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Rodent food quality and its relation to crops and other environmental and population parameters in an agricultural landscape

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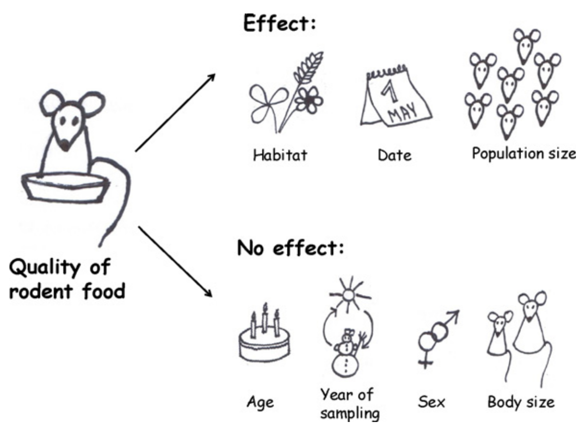
HIGHLIGHTS

- The nitrogen content of rodent stomachs from agriculture landscape was studied.
- Strong influence of habitat and date on food quality was observed.
- The higher nitrogen content in stomachs was found in higher densities.
- Body length, sex, year and age have no influence on the nitrogen content.

GRAPHICAL ABSTRACT



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ABSTRACT

The diet, its quality and quantity considerably influence population parameters of rodents. In this study, we used NIRS methods for estimation of nitrogen content in stomachs of rodent populations. The study was carried out in diverse arable landscape in South Moravia, Czech Republic. Rodents were sampled in cultural crops (alfalfa, barley, wheat, sunflower, maize and rape) as well as in fallow habitats (herbal set-aside and old orchard). Influence of habitat, date, year, individual parameters (body length, sex, breeding and age), and relative abundance on quality of consumed food was studied. Under conditions of higher population density, dominant species [wood mouse (*Apodemus sylvaticus*) and common vole (*Microtus arvalis*)] consumed food richer in nitrogen. Also the strong effect of crop and date (season) was found in both species. There was no significant effect of the other parameters studied on food quality (*N*-content).

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1. Introduction

The diverse arable landscape with various planted crops, fallow land, shrubberies, banks of streams and ridges represent environment offering variety of niches for animal and plant communities. Miscellaneous vegetation cover provides variable food opportunities for wide spectrum of animals. Small rodents belong to the most numerous vertebrates in these habitats. As they live also in cultural crop fields, they can be sometimes considered pest species. There is a question, if small rodents reflect the variable food supply in this landscape and in that case how it is reflected.

South Moravia, Czech Republic, is a diverse arable landscape and after the introduction of the Agri-Environmental Scheme [Council Regulation (EC) No 1698/2005 by the European Agricultural Fund for Rural Development (EAFRD), available on http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:277:0001:0040:EN:PDF] aiming at mitigating intensive agricultural impact also high proportion of fallow plots have been incorporated into the area in the last decade (Czech statistical Office: https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=statistiky#katalog=30840). The uniqueness of arable landscape in central Europe is that there are two dominant rodent species — wood mouse and common vole (Heroldova et al., 2005, 2007; Jacob and Tkadlec, 2010; Janova et al., 2011), contrary to southern Fennoscandia and British Isles where wood mice is dominant and common vole is not present in fields (e.g. Loman, 1991; Tew and Macdonald, 1993; Tattersall et al., 1999; Todd et al., 2000). This means that rodent studies so numerous in northern countries and Great Britain, do not describe the situation comparable to conditions of central Europe.

The food, its quality and quantity, substantially affect population-specific traits of small rodents, such as body size, reproduction rate, life history and population dynamics (e.g. Hansson, 1979; Batzli, 1986; White, 1993; Lin and Batzli, 2001; Sibly and Hone, 2002). The food quality is often expressed as nitrogen values because it is important for the production of proteins essential for body growth and reproduction (Karasov and Martinez del Rio, 2007; Palo and Olsson, 2009; White, 1993). Nitrogen can be easily estimated by chemical analysis. However, this method is not suitable for studies of food of small rodents because of small size stomachs and usually high number of samples, which make the chemical methods too laborious and expensive. Only one study on nitrogen content in rodent stomach was carried out by this method up to date (Butet, 1996). The absence of a usable study method was a reason why the Near infrared reflectance spectroscopy (NIRS) method was recently adjusted for studies of small mammals (Cepelka et al., 2013, 2014; Janova et al., 2015). NIRS is a non-destructive and low-cost analytical technique suitable for estimating a variety of chemical components in small samples of soil, plant and animal tissue (e.g. Büning-Pfaue et al., 1998; Foley et al., 1998).

Here, we used this method to estimate food quality of rodent populations living in diverse arable landscapes — in cultural crops and fallow habitats. Population parameters and information about body conditions of individuals were analysed and partially published previously (Janova and Heroldova, submitted; Janova et al., 2011); here, we analysed populations in the new context of food quality.

The tested hypotheses were that food quality:

1. differs among rodent species because of the food preferences, such as voles are herbivorous and mice are granivorous and the amount of nitrogen is higher in seeds than in green biomass
2. is determined by habitat and differs in different habitats as vegetation cover offers different food quality, i.e. some vegetation offers especially green biomass and also other seeds
3. changes in time (during seasons and years) according to phenophase and the maturation of seeds
4. is influenced by individual parameters such as body length, age, sex and reproduction state, because individuals in growth and gravid females have different food requirements
5. is related to rodent population density; on the one hand, the population density influences, for example, pressure on the food resources and demand of energy for reproduction, on the other hand, reproduction is affected by food supply.

2. Material and methods

Small mammals were studied in the years 2004–2006 and 2008–2010 in crop fields in South Moravia, the Czech Republic. In the second period, the fallow habitats were added into the study. The studied fields were situated in the area between the towns Brno and Breclav, GPS coordinates 48°40′N–49°06′N and 16°29′E–16°53′E. Small mammals were captured in crop fields – alfalfa, barley, maize, winter rape, sunflower and winter wheat, and in fallow habitats – in herbaceous set-aside and old orchard in the second period. For gaining more reliable results, between 5 and 10 plots of each habitat were sampled each year, at least two plots of the same habitat were sampled in the same term. The sampling was done every four weeks in the growing season (April–October) and every six weeks out of the growing season, simultaneously for all crops. The habitats with perennial vegetation (alfalfa, set-aside, old orchards) were sampled over the year; other crops were sampled from seeding until harvest or time, when great amount of its biomass remained on the plot. Number of trapping sessions is summarised in Table 1. We carried out a snap trapping design of the study. This was justified by the fact that the samples of rodents were further used for research on presence of zoonotic diseases (Treml et al., 2012). Snap traps were baited with fried wicks (soaked in fat and flour). Traps were exposed for two nights in lines with 50 traps spaced 3 m apart in each plot. Trap lines began about 50 m from the borders of the field (habitat) to avoid the edge effect (Chudoba and Huminski, 1980).

The population size for each trapping session and crop was estimated as relative abundance (rA), i.e. the number of individuals caught in a particular plot per 100 trap-nights. For analyses, we used relative abundance for all species as a total abundancy; it reflects the total impact of rodents on food and other environment sources. It was followed by the estimation of the species specific relative abundances for dominant species — the common vole (*Microtus arvalis*, Pallas 1778) and the wood mouse (*Apodemus sylvaticus*, Linnaeus 1758). The population of common vole slightly fluctuated with decline in 2006 (Janova et al., 2011). Mice densities did not show distinct inter-year differences (Janova and Heroldova, submitted; Janova et al., 2011).

In total, 1321 individuals of six rodent species were trapped during the study (Table 1). All captured individuals were identified to species, weighted, sexed, measured and dissected. Females with embryos, lactating or with visible maculae cyaneae were considered as breeding. Adult males were identified through enlarged testes and seminal vesicles.

The age of common voles was estimated using eye lens mass method (Adamczewska-Andrzejewska, 1981; Mallory et al., 1981; Martinet, 1966). Vole eyes were removed during dissection and fixed in 10% formalin. The age was estimated according to a calibration model published previously (Janova et al., 2007a, 2007b).

During the dissection, stomachs were removed and dried. The sufficiently large stomachs (larger than detection window of the NIRS equipment and thick enough for non-penetrating by a light beam) were grinded by sand paper on one side and analysed using the Nicolet Antaris II FT-NIR near infrared spectrophotometer (Thermo Scientific, USA) in the 1100–2500 nm wavelength range and 50 scans for each sample. This produced a spectrum encompassing the complete physical and chemical composition of the sample. A NIRS calibration model for nitrogen content was developed using chemometric and statistical methods of least square regression. For details about the calibration and verification of the method, see (Janova et al., 2015). Food quality was expressed by a percentage of total nitrogenous compound (NC [$= N * 6.25$]) in total dry matter of stomach content (according to AOAC, 1990).