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Habitat Use, Food and the Importance of Poultry in the Diet of the Red Fox *Vulpes vulpes* in Extensive Farmland in Poland

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Abstract: Studies on red fox *Vulpes vulpes* biology, including habitat and food preferences have been very popular during recent decades. However, the majority of them were mainly carried out mainly in highly human-modified habitats. In this paper we present data on the diet of the red fox, with special attention to domestic poultry and on den site selection in extensive farmland in Poland. During the years 2006-2008, 632 scats were collected and 82 dens were recorded. 58.5% of dens were situated in under cover (40 in forest, 8 in scrub) and the rest in open areas, such as arable fields and pasture. Fox den entrances occurred significantly more often in N, NE and W directions. Scat analyses revealed a high biomass of rodents (44.6%) and birds (35.0%-mainly poultry). Fox adaptation to use of poultry makes them partially more independent from natural resources. We found that importance of poultry in the red fox diet decreased significantly with distance to the nearest farm buildings.

Key words: Red fox · Food composition · Poultry use · Protected areas

INTRODUCTION

The red fox (*Vulpes* vulpes) is the most widely distributed carnivore in the world and an extremely adaptable species [1, 2]. In recent decades the population of red foxes has increased rapidly, often as a consequence of vaccination programmes following an outbreak of rabies, human abandonment of the countryside and dump proliferation [1-3]. In consequence, foxes have had a stronger detrimental influence on small game birds and mammals, including endangered species, directly or indirectly via habitat change [4-6]. Moreover, throughout Europe, the red fox poses a range of other potential management problems, including the transmission of diseases, such as rabies and echinococcosis and predation on livestock [2, 7, 8]. However, to date the majority of studies on red fox were carried out in habitats intensively modified by man, such as, urban areas and intensive farmland [for review see: 1, 2, 9, 10]. On the other hand data from less disturbed habitats suggest that red fox may have a strong influence on wild animals living in the same area, including high priority protected species [4-6]. Therefore we chose to study an area of extensive farming, protected under Natura 2000 (see study area section). To evaluate the possible impact of red fox predation on different prey species in protected areas it is necessary to obtain at least two pieces of information: fox distribution and density, as well as diet composition. Therefore, the first aim of our study was to describe den location and diet composition of the red fox in the study area.

Recently red fox has adapted to new anthropogenic conditions, e.g. changes in habitat, use of human-produced food [2, 10, 11]. There is some evidence that foxes have reduced their fear of humans, started to use artificial shelters and included garbage and poultry in their diet [2, 3, 8, 11, 12]. Therefore we described basic parameters of red fox ecology in an extensively used farmland and we ask particular question: how important is poultry as a food source to foxes living in extensive farmland and does the use of poultry in the diet reduce the predation pressure on wild birds living in this protected study area?

MATERIALS AND METHODS

Study Area and Fox Density: The study was conducted between May 2006 and May 2008 near the town of

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Odolanów, Wielkopolska province, western Poland (51°34'N, 17°40'E). This study area was characterized by extensive farmland with a mosaic of arable fields, meadows, small woodlots and scattered trees and shrubs of different ages, with a dominance of white willow (*Salix fragilis*), birch (*Betula pendula*), black poplar (*Populus nigra*) and pine (*Pinus sylvestris*). The majority of the study area belongs to the "Dolina Baryczy" Landscape Park and is also protected by European Union law under Natura 2000 as important area for birds. Density of foxes was established by local hunters only in 2006, when number of observed individuals was 1.03 indiv./1 km^2 and shot value was 0.46 indiv./1 km^2.

Den Site Characteristics: Fox dens were searched by intensively visit to whole study area, mainly during the autumn-winter period, when were more easy to find and next controlled again during whole study period. During the first visit and entrance orientation and habitat of den location were recorded. Habitat was defined as covered area (forest), semi-enclosed area (scrub) or open area (arable land, meadow, fallow land).

Food Composition: The diet of foxes was examined by analysing their faeces (scats). Scats were collected randomly between May 2006 and May 2008 in the whole study area. We noted the location and distance to the nearest farm building. Scats were placed in plastic bags and stored for later analysis. Later scats were soaked in water, crumbled and inspected for macroscopic remains (mainly bones and teeth) to identify prey species. Fur and feather remains found within scats were identified using a light microscope. Identified food remains were classified into the following categories: *Rodentia*, *Aves*, large *Mammalia*, *Mustelidae*, *Insecta*, *Pisces*, *Reptiles* and *Amphibia*, *Mollusca*, plants, fruits, soil and little stones, trash. Birds preyed by fox were divided into three groups: small birds (the size of a sparrow), medium sized (starling-pigeon) and large birds (mainly poultry and game birds). The frequency of each food type was expressed as a percentage of the total number of scats. The sorted material was weighed and the weight of each group was multiplied by a factor characterizing their coefficient of digestibility [14, 15]. Percentage by weight of individual groups in the diet of foxes was calculated as a ratio of the biomass of a given food category to the total biomass consumed. The total number of analysed scats was 632, but remains only from 433 scats were weighed; the remaining scats were sorted only to the prey categories. Besides faecal analyses pray remains in the field were also collected during the entire study period. To establish the importance of poultry in the red fox diet in different territories, analysis was limited to territories where more than 30 scats were collected (n = 13).

Statistical Analyses: All basic statistical analyses were performed according to Zar [16] using SPSS for Windows. The spatial orientation of den entrances was tested using circular statistics (Oriana for Windows ver. 1.2).

Because we did not find any significant differences in the distribution pattern and food contents between study seasons and to improve the relatively small sample size, the data were pooled. Results are presented as mean ± SD and all statistical tests were two-tailed.

RESULTS

Den Characteristics: Among 82 dens, 48 (58.5%) of them were situated in covered areas (40 in forest, 8 in areas among bushes). Dens located in open areas were in the minority (29.3%) and ten (12.2%) dens were in sloping places, like sandy banks of river channels.

Den entrance orientation was not randomly distributed (μ_{mean} = 19.12°; 95% confidence intervals = 10.68° = μ = 27.56°, $p < 0.0001$) and den entrances occurred more often in N and W directions. There were no significant differences in entrance orientation and habitat type: covered (5.60° = μ = 10.15°), open (4.48° = μ = 18.02°, Fig. 1).

Diet Composition: Food composition is shown in Table 1 and Table 2. The main food items were rodents of the family *Arvicolidae,* especially *Microtus arvalis.* Larger species dominated the birds. Large mammals occurred in a small number of scats whereas plant fragments and insects were quite frequent.

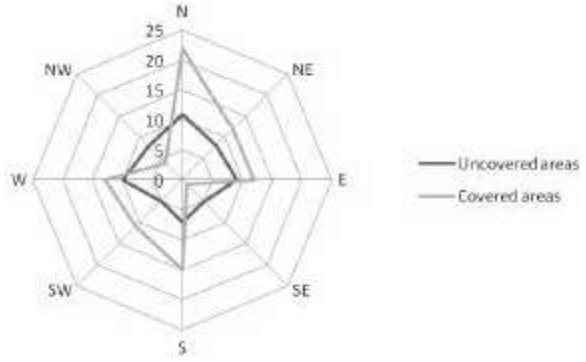

Fig. 1: Number and orientation of red fox den entrances in covered and open areas.

Table 1: Food composition (frequency of occurrence in all prey (% Prey), frequency of occurrence in scats (% Occ)

Food content		% Occ	% Prey	Number of prey
Rodentia		74.1	43.6	620
Arvicolidae		55.9	35.5	512
	Microtus arvalis	12.5	5.5	79
	Microtus eoconomus	4.3	1.9	27
	Microtus agrestis	0.2	0.1	1
	Pitymys subterraneus	1.9	0.8	12
	Arvicola terrestis	2.7	1.2	17
	Unidentified *Arvicolidae*			
Muridae		4.5	2.0	28
	Apodemus sp.	4.1	1.8	26
	Mus sp.	0.2	0.1	1
	Rattus sp.	0.2	0.1	1
Unidentified *Rodentia*		12.7	5.5	80
Insectivora		2.8	1.2	18
	Sorex sp.	0.9	0.4	6
	Talpa europea	1.9	0.8	12
Aves		33.5	15.0	212
	Small bird species	9.3	4.2	59
	Medium bird species	4.3	1.9	27
	Large bird species	17.2	7.7	109
	Eggs	1.4	0.6	9
	Unidentified *Aves*	1.3	0,6	8
Large *Mammalia*		11.5	5.1	72
	Lepus europeus	2.2	1.0	14
	Capreoulus capreoulus	4.0	1.7	25
	Sus scrofa	1.7	0.8	11
	Canis domesticus	0.2	0.1	1
	Felis domesticus	0.2	0.1	1
	Unidentified *Mammalia*	3.2	1.4	20
Mustelidae		0.9	0.4	6
Insecta		23.1	10.2	146
	Coleoptera	21.7	9.6	137
	Orthoptera	1.4	0.6	9
Pisces		0.5	0.2	3
Reptiles and *Amphibia*		1.2	0.5	7
	Lacerta sp.	0.8	0.3	5
	Serpentes	0.2	0.1	1
	Amphibia	0.2	0.1	1
Mollusca		1.3	0.6	8
Plants		37.0	16.3	234
Fruits		9.2	4.0	58
Soil and little stones		19.3	8.5	122

Additionally, the remains of 26 birds and 12 mammals were found near fox dens in the study area. Most of the bird prey were domesticated species: hens (*Gallus gallus*, 9 birds and also 9 eggs) and pigeons (*Columba livia* ver. *domestica*, *n*=4). We also found remains of three pheasants (*Phasianus colchicus*) and three common buzzards (*Buteo buteo*), two grey herons (*Ardea cinerea*), a white stork (*Ciconia ciconia*), hooded

Table 2: Food composition of red fox expressed as frequency of occurrence in all prey (% Prey), frequency of occurrence in scats (% Occ) and frequency of consumed biomass (% Bio). Only data of prey remains weighed for analysis are included.

Food type	% Prey	% Occ	% Bio
Rodents	48.5	79.2	44.6
Birds	14.9	35.1	35.0
Lagomorphs	0.9	2.1	3.1
Cervidae carcass	1.4	3.2	2.1
Plants	17.4	41.6	14.5
Insects	9.9	23.6	0.7

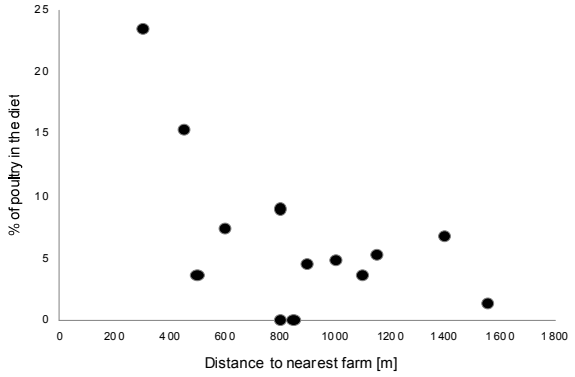

Fig. 2: Poultry occurrence (% of prey) in relation to distance to nearest (in metres) farm building

crow (*Corvus cornix*), raven (*Corvus corax*), mallard (*Anas platyrhynchos*) and graylag goose (*Anser anser*). Among mammals we found remains of seven roe deers (*Capreolus capreolus*), three brown hares (*Lepus europaeus*), one feral cat (*Felis catus*) and remains (presumably carrion) of domestic cattle.

Frequency of Poultry Occurrence in Red Fox Diet: The percentage of poultry consumed in relation to the whole food spectrum was generally higher in territories located close to farm buildings (percentage consumption *arcsin* transformed before analysis, r = 0.587, n = 13, p = 0.035, Fig. 2). However, we did not find a significant relationship between the proportion of consumed poultry and that of wild birds (both proportions were *arcsin* transformed before analysis, r = 0.315, n = 13, p = 0.318).

DISCUSSION

The red fox is the main mammalian predator in the studied extensive farmland. As for results obtained in intensive farmland in Poland [1, 3, 12, 13], we also described dens dogged in open fields, meadows and pastures. The increased use of breeding dens located in an agricultural landscape may indicate profound changes of habitat use by foxes and adaptation to a human-modified environment [3, 13], Interestingly, we did not found differences in entrances direction between dens located in covered and open habitats. Therefore, we think the direction of the entrance is influence more than just protection from the winds [12, 17]. The magnitude of westerly winds in the region may suggest an avoidance of western exposures, but this was not the case in the study area, even in very open habitats and the entrance direction may be also an adaptation to other non-microclimate factors, such as visibility of den environs and food accessibility.

The results of diet analyses obtained in the present study are generally similar to those from other farmland studies in Central Europe [15, 18, 19]. The red fox is the archetypal generalist predator with a broad food spectrum and a global distribution which includes most areas with cyclic vole populations. Therefore microtine rodents are important components of its diet in many habitats. The high frequency of rodent remains and biomass is related to the fact that foxes forage mainly in open habitats where this prey is most abundant [1, 12, 18, 20]. Birds were a high proportion of the diet in the present study (35.3% biomass) and the majority of them were poultry, which also dominated the prey remains eaten by foxes. Birds also formed an important part of the fox diet in other agricultural areas in the former Czechslovakia [19] and Poland [12, 15, 18]. However, our results indicate that poultry constituted an important and easily available fox prey even in extensive farmland. Not surprisingly, we show a clear negative relationship between the proportion of poultry in the diet and distance to farms. On the other hand, eating poultry did not reduce predating wild bird species living in this protected study plot, but rather poultry was eaten in place of hares and roe deer, here quite rare in comparison to other studies [12, 15, 18, 20].

The presented study shows that farmland populations of foxes adapt to anthropogenic conditions. Animals probably learned to use poultry as major food items. The extra food provided by humans probably caused a rapid increase of fox population density in farmland areas. Favourable trophic conditions caused the foxes to switch from traditional dens habitat to new ones. And, we think, such change of behaviour might be caused by lower human hunting pressure in recent years.

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