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Diet of the European polecat *Mustela putorius* in an agricultural area in Poland

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Abstract. The diet of the polecat (*Mustela putorius*) was studied by analysing 1078 scats collected in extensive farmland in Poland between 2006 and 2008. The diet included a wide variety of prey species; the main component were rodents (51.7 % of biomass), mainly *Microtus arvalis*. Birds were the second most common group in the diet (%Fr = 4.5). Anurans, reptiles, invertebrates and other items were additional elements of the diet. Seasonal comparisons reveal differences in diet. Rodents and birds were exploited throughout the year. Other mammals and carrion were the main component of a winter diet, whereas in spring amphibians and reptiles were characteristic prey. Diet of polecat from the studied agricultural landscape in Poland was more similar to diet of population from Hungary than to France. All these patterns confirm that polecat is a food generalist with almost exclusively carnivorous diet and can easily exploit different food resources.

Key words: mustelid, feeding habits, seasonality, farmland

Introduction

The European polecat (*Mustela putorius* Linnaeus, 1758) occurs throughout most of Europe, except the extreme northern and southern parts of the continent (Brzeziński et al. 1992). During the last 150 years the range of this species has increased towards the north of Europe, however in the same period populations in the west have declined or disappeared (Blandford 1987, Brzeziński et al. 1992). The reason for this decline is probably a combination of few factors: persecution by gamekeepers, collisions with cars, introduction of alien species, hybridization with other species, and habitat changes (Mestre et al. 2007, Barrientos & Bolonio 2009).

Several aspects of polecat biology as well as ecology, are generally well known (review in: Blandford 1987). However, the foraging ecology of the polecat is still unclear. Many authors regard the polecat as a generalist feeder (Rzebik-Kowalska 1972, Blandford 1987, Hanski et al. 1991, Prigioni & De Marinis 1995), as an amphibian specialist (Weber 1989a, Jędrzejewski et al. 1989, Jędrzejewski et al. 1993, Lodé 1996) or even a lagomorph specialist (Blandford 1987, Lodé 1997). Despite these differences all authors agree that polecat's diet is almost exclusively carnivorous. Plant material is scarcely exploited with the exception of young individuals (Weber 1989b). As in many mammals, diet composition is strongly affected by habitat. In wetlands polecats principally fed on rodents and anurans (Lodé 1996). In pristine nature forest anurans are dominant group of prey (Jędrzejewska & Jędrzejewski 1998). Polecats living near human settlements often feed on farmyard rodents (especially rats *Rattus* sp.; Birks 1998). The variety of preys and their frequency in the diet also depends on seasonal availability. In spring anurans can be the dominant prey because of their congregation during the spawning period (Lodé 1994). In winter, when anurans are hibernating, polecats mostly feed on rodents (Sidorovich 1992, Lodé 1994), however Jędrzejewski et al. (1993) reveal a high consumption of amphibians in the whole year, also during harsh winter.

In their primary habitats of European temperate forests, polecats are semiaquatic predators and prefer riparian forest, river banks or alder woods (Blandford 1987, Jędrzejewska & Jędrzejewski 1998). Drainages of wetlands carried out on a large scale in Europe

have deprived polecats of their natural habitats. In many regions they switch in secondary habitats, most often in agricultural landscapes (Jędrzejewski et al. 1993). Extensive farmland with a mosaic character may provide shelters and abundant food for polecats and hence it could be a crucial habitat for polecats in a man-modified environment.

The aim of this study was to analyse diet of polecat in the agricultural landscape in Poland and its seasonal variability using scat samples and prey remains. We have also investigated diet similarity between European populations in agricultural landscape.

Material and Methods

Study area

The study was carried out in the Wielkopolska region, near the town of Odolanów (51°34′ N, 17°40′ E) in western Poland. This study area is characterized by extensive farmland with a mosaic of arable fields, both dry and seasonally flooded meadows, wasteland and scrubs on different ages, with a dominance of birch (*Betula pendula*), black poplar (*Populus nigra*) and pine (*Pinus silvestris*). The majority of studied area belongs to "Dolina Baryczy" Landscape Park. Within the study area there are also many natural and artificial streams. Forests, mainly coniferous, occupy only a small percentage of this area.

Diet composition

This study is based on 1078 scats collected from August 2006 to November 2008. Scats were collected in known polecat territories (29 sites identified by tracks and dens and also personal observation of polecat), mainly from dens and shelters. All scats were determined after size, shape and colour. Collected faeces were dried for several days, then sieved (mesh size 1 mm) and put into envelopes to dry further. After drying, non digested remains were weighed and analysed. Mammal species were identified by teeth, bones and hair according to references of Pucek (1984). Feathers and shells were identified to species level if possible using the key of Brown et al. (2006). Invertebrates were identified by exoskeletons (Pokorný 2002). Identified remains of individual prey from one scat were also weighed on an electronic balance with an accuracy of 0.01 g. Birds preyed by polecats were divided into three groups depending on size: small bird species (the size of a sparrow), medium sized (starling-pigeon) and larger birds. Prey remains found near polecat dens were also taken account to complement the diet but analyzed separately.

The contribution of each group identified from scat samples was expressed as: percent frequency of occurrence in all food item (%Fr) and percentage of consumed biomass (%B). For the biomass estimation, we used the following coefficients of digestibility (Jędrzejewska & Jędrzejewski 1998): rodents 17.8, insectivores 15.2, medium-size mammals 50, carcasses of cervids 15, birds 12.4, anurans and reptiles 41.3, fish 25, insects 5, fruits and plant material 14. Seasonal comparison was made between the four seasons: spring (March-May), summer (June-August), autumn (September-November), winter (December-February), and only fresh scats were taken into account. Additionally, prey were combined into 10 categories of food: rodents, insectivores, other mammals (bat, unidentified mammals), birds, amphibians, reptiles, fish, carrion (Artiodactyla, cats), invertebrates, others (for example fruits, other plant material, trash). Food niche breadth was calculated using Simpson's index ($B = 1/\sum p_i^2$) where p_i is the proportion of food category i in the diet.

Statistical analysis

Descriptive statistics were performed according to Zar (1999). For comparison of seasonal variation in the diet composition between agricultural areas indirect ordination methods were applied, using Canoco 4.5 software to perform the analyses (Lepš & Šmilauer 2003). Detrended Correspondence Analysis is a useful method to explore patterns of variance between species composition and environmental variables. We used data from 2008 because in this year the sample sizes between seasons were more balanced.

The food composition (prey categories) were displayed against particular seasons and given geographical location in ordination diagrams. The ordination diagrams display scores of the response (prey types) as circles and quantitative explanatory variables as triangles. The position of particular seasons on diagram indicate similarity among them and prey. Significance of the multivariate model for all canonical axes due to differences in sample size between seasons following covariables were applied: number of scats and number of prey items. Secondly, the DCA method was used to compare diet of populations from Europe and the study area. In this case the percent of occurence of prey in particular seasons (spring, summer, autumn and winter) per study site was used. Data were taken from Hungary (agricultural area, Lanszki & Heltai 2007), Western France (agricultural area, Lodé 1990), and Poland – Odolanów (agricultural area) – this study.

Table 1. Diet composition of the polecat in Western Poland. %Fr – percentage frequency of occurrence in all prey, %B – percentage of biomass.

Food category		%Fr	%B
Rodents		30.7	51.7
	Microtus arvalis	14.2	24.3
	Microtus oeconomus	2.0	3.0
	Microtus sp.	9.2	14.6
	Myodes glareolus	0.1	0.3
	Apodemus agrarius	0.5	1.3
	Apodemus flavicollis	0.2	0.2
	Apodemus sylvaticus	+	+
	Apodemus sp.	3.4	4.4
	Mus musculus	0.1	0.2
	Micromys minutus	0.1	0.2
	Arvicola amphibius	0.8	3.3
Insectivores		0.9	0.6
	Sorex araneus	0.3	0.2
	Soricidae	0.2	0.2
	Talpa europaea	0.3	0.2
	Erinaceus europaeus	0.2	0.1
Carrion		0.4	3.3
	Felis catus	0.2	2.3
	Artiodactyla	0.2	0.9
Other mammals		11.1	13.7
	Unidentified mammals	11.1	13.6
	Myotis nattereri	+	0.1
Birds		14.5	20.9
	Small-size birds	3.5	3.4
	Medium-size birds	4.7	8.6
	Large-size birds	3	7.1
	Unidentified birds	1.1	1.5
	Eggs	2.1	0.3
Reptiles		2.5	1
	Lacerta sp.	2.1	0.8
	Natrix natrix	0.3	0.2
	Anguis fragilis	0.1	+
Amphibians		2.2	5.5
Unidentified fish		0.1	+
Invertebrates		31.7	1.3
	Coleoptera	13.5	0.8
	Other insects	17.5	0.5
	Unidentified insects	0.6	+
	Mollusca	0.1	+
Others		5.8	1.9
	Fruits	0.4	0.2
	Other plant material	3.7	1.7
	Trash	1.7	+

Results

Diet composition

Analysis of polecat scats revealed a wide variety of prey species (Table 1). Main foods of polecat were mammals (%Fr = 43.1). Rodents were the dominant group and constituted about half of the overall diet. Insectivores were a minor component of the diet. Birds were the secondary prey group, dominated by medium-sized species. Anurans (frog or toads), reptiles and fish jointly complement the diet. Invertebrates occurred frequently in the food of polecat, but constituted only little percent of biomass. Fruit and other plant material (grass, leaves, grain) were scarcely consumed by the polecat.

Additionally, remains of six mammals, 14 birds, two grass snakes *Natrix natrix* and one unidentified amphibian (frog or toad) were found near polecat shelters. Among mammal there were voles *Microtus* sp. (2 specimens), domestic cats *Felis catus* (2) and unidentified mammals (2). Among birds remains we have identified mallard *Anas platyrhynchos* (3), domestic hen *Gallus gallus domesticus* (3), yellowhammer *Emberiza citrinella* (2), European magpie *Pica pica* (2), Eurasian siskin *Carduelis spinus*, wood pigeon *Columba palumbus*, grey patridge *Perdix perdix* and blackbird *Turdus merula*.

Seasonal comparisons

Seasonal diets from the two years differed considerable, therefore appropriate seasons are presented separately Characteristic categories for the winter season were: other mammals, carrion and other prey. The spring diet was characterized by a relatively high contribution of anurans and reptiles. We did not observe any distinctive elements in the summer and autumn diet and in summer 2008 rodents were major preys. Data on food niche breadth confirm the above (Table 3). However, the widest food niche was observed in autumn (B = 2.71) and the narrowest in summer (B = 1.97).

Geographical variation in diet

The diet of polecats from Odolanów was more similar to diet of population from Hungary than from population from France. Characteristic components of diet polecats from France were lagomorphs which were lacking in Central Europe (Fig. 1a, b). However, considering the seasonal variation in the diet, composition of diet in our population of polecat was not so variable as diet from Hungary. The similarity of diets from Central Europe might be a result of similar climatic conditions as well as habitat composition (farmland).

Discussion

The results of our investigation show a high diversity of food in the examined population. Small contribution of plant material confirms that polecats are generalist predators with an almost totally carnivorous diet

Table 2. Seasonal variability of polecat diet expressed as percentage frequency of occurrence in all preys (%F) and percentage biomass (%B) based on 829 fresh scats in Western Poland. N = 378 (2007) and 451 (2008).

	winter 2007		spring 2007		summer 2007		autumn 2007		winter 2008		spring 2008		summer 2008		autumn 2008	
	%F	%B	%F	%B	%F	%B	%F	%B	%F	%B	%F	%B	%F	%B	%F	%B
Rodents	43.5	47.0	4.1	20.1	44.3	68.0	41.8	58.5	38.4	60.1	44.7	61.0	22.5	30.8	45.9	46.6
Insectivores	0.8	0.4	0	0	1.1	1.5	3.3	2.9	1.2	1.6	0.8	0.3	1.1	0.1	0	0
Other mammals	23.0	17.9	4.1	9.6	5.3	5.0	7.8	14.8	22.1	22.2	10.9	11.3	14.8	34.1	24.3	37.5
Carrion	0	0	0	0	0	0	0	0	1.2	1.5	0.3	0.6	0	0	0	0
Birds	20.2	33.2	4.9	46.7	15.5	20.3	12.4	18.0	19.8	14.5	12.0	9.1	20.9	24.8	21.6	15.9
Reptiles	0	0	2.5	0.8	1.9	0.4	0.7	0.2	0	0	3.1	0.8	4.4	1.4	0	0
Amphibians	0.8	0.6	2.5	16.8	0.4	0.1	0.7	0.2	0	0	9.2	15.1	2.2	4.2	0	0
Fish	0.8	0.1	0	0	0	0	0	0	0	0	0	0	0.5	0.1	0	0
Invertebrates	0.4	+	77.0	2.9	26.1	0.9	25.5	2.4	1.2	0	12.3	0.4	24.7	0.8	2.7	0
Others	10.5	0.8	4.9	3.0	5.3	3.9	7.8	3.1	16.3	0.1	6.7	1.3	8.8	3.8	5.4	0

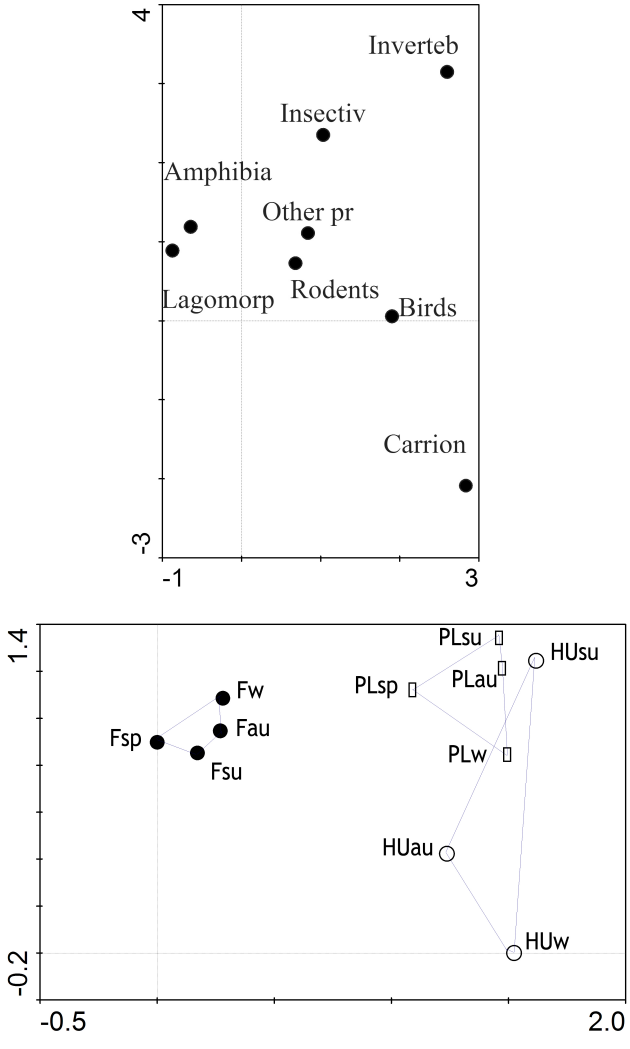

Fig. 1. Results of detrended correspondence analysis DCA of prey composition in seasonal diets of polecat in Europe (upper). The data were taken from following populations: France (Lodé 1990), Hungary (Lanszki & Heltai 2007) and Poland (this study). PL denote our study area, Hu denote Hungary, F denote France. Following abbreviations denote seasons: sp – spring, su – summer, au – autumn, w – winter. The importance of each group is reflected by proximity with regard to each season and study area (lower). Eigenvalues of axes I and II were 0.396 and 0.119 and cumulative percentage of explained variability was 71.3 %.

Table 3. Seasonal variability in the food niche breadth of polecat in Western Poland.

	Mean ± SE	CI ± 95	N
Winter	2.09 ± 0.20	1.70 ± 2.49	26
Spring	2.38 ± 0.21	1.96 ± 2.80	23
Summer	1.97 ± 0.30	1.36 ± 2.57	11
Autumn	2.71 ± 0.30	2.10 ± 3.31	11

(Rzebik-Kowalska 1972, Blandford 1987, Hanski et al. 1991, Prigioni & De Marinis 1995). In our study rodents, mainly voles, were the dominant prey throughout the year. This large contribution is probably connected with the habitat (agricultural landscape where small mammals are available throughout the year; *c.f.* De Marinis & Agnelli 1996). Furthermore, voles are relatively easy to catch (Lodé 1999). Even in winter, polecats are able to dig voles up under a thick snow cover (Jędrzejewski et al. 1993). The small contribution of insectivora in the polecat diet confirm that they are not preferred by predators because of their unpleasant taste (Lodé 1999). The presence of Natterer's bat (*Myotis nattereri*) is the first such record in the diet of the polecat. Moreover in diet of other carnivores bats are very rare (Tryjanowski 1997).

Birds were the second most important group of prey and constituted a substantial element of the diet throughout the year. In spring and summer a relatively high frequency of preyed birds is connected with the migration period and bird breeding season. Additionally in winter polecats move closer to human settlements where they can hunt for poultry (Brzeziński & Romanowski 1997). The presence of poultry remains in our study confirm this statement. The large diversity of birds in the diet did not differ from results of other studies conducted in agricultural landscapes (Rzebik-Kowalska 1972, Prigioni & De Marinis 1995, Lanszki & Heltai 2007). This means

that polecat hunts for terrestrial and sometimes also arboreal prey species.

Anurans were rarely exploited, mainly in spring, during the spawning period. However polecats are able to find and excavate hibernating frogs (Jędrzejewska & Jędrzejwski 1998), therefore there are also found in scats in autumn and winter. Fish rarely featured in the diet of the studied population; it has been suggested that this may result from an aversion of polecats to swimming (Blandford 1987). Invertebrates were detected in the diet, however they are eaten only accidentally.

Plant material and fruits were scarcely exploited which confirms that the polecat is mainly carnivorous and plant material is most probably eaten accidentally (Blandford 1987, Weber 1989b, Jędrzejewski et al. 1993). However, some authors have observed a larger contribution of fruits and seeds in the diet (Rzebik-Kowalska 1972, Prigioni & De Marinis 1995) what could be a characteristic trait of young polecats (Weber 1989b).

Seasonal variation in the diet is a result of variation in the availability of each prey-type within the year (Prigioni & De Marinis 1995). Rodents and birds were exploited throughout the year. Other mammals and carrion were the main component of a winter diet, whereas in spring amphibians and reptiles were characteristic prey. Changes in prey species result also from the polecat's habitat changes (Weber 1989c, Baghli et al. 2005, Brzeziński et al. 2010). In times of low abundance of natural food sources polecats move closer to human settlements, where they can prey on poultry and farmyard rodents (mice and rats; Jędrzejewska & Jędrzejewski 1998). Despite a lack of significant differences in the food niche breadth between seasons, the winter and spring diet stand out in the annual diet. In winter the diet contains rodents and other mammals (i.e. insectivores), carrion and others (fish, fruit and plant material). In the spring diet anurans and reptiles were characteristic components. This confirms earlier results of Lodé (2000), who considered that in times of low rodent abundance, predation on this group decreased, while the contribution of other prey and carrion in the diet increased. Rodents, mainly voles *Microtus* sp. were the main and stable component of diet in all seasons.

The polecat diet was studied intensively throughout Europe (Weber 1989b, Lodé 1990, Lodé 1996, Lanszki & Heltai 2007, Ryšavá-Nováková & Koubek 2009). Analyses presented in current paper show that polecat diet from our study plot was more similar to the Hungarian population than to that in Franch. Population from France heavily exploited rabbits and amphibians which were lacking in studied Central European agricultural areas. This pattern indicates that polecats easily use different food resources and are flexible predators.

In conclusion, a large diversity of food types in the diet of the examined population provides that in a human-modified environment polecats are forced to use almost every available food source. It could be an optional adaptation needed to survive for this predator (Jędrzejewski et al. 1993). Thus the results presented in this paper show that polecats are rather generalist than specialist predators in an agricultural area.

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