Does urban structure explain shifts in the food niche of the Eurasian Kestrel (*Falco tinnunculus*)?

Vysvětluje struktura městského prostředí posun potravní niky poštolky obecné (*Falco tinnunculus*)?

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ABSTRACT. We studied the diet composition of Eurasian Kestrel (*Falco tinnunculus*) in Ziemia Chełmińska (Kujawy, north-central Poland) from autumn 2000 to early spring 2002 to ask if differences in landscape exploitation impact this species food niche. We analyzed a total of 1068 pellets; 2092 prey individuals were found in three localities. A total of 32 prey categories were detected. Mammals represent a substantial part of the diet, approximately 76% - by number (N) and 97% - by biomass (B). Voles, primarily Common Vole (*Microtus arvalis*), were the main prey items: 65% - N, 86 – B. The remaining groups had a small impact on total diet biomass. However, insects were frequently detected: 23% - N. Differences in food composition between sites reflects a higher frequency of insects and generally more categories in sites with a higher habitat heterogeneity - Toruń, compared to Chełmża and Papowo Biskupie (which were mostly large fields). Diet specialization vs. prey availability/abundance is discussed.

INTRODUCTION

The Eurasian Kestrel (*Falco tinnunculus*) is a frequent seasonal migrant or breeder in urban and suburban areas. It hunts mainly on small mammals, generally voles (e.g. RIJNSDORP et al. 1989, VIITALA et al. 1995, KOIVULA et al. 1999, THIRGOOD et al. 2003). This forces the raptor to optimize daily patterns of flight-hunting behaviour and site choice in relation to vole abundance. As has been noted, some vole-kestrel interactions can result from this type of "monophagy", e.g. stabilization of vole population dynamics, as well as synchronization between prey and predator population dynamics (GALUSHIN 1974, VILLAGE 1982, IMS & ANDREASSEN 2000, HUITU et al. 2003). On the other hand the importance of other alternative types of prey in kestrel diet, such as birds and insects, has been suggested too (YALDEN & WARBURTON 1979, KORPIMÄKI 1985, ROMANOWSKI 1996, PIATTELLA et al. 1999).

Here we address the question of whether the Eurasian Kestrel is a true diet specialist, or whether prey choice reflects prey availability/abundance. We shed light on this important aspect of the autecology of this species by describing the diet composition between Kestrel localities with different landscape structure in Ziemia Chełmińska, Poland, verifying the importance of different constituents of Kestrel diet and describing variation between sites.
MATERIAL AND METHODS

The study was carried in autumn through early spring during the 2000-2002 seasons in the Ziemia Chełmińska district (Kujawy, north-central Poland). Kestrels were detected by finding active roosts in monuments (churches, old buildings, town halls) and modern (apartment) buildings or ruins in Ziemia Chełmińska. These structures were used as night or bad weather shelters. Pellets were collected at least every third month in each collection place. Because pellet collections were mostly small, they were split into five groups for each locality separately. Comparisons were done for pellets from the autumn only, due to their similarity in collection time (Table 1). Three localities represented different types of anthropogenically modified environment. Toruń (“T”, city: 206 thousand people) is surrounded by rural and agricultural areas with forested fragments. Chełmża (“C”, town: 15.5 thousand people) and Papowo Biskupie (“P”, village: 700 people) are surrounded by large fields. Chełmża is located near Chełmżyńskie Lake with a narrow belt of trees along the lakeside. Pellets in Papowo Biskupie were collected from the ruins of a castle located on a field border where birds could potentially hunt. A total of 1068 pellets were collected from Toruń, Chełmża and Papowo Biskupie (487, 303 and 278 respectively).

Pellets and prey remains were dissected in water. Prey items were identified using diagrams and diagnostic keys (Yalden & Warburton 1979, Pucek 1984) and by comparison with specimens collected and deposited in the departments of Zoology and Animal Ecology, Nicolas Copernicus University, Toruń, Poland. Mean masses for prey categories were estimated using data from the literature (Yalden & Warburton 1979, Pucek 1984). When possible, a minimum number of prey items per pellet were estimated by summation of the most numerous elements of one body side (e.g. mandibles of mammals). In most cases, it was not possible to count the number of insects per pellet using this method. However, this allowed estimation of the frequency of occurrence of prey number (N) and prey biomass (B) in all collected material.

![Figure 1](image.png)

**Fig. 1** – Percentage of variance explained by the following prey categories (extracted from PCA Component Score Coefficient Matrix).

**Obr. 1** – Procenta variability vysvětlená jednotlivými kategoriemi potravy (výsledky PCA, Component Score Coefficient Matrix).
All analyses were performed using STATISTICA 5.1 and SPSS 11.5 software packages. Diversity indexes: Simpson; $D = 1 - \Sigma p^2$ and Shannon-Wiener index; $H = -\Sigma (p)*(\log_2 p)$ were used to compare diet diversity from three localities during autumn (Table 1). The Chi-square method was used to compare the indexes as well as the differences in mean number of vertebrate specimens per pellet between localities. Principal Component Analysis (PCA-biplots, programme CANOCO 4.02, Ter Braak & Šmilauer 1998) was used to estimate which of the seven obtained prey categories have the largest impact on variation in kestrels diet (Fig. 1) and for visualising the differences in diet composition at three localities (Fig. 2).

**RESULTS**

A total of 2092 prey individuals were identified from three sites with a total biomass of 37055 g. In 996 pellets (those containing vertebrates), 1290 vertebrates were found (locality – number of vertebrates/number of pellets: T – 590/482, C – 324/239, P – 376/275). The mean number of vertebrate specimens per pellet differed significantly in Toruń from other localities (1.2 instead of 1.4; $\chi^2 = 19.97$, df = 2, $p < 0.01$, n = 3) indicating a lower intake of these prey categories there. Because highly fragmented insect exoskeletons easily drop out of pellets, it was not reasonable to accurately estimate the number of invertebrates per pellet.

Prey items were allocated into one of 32 taxonomic categories (18 for vertebrates and 14 for invertebrates) referred to as 13 vertebrate and 13 invertebrate separate species. Small mammals were the most frequently observed prey item (76% by number, 97% by biomass). Voles, including the Common Vole (Microtus arvalis), were the most abundant mammalian preys (as calculated after splitting with Microtus sp.: 65% by number and 86% by biomass). The second most important prey categories were insects, although by number of specimens only (23%). Other prey categories were low in

![Fig. 2 – PCA-biplot diagrams for both number (a) and biomass (b) of main prey categories. X and Y axis refers to correlation matrix between prey categories.](image-url)
abundance and had only a small impact on total biomass. However, there were significant differences between localities in both diversity indexes (Table 1; both: \( \chi^2 = 174.75, \text{df} = 2, p < 0.001, n = 3 \)). This resulted from different proportions of major groups of prey and absence or presence of uncommon prey in diet. Toruń most of the prey species were found (19 of 26). It was the most variable locality (\( D = 0.75 \) and \( H = 0.87 \)). As shown by PCA analysis, prey categories that explained most of the variance in diet composition were: Soricidae and Ensifera; mostly because lack of them in Papowo Biskupie (Figure 1, Figure 2a and 2b). Altogether, insects explained 37.5% of variability. The lowest impact on differences between localities had the most frequent category: Microtinae, which explains 6.9% of variance only. This indicates stable and high proportion of he prey in Kestrel diet.

DISCUSSION

Kestrels are known to hunt in open areas such as farmland. The large proportion of mammals, especially voles (Microtus sp.), in the diet from Ziemia Chełmińska is in agreement with similar research from almost all of Europe (Yalden & Warburton 1979, Shrub 1982, Korpimäki 1985, Romanowski 1996, Piattella et al. 1999). In open grassland (or farmland) the Common Vole is the most frequently found rodent (93-100%; Jacob & Hempel 2003) and the composition of predators’ diet reflects this abundance (e.g. Goszczyński 1977). Surprisingly, our results do not agree with the prediction that birds are important food source for Kestrels, particularly (but not only) in urban areas (Korpimäki 1985, Darolová 1989, Romanowski 1996, Piattella et al. 1999). Large hunting areas of kestrels (up to 1.8 km), exceeding the expanse of urban areas probably cause this. On the other hand, a high frequency of insect occurrence previously noted by Yalden & Warburton (1979) - % of diet composition is in concordance with our work (23%). But this is only supported by number, not by biomass (1%; maximum in Toruń = 3%), although this is probably highly underestimated. As noted by Yalden & Yalden (1985), the recovery of different rodent prey varies between 35 to 62%. Thus, the proportion of insects could be much higher as a consequence of digestion and loss of chitin fragments.

Divergence between the three localities could be explained by differences in land structure surrounding the collecting sites. The more diverse landscape structure around Toruń (woodland, rural and grassland patches, riverbank) results in a greater variety of potential prey and therefore a diversified composition of kestrel food items (Table 1; Fig. 2a). Similarity between Chełmża and Papowo Biskupie seems to support this prediction. Since birds can be detected hunting within 1.8 km from their shelters (Shrub 1982), a varied landscape may better explain diversified diet rather than the expanse of urban areas. However, the expensed city may generate the scarcity of optimal hunting areas in Toruń and may lead to hunting in suboptimal areas with lower vole abundance. In this case, a greater variety of prey may be caught. This seems to be in accordance with general Optimal Foraging Theory predictions (Emlen 1966, MacArthur & Pianka 1966, Sih & Cristensen 2001) that animals feed on items that maximize energy and/or nutrient intake per unit of time.

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<th>Prey category</th>
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<th>Fisher’s alpha</th>
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<th>Body mass</th>
<th>Mass contribution to total mass</th>
<th>Contribution (%)</th>
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**Table 1**

Number, percentage and mass of prey categories collected at three localities in Zemina, Czech Republic during summer 2000-2002.
Souhrn

Celkem bylo analyzováno 1086 vývržků, ve kterých bylo nalezeno 2092 položek kořisti. Jednotlivé taxony byly zařazeny do 32 kategorií (18 pro obratlovců a 14 pro bezobratlé). Průměrný počet obratlovců v jednom vývržku se pohyboval mezi 1,2 a 1,4 pro jednotlivé lokality, rozdíly mezi jednotlivými lokalitami byly statisticky průkazné (χ² = 9,97, d.f. = 2, n = 3). Savci představovali velkou část kořisti: 76 % kusů kořisti (N) a 97 % biomasy (B). Hraboši, především hraboš polní (Microtus arvalis), byly dominantní kořistí: 65 % (N), 85 % (B). Vysoké zastoupení hmyzu se projevilo pouze v počtech (23 %), v biomase představoval pouze 1 % (max. Toruń: 3 %). Výsledky potvrdily velký význam hlodavců v potravě poštolky, publikovaný v dřívějších studiích. Statisticky průkazné byly i rozdíly v indexu diverzity složení potravy na lokalitách (χ² = 174.75, d.f. = 2, n = 3; Tab. 1). Nejvyšší hodnoty dosahovaly indexy ve velkoměstě Toruń (D = 0.75, H = 0.87). Největší vliv na varianci v potravě měly kobylky (Ensifera) a rejskovití (Soricidae), 27,6 % respektive 23,4 % (Obr. 1 a Obr. 2). To může být vysvětleno vyšší heterogenitou prostředí a nedostatkem optimálních lovišť v okolí velkoměsta Toruń, v porovnání s lokalitami Chełmża a Papowo Biskupie.

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