czech Republic. In all, we evaluated data from 75 districts of the Czech Republic obtained from 1955 to 1998. The density counts are performed two times a year, in spring (from March 15 to April 15) and autumn (September 15 to October 30), and according to the method described by ZAPLETAL *et al.* (1999). As an example we present results from the districts Vyškov and Kolín which were most affected by field vole overcrowding in 1998. In the following some basic characteristics of the two districts are listed; they are expressed as the percentage of the area with a given condition. The climatic and ecological data for each district are 50-year mean values (SYROVÝ *et al.* 1958; GÖTZ *et al.* 1969).

	Percentage of the district	
	Vyškov	Kolín
Mean annual air temperature		
over 10°C	–	14
8–10°C	60	54
6–8°C	40	32



	Percentage of the district	
	Vyškov	Kolín
Maximum mean snow cover		
less than 150 mm	–	23
150–300 mm	100	77
Mean duration of sunshine a year		
1600–1800 hrs	–	55
1800–2000 hrs	100	45
Soil type		
black earth soils	35	45
brown soils	25	9
podsoils	20	27
alluvial soils	–	5
rendzinas	20	14
Soil kind		
clayey soils and clays	25	–
clay-and-earthen soils	10	23
earthen soils	65	41
sand-and-clay soils	–	4
clay-and-sand soils	–	32
Agricultural production type		
beet-growing type (200–350 m a. s. l.)	75	73
potato-growing type (350–550 m a. s. l.)	–	27

The comparison shows that the districts differ in their ecological conditions. In the district Vyškov the climate is colder, there is a greater proportion of areas with higher snow cover and a longer duration of sunshine per year. There are also differences in the proportions of black earth and brown soils and soil kinds compared to district Kolín. In the district Vyškov the beet-growing agricultural production type prevails, while in district Kolín part of the production is also of the potato-growing type.

We used common statistical procedures and a special set of programs for time series processing (e.g., methods to search for so-called hidden periods, spectral analysis, auto-regression models – ANDĚL 1976). For a detailed description see PIKULA and BEKLOVÁ (1988). To determine the periodicity of the population development of field voles in both districts, we computed the index of periodicity according to HENTTONEN *et al.* (1985), i.e., natural logarithm of standard deviation (base 10). An index higher than 0.5 is typical for cyclic populations, while an index lower than 0.5 for non-cyclic ones.

## RESULTS

### Fluctuations of the Field Vole Population Level

Quantitative data on the field vole population from all districts of the Czech Republic during 1955–1998 were analysed using the time series methods. In none of the districts were hidden periods of population development found, and therefore it may be stated that the population development of the field vole was acyclic. This acyclic population development was probably caused by the rather mild climatic conditions of the Czech Republic with no

great extremes. Since the population development of the field vole was acyclic in all districts, we chose for detailed study only two districts (i.e., Vyškov and Kolín) which had been regularly and severely affected by the field vole. One of them lies in the eastern part of the Czech Republic and is influenced by continental climate, while the other is in the western part influenced by maritime climate.

### District Vyškov

The field vole population in district Vyškov reached calamitous overcrowding densities 15 times during the 44-year period from 1955 to 1998 (Figs 1a, b). Thus, overcrowding densities recurred on average every 2.9 years.

### District Kolín

The field vole population in district Kolín reached calamitous overcrowding densities six times during the 44-year period from 1955 to 1998 (Figs 2a, b). Thus, overcrowding densities recurred on average every 7.3 years.

### Spectral Analysis of the Field Vole Population Changes in Districts Vyškov and Kolín

This analysis was based on computing the index of cyclicity to differentiate typical cyclic populations from irregularly or only seasonally fluctuating non-cyclic populations (HENTTONEN *et al.* 1985).

The index of cyclicity of the population fluctuations in district Vyškov was 0.42, and in district Kolín 0.54. Thus, the field vole population of district Vyškov was rather non-cyclic, while the population of district Kolín was cyclic.

Using the methods of searching for hidden periods in the time series of population densities from both districts, we found no hidden periods in the development of field vole populations in these two districts.

### Correlation between Spring and Autumn Field Vole Population Densities in both Districts

We wanted to find out whether the population densities of the field vole during spring and autumn were correlated. It took the same course, i.e., was rather synchronous. The coefficient of correlation between spring and autumn population densities in individual districts was calculated. It was  $r = 0.13$  for the district Vyškov, which means that spring and autumn population densities are not correlated. In contrast, the coefficient of correlation  $r = 0.46$  ( $P = 0.01$ ) for the district Kolín is statistically significant. Thus, in this district the spring population density may indicate the possibility and danger of field vole overcrowding during autumn months. This may occur in years when the spring densities are of at least medium values.

The frequency of different levels of the density of the field vole in both districts may be used as another indicator. For this purpose the quantitative values of densities were classified into three levels. The following table lists how frequent each level of population density occurred in both districts:



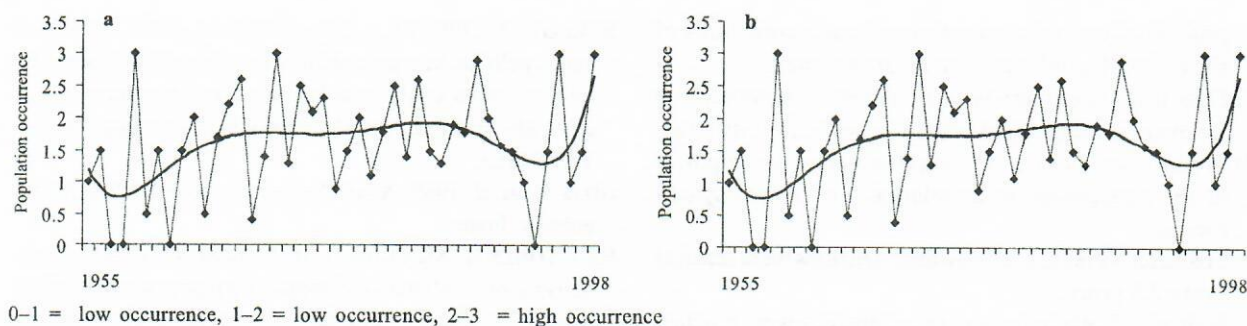


Fig. 1. The development of the field vole population during 1955 to 1998 in the district Vyškov interpolated by a straight line (a) and by a 6<sup>th</sup>-degree polynomial curve (b)

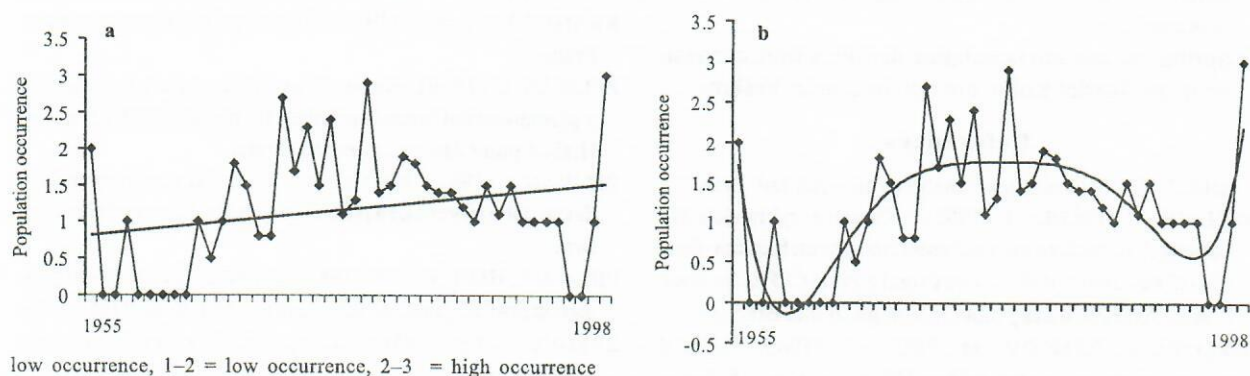


Fig. 2. The development of the field vole population during 1955 to 1998 in the district Kolín interpolated by a straight line (a) and by a 6<sup>th</sup>-degree polynomial curve (b)

Number of occurrence	Level of field vole density	
	district of Vyškov	district of Kolín
low (0–1)	27	34
medium (1–2)	21	41
high (2–3)	24	13

Field vole overcrowding (during spring or autumn) occurred 24 times in Vyškov and 13 times in Kolín from 1955 to 1998. A comparison of the mean autumn densities in these two districts showed:

district Vyškov (mean = 1.55;  $s_x = 0.17$ ; min = 0.1; max = 3;  $n = 36$ )

district Kolín (mean 0.99;  $s_x = 0.17$ ; min = 0.1; max = 3;  $n = 36$ ).

The district Vyškov was thus affected more frequently and to a greater extent than Kolín.

## DISCUSSION

Fluctuations of population levels of animals have always been of interest to zoologists and ecologists. In game animals these questions were studied by e.g., HORÁČEK (1944), BEKLOVÁ *et al.* (1983), PIKULA and BEKLOVÁ (1988) in the Czech Republic. Periodic fluctuations of the field vole in the Czech Republic were described by KRATOCHVÍL *et al.* (1959) and PELIKÁN (1981), but both authors used improper methods to evaluate the cyclicity of populations. HENTTONEN *et al.* (1985) studied the cyclicity of population development of several *Clethrionomys* species from different geographic areas by

using a special formula to evaluate the cyclicity of population densities. They proved that populations of one species from different geographic areas may be cyclic or non-cyclic, and that the kind of population development over time depends on different conditions in the area.

The differences in fluctuations of the field vole in the two districts studied here are probably also caused by differences in local conditions. While the district Vyškov has a more continental climate, that of Kolín is influenced by maritime climate. We also suppose that the district Vyškov was inhabited by the field vole on its spread through the agricultural land before it reached the district Kolín. Contrary to game animals in the Czech Republic (PIKULA & BEKLOVÁ 1988), no statistically significant hidden periods of population development of the field vole were found in either district.

## Conclusion

On the basis of data collected by workers of the State Phytosanitary Administration in the Czech Republic in 75 districts from 1955 to 1998, we evaluated fluctuations in the population densities of the field vole.

It was found that:

- 1) In none of the districts were hidden periods of the field vole population development found. Therefore, it may be stated that the field vole population was acyclic,



- probably due to the temperate climatic conditions of the Czech Republic with no great extremes.
- 2) Data from two districts were analysed in detail. The fluctuations of the field vole in these districts differed.
  - 3) In both districts, however, was the annual development of the populations in correlation, i.e., it was synchronous.
  - 4) In district Vyškov, overcrowding densities were reached every 2.9 years.
  - 5) In district Kolín, overcrowding densities were reached every 7.3 years.
  - 6) According to the index of cyclicity, the field vole population from Vyškov was non-cyclic, while that from Kolín was cyclic.
  - 7) Spring and autumn population densities were correlated in the district Kolín, but not in district Vyškov.

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### Souhrn

ZAPLETAL M., OBRŽÁLKOVÁ D., PIKULA J., PIKULA J. JR., BEKLOVÁ M. (2000): **Dlouhodobá populační dynamika hraboše polního (*Microtus arvalis*)**. Plant Protect. Sci., 36: 11–14.

Znalost periodického kolísání populační hladiny umožňuje předvídat populační vývoj hraboše polního. V letech 1955–1998 byly v České republice shromážděny informace o populační hustotě hraboše polního. Jako příklad kolísání populační hustoty je uveden stav v okresech Kolín a Vyškov. Bylo zjištěno, že kolísání populační hladiny hraboše polního se v obou okresech liší. V okrese Vyškov byl zjištěn interval přemnožení 2,9 roku a v okrese Kolín 7,3 roku. Index cykličnosti ukázal, že populace hraboše polního z okresu Kolín se jeví jako cyklická, populace z okresu Vyškov jako acyklická. Byla prokázána korelace mezi průměrnými hodnotami populační denzity z okresu Vyškov a Kolín a mezi jarními a podzimními stavy hraboše polního na okrese Vyškov.

**Klíčová slova:** hraboš polní; populační dynamika; ekologické podmínky; Česká republika

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