Winter diet of the noctule bat *Nyctalus noctula*

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Abstract. The food composition of noctule bats (*Nyctalus noctula*) was investigated using droppings analyses methods (29 samples/ 322 pellets) over two winters (2001/2002 and 2002/2003) in ten urban and rural localities in Central Europe (Slovakia, Czech Republic). Two orders of arachnids (Araneida, Acarina) and nine orders of insects (Homoptera, Heteroptera, Psocoptera, Neuroptera, Coleoptera, Hymenoptera, Lepidoptera, Diptera, Siphonaptera) were identified in the droppings. The most important order in all samples was Lepidoptera (mean F = 53 %, mean V = 35 %), followed by Diptera (F = 38 %, V = 12 %), Coleoptera (F = 21 %, V = 9 %) and Araneida (F = 15 %, V = 3 %). Differences were found in the composition of the most important food components among two urban and one rural locality as well as in the portion of secondary components (hair, slime). Regarding seasonal changes in the food composition, three periods were identified in winter – the beginning (November – January), the middle (February) and the end of the season (March). Some seasonal trends could be identified in the Diptera and Coleoptera, with a decrease in frequency and volume in the middle of the winter. The most important food component (Lepidoptera) showed no seasonal trend over winter. The bats could hunt insects outside or collect them also very probably directly in the shelters.

Key words: Chiroptera, foraging ecology, winter, Europe

Introduction

The winter activity of holarctic bats at latitudes above 48° was reported in some species dwelling in caves or other underground habitats as well as in species hibernating in buildings (e.g. Ransome 1971, Avery 1985, 1986, Brigham 1987, Park et al. 1999). However, food quality was not analysed in these studies. It is clear that this activity of bats during winter time depends on a sufficient energy supply which means on the amount of available food (invertebrates) during this unfavourable time (Brigham 1987).

The common noctule bat *Nyctalus noctula* (Schreber, 1774) is a species that is conspicuous by flight and calling activity during winter, and also at temperatures under 0 °C (feeding buzzes can be registered using a bat-detector) (Gaisler et al. 1979, Avery 1986). It is possible to observe flying and calling activity mainly in the vicinity of prefab houses in towns of Central Europe, where this species is roosting mainly in autumn and winter months (c.f. Gaisler et al. 1979, Beck & Schelbert 1999, Kaňuch & Celuch 2000, Prokoph & Zahn 2000, Zahn et al. 2000).

The foraging ecology and diet composition in the noctule bat have been up to now known only for the out-of-winter period. The diet of the noctule bat in Europe was studied using faecal pellet analyses in Great Britain (e.g. Howes 1974, McKenzie & Oxford 1995, Jones 1995 and reviewed by Vaughan 1997), Switzerland

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(B e c k 1995, G l o o r et al. 1995), Germany (T a a k e 1996) and Latvia (R y d e l l & P e t e r s o n 1998). These authors described the wide spectrum of food components during the vegetation period as well as the foraging opportunism in this species, assuming preying and hunting for some suitable food also occurs in the unfavourable winter period.

The aims of this study were: i) Determination of the noctule food composition and variability during winter; ii) Comparison of the food composition in three independent localities; iii) Analysis of changes in food composition over winter in one regularly checked model locality (Central Slovakia).

Study Area

The samples were obtained from ten localities in several settlements of prefab houses in Slovakia and the Czech Republic (48° 05' – 49° 40' N, 16° 30' – 21° 15' E, Fig. 1). Localities in Bratislava and Brno (160–230 m a.s.l.) are the settlements situated on the border of larger towns (hundreds of thousands of inhabitants) with high (13 floors) prefab houses in a lowland landscape. The bats roosted here mainly in crevices between the panels. On the contrary, locality Kováčová (320 m a.s.l.) is situated in a mountain valley with a settlement of a few prefab houses in a small village. The bats roosted there in a larger hollow space in a double roof.

All of the studied localities with shelters were surrounded by an open agricultural landscape, always in the vicinity of larger oak-hornbeam and beech-oak forests (up to 500 m from the roosting place).

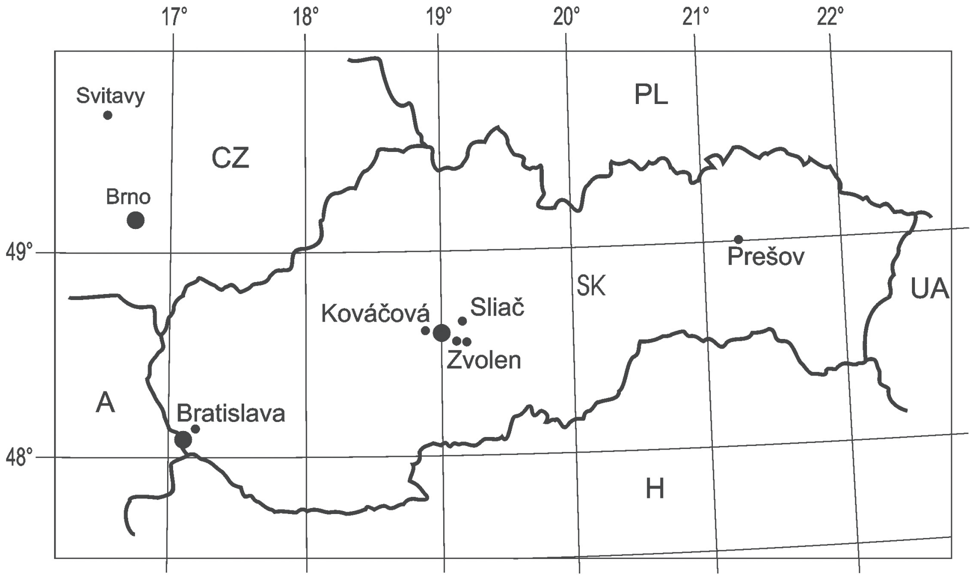

Fig. 1. Study localities in settlements (prefab houses) in Slovakia and the Czech Republic (large circle – multiple samples, small – occasionally taken samples).

Material and Methods

The food composition was examined using faecal pellet analyses. Arthropod fragments in bat droppings were analysed and identified using a method similar to M c A n e y et al. (1991)

and W h i t a k e r (1988). The faecal pellets were collected under winter roosts of noctule bats (Bats often excrete faeces near the entrance of shelters during flight activity). Altogether 25 samples (295 pellets) were obtained using this method over two seasons (November 25th, 2001 – March 18th, 2002 and November 13th, 2002 – February 26th, 2003), when air temperatures ranged between -16° and +8°C. The collections of faeces were taken more regularly in three localities (Kováčová 9 times, Bratislava 4 and Brno 9), and in another seven localities only occasionally (Fig. 1). The seasonal dynamics in food composition was studied on pellets collected regularly at one month or two week intervals in the locality Kováčová over the winter period 2001/2002. Only four dropping samples (27 pellets) were obtained as exceptions – from bats trapped in the flats.

Qualitative and quantitative structure of food composition was estimated through the volume of prey category in one dropping (V %) and frequency of occurrence in faecal pellets (F %) (cf. R y d e l l & P e t e r s o n s 1998). Selected, regularly checked localities were compared according to the frequencies of the characteristic food components. We used the significance test of the difference between two proportions (Statistica ’99, © StatSoft, Inc.).

Results

W i n t e r f o o d c o m p o s i t i o n

Two orders of arachnids (Araneida, Acarina) and nine orders of insects (Homoptera, Heteroptera, Psocoptera, Neuroptera, Coleoptera, Hymenoptera, Lepidoptera, Diptera, Siphonaptera) were found in 322 examined droppings (Fig. 2) at the ten examined localities. In the three key localities (Bratislava, Kováčová, Brno) we collected 86 % of all pellets. Moths (Lepidoptera) were as the most important in all samples (mean F = 53 %, mean V = 35 %), followed by Diptera (F = 38 %, V = 12 %), Coleoptera (F = 21 %, V = 9 %) and Araneida (F = 15 %, V = 3 %).

Altogether 18 groups of arthropods were identified in all these samples (Araneida, Acarina, Homoptera – Aphididae, Heteroptera, Psocoptera, Neuroptera, Coleoptera – Carabidae, Scarabaeidae and some unidentified beetle species, Hymenoptera – Apidae, Formicoidea and some unidentified species, Lepidoptera, Diptera – Tipulidae, Nematocera, Brachycera and some unidentified fly species and Siphonaptera). Besides these invertebrate food taxa we found in the faeces also considerable amounts of slime from enteral epithel (F = 40 %, V = 18 %) and hairs (F = 39 %, V = 18 %).

The prey body length in winter food ranged from 2 (Homoptera – Aphididae, Diptera – Nematocera) to 23 mm (Lepidoptera – Noctuidae, Coleoptera – Carabidae), but invertebrates under 10 mm were found regularly.

C o m p a r i s o n o f t h e d i e t c o m p o s i t i o n i n t h r e e l o c a l i t i e s

Overwintering imagines of the orders Lepidoptera, Diptera, Coleoptera and Araneida dominated the winter food at all three key localities. The food composition was alike in localities Brno and Bratislava, where significant differences were only detected in five of the ten compared food components ($p < 0.01$). Less similar were localities Bratislava (town) and Kováčová (village), where significant differences were detected in seven ($p < 0.01$), or in nine ($p < 0.05$) of the ten food components compared (Fig. 3). The highest diversity in

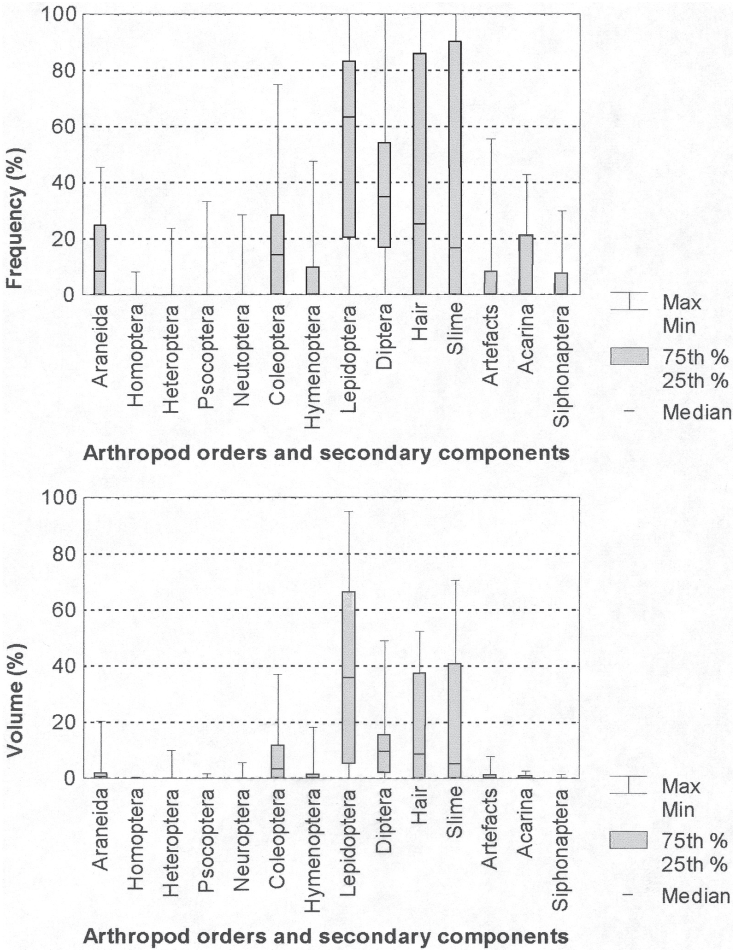

Fig. 2. Winter food composition (frequency %, volume %) in the noctule bat in ten localities of Central Europe (N = 29 samples/ 322 pellets).

food components was found in the rural locality Kováčová, where the shelters are in contact with an adjacent complex of forests and meadows. Significantly lower portions of secondary faeces components (hair, slime, artefacts) were detected in this locality. The most of common food components in the big towns (Brno, Bratislava) did not reach values as high as in the rural locality Kováčová. The only exceptions were Homoptera (significantly in Bratislava) and Homoptera, Coleopera and Diptera (not significantly in Brno) in which higher portions were detected in towns.

Changes in food composition during winter

Regarding seasonal changes in the food composition, three periods were identified – the beginning (November – January), the middle (February) and the end of winter (March, Fig. 4). Some seasonal trends occurred concerning the abundance of Diptera and Coleoptera, with

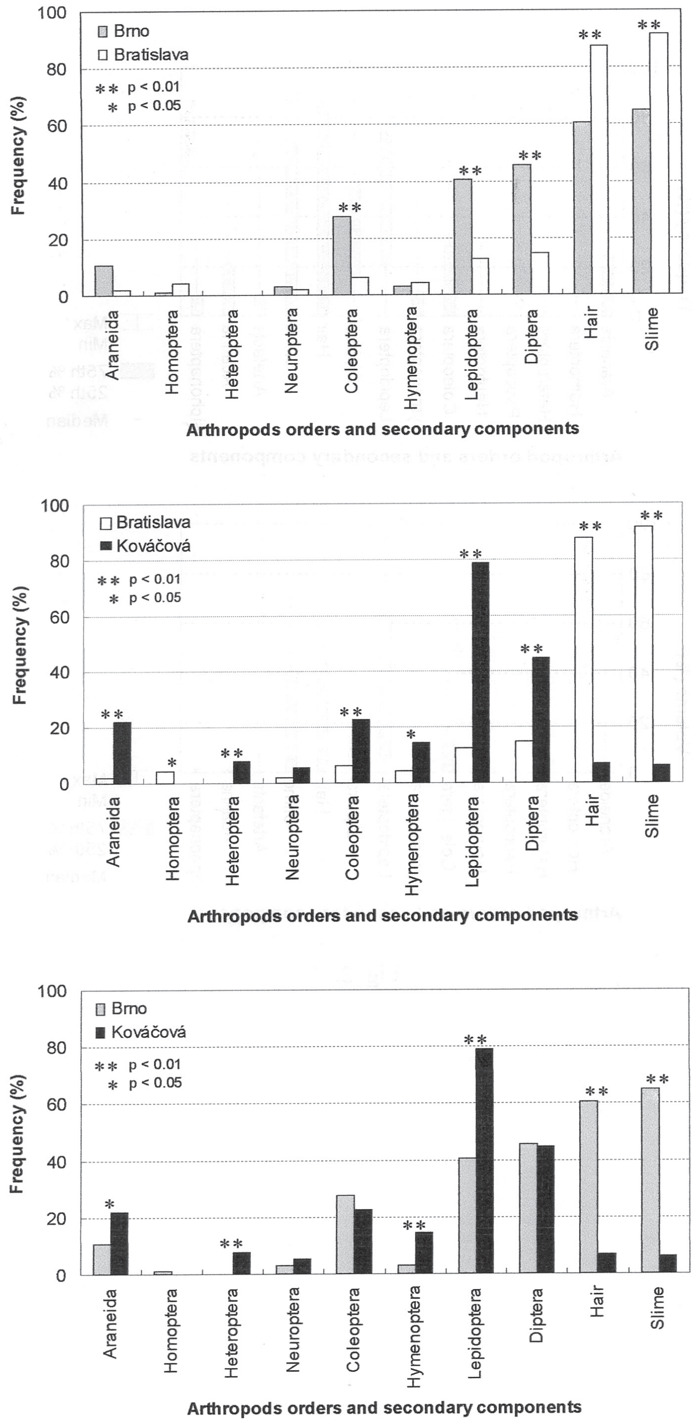

Fig. 3. Comparison of food composition (by frequency %, N = 22 samples/ 274 pellets) in three independent localities (Brno N = 9/94, Bratislava N = 4/48, Kováčová N = 9/132).

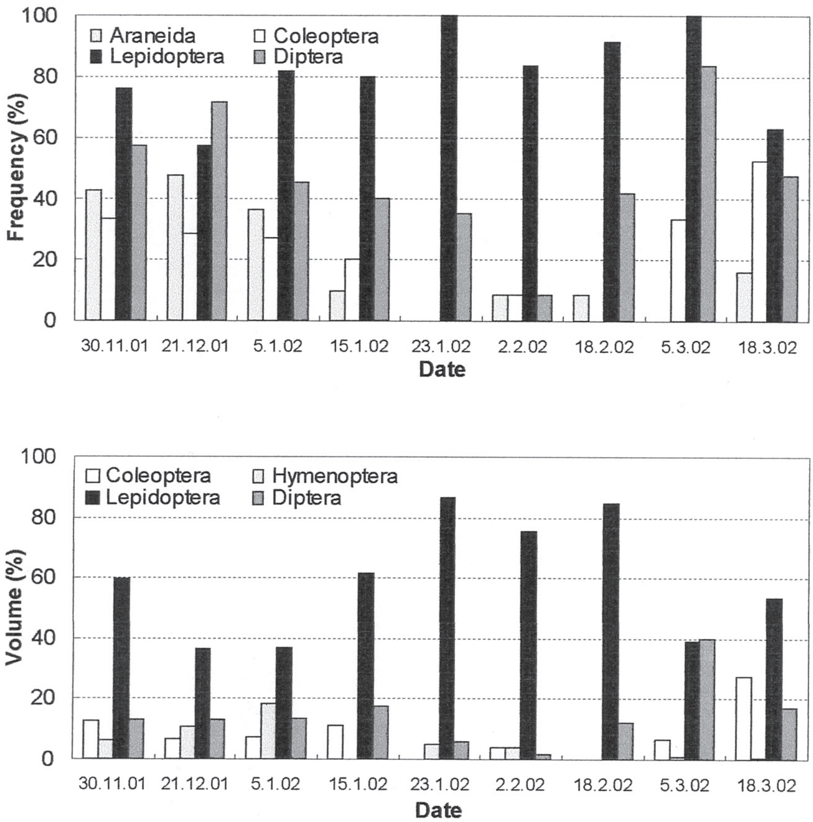

Fig. 4. Changes in food composition (frequency %, volume %, n = 132) over winter 2001/2002 in locality Kováčová (Central Slovakia).

a decrease in frequency and volume in the middle of the winter. The most important food component (Lepidoptera) showed no seasonal trend in the food over winter (F = 57–100 %, V= 36–87 %). Further important food components in regard to frequency and volume were Diptera (F = 8–83 %, V = 2–40 %) and Coleoptera (F = 0–53 %, V = 0–27 %). The order Araneida was the fourth most important food group in regard to frequency, the order Hymenoptera in regard to volume (Fig. 4).

Discussion

Moths (Lepidoptera) were the most important component in all faecal samples in regard to volume and frequency (Fig. 2). This result can be somewhat overestimated because scales of moth wings are very conspicuous in faeces, and they represent a large volume share, in spite of the fact that the bats can consume only small numbers of individuals (c.f. R o b i n s o n & S t e b b i n g s 1993). On the contrary, low incrusted and soft insect and invertebrate groups could be underestimated owing to better digestion. However, in spite of this inconsistency, we suppose that just the imagos of moths (Lepidoptera) play an important role as an energy resource for bats wintering in prefab houses. Data from the summer period also confirm considerable importance of moths in the food of the noctule bat (V = 18–36 %, Vaughan 1997). The wide winter food variety of the noctule bat confirmed its ability to consume various foods in the vegetation period (Howes 1974, McKenzie & Oxford 1995, Jones 1995, Beck 1995, Gloor et al. 1995, Taake 1996, Rydell & Peterson 1998). We suppose that Acarina and Siphonaptera get into the digestion tract of bats mainly as a result of their grooming activity.

The bats could hunt insects outside (in the shelter vicinity) or collect them directly in the shelters. Avery (1985, 1986) and Brigham (1987) registered feeding-buzzes of bats regularly in winter – mainly at night, when the temperature increased and insects started to be active too. Start of flying activity observed in the noctule bat in Switzerland was at +2 °C (Gebhard 1984). Collection of insects from shelter surfaces is known in bats living in captivity (Wilson 1988). We suppose that bats in our localities also consumed the invertebrates directly in shelters in the prefab houses. This hypothesis was confirmed with faeces containing the remains of bodies of *Monomorium pharaonis* and plaster inhabiting Psocoptera, hence insects related to buildings. Larger portions of secondary faecal components (hair, slime and artefacts) in the two urban localities (Brno, Bratislava) can be related to insufficient food supply (Fig. 3). This hypothesis was also confirmed with faecal samples in starved bats found in flats (slime: F = 100 %, V = 47 %, hair: F = 100 %, V = 46 %). Different types of shelters at urban (Bratislava, Brno – crevices between panels) and rural (Kováčová – big hollow spaces in double roofs) localities could also be a reason for different food supply. They offered different microclimates for wintering invertebrates and also different amounts of food available for bats.

One could expect that winter foraging of bats can be influenced by invertebrates wintering in bat shelters. Moths are frequently wintering in crevices, cavities in buildings as well as in cellars and caves (Feldmann 1972). Warm air escaping from flats under roofs could also have some influence on increased body activity in bats and insects wintering under the roof. Bats flying in the shelter vicinity can only be an analogy with flying in the underground space during wintering, when bats sometimes fly during hibernation (Park et al. 1999). We expect that bats do not have enough space for flight in prefab houses, and consequently, prefer to fly in the vicinity of shelters. Furthermore, the bats may be compelled to be active during winter months because of reduced energy reserves (e.g. Active big brown bats *Eptesicus fuscus* have smaller weight during the winter than non active ones; Brigham 1987). Consumption of small insects by such big bat species was denied by some authors (Barclay & Brigham 1991). However, regular eating of small invertebrates (≅ 5 mm) by noctule bats can corroborate the hypothesis about opportunistic foraging behaviour of the species in the unfavourable and critical periods. On the other hand, the noctule bat is naturally well adapted for hibernating in poor microclimate conditions (tree-hollows, rock crevices). Thereafter such winter foraging behaviour may be only a natural result of evolution.

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