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# Garbage in the diet of carnivores in an agricultural area

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## ABSTRACT

Human food waste is considered to be richer in carbohydrates, lipids and proteins than most natural food supplies; however, it is very well digested in scats. So, as an indication of this kind of food in the diet, we have used each indigestible, anthropogenic origin element found in faeces (e.g., glass, plastic, rubber, etc.). There are few studies discussing the importance of garbage in the diet of mammalian predators living in farmland; definitely, most focus on this issue in urban areas. We studied the contribution of garbage in the diet of raccoon dog (*Nyctereutes procyonoides*), red fox (*Vulpes vulpes*), marten (*Martes* sp.), polecat (*Mustela putorius*), stoat (*Mustela erminea*), American mink (*Neovison vison*) and Eurasian otter (*Lutra lutra*) in the agricultural areas of western Poland in 2006-2010. In addition, we examined the spatial changes in the diet of red fox and polecat. The largest contribution of garbage was found in scats of raccoon dog (8.8%), red fox (4.8%) and marten (4.3%). The diet of polecat, stoat and Eurasian otter contained 2.5%, 1.7% and 0.2% garbage items respectively. The most frequent item was plastic. Our analysis showed that garbage consumption by red fox and polecat was greater closer to human settlements. The results reveal a continuous gradient in the garbage consumption that corresponds with the degree of synanthropization of particular species.

## KEYWORDS

carnivores, diet, garbage, generalist species, synanthropization, human settlements



## INTRODUCTION

Human food waste is considered to be an important supplement to natural food supplies for some mammals and may positively affect urban populations (Contesse et al. 2004; Gehrt 2004). Some species can easily change their behaviour and learn how to find and use human food waste and, as a consequence, become partially independent from fluctuations in natural food resources (Gołdyn et al. 2003; Ditchkoff et al. 2006). On the other hand, they may be forced to use human food waste due to a high density of their population (Contesse et al. 2004), an increase in urban areas (Pickett et al. 2011) and the lack of natural prey (Martina & Gallarati 1997). It is believed that the most common human food wastes of many wild animals are fruits, vegetables and scavenged meat (Harris 1981; Contesse et al. 2004; Oro et al. 2013; Tryjanowski et al. 2015).

In most studies of the carnivore diet, garbage are omitted and usually not included in the analysis and discussion (e.g., Lindström 1994; Tryjanowski 1997; Lanszki et al. 1999; Lanszki 2003), and mostly discussed in surveys of species living in urban areas (Harris 1981; Saunders et al. 1993; Contesse et al. 2004) and rarely those in farmland areas (Cavallini & Volpi 1996; Gołdyn et al. 2003). Even rarer are studies discussing the importance of garbage in communities of carnivorous species. In fact, only Prigioni et al. (2008) roughly discussed the occurrence of garbage in diets of four carnivore species. There is also little information about the types of garbage found in scats.

Most species whose diet is supplemented with anthropogenic food are highly opportunistic and use garbage dumps as a source of food (Martina & Gallarati 1997). The best known such mammal is red fox, which has a partly urbanized population (*Vulpes vulpes*; Harris 1981; Gołdyn et al. 2003). The surveys revealed that raccoon dog (*Nyctereutes procyonoides*) could consume anthropogenic food (Kauhala et al. 1998); however, there is no obvious confirmation of preference to hu-

man settlements, at least in the European population (Drygala et al. 2008). Literature of this species indicates the occurrence of raccoon dogs in the cities, however it was found in Japan (Saeki 2001). Mustelids are also typical consumers of garbage (Fedriani et al. 2001), especially stone marten (*Martes foina*) (Broekhuizen 1999; Goszczyński et al. 2007). The European polecat (*Mustela putorius*) is considered to be a generalist feeder with an almost exclusively carnivorous diet, and has had a recent tendency to occur in human settlements (Baghli et al. 2002). Stoat (*Mustela erminea*) is regarded as a specialist predator feeding mostly on rodents, but also as a semi-generalist – feeding occasionally on other food resources (Korpimäki et al. 1991; Martinoli et al. 2001). American mink (*Neovison vison*) is characterized as an opportunistic predator which establishes territories along rivers or other water bodies (Sidorovich 2000). Contrastingly, Eurasian otter (*Lutra lutra*) is described as a fish-eater, specialist in Central Europe (Lanszki & Sallai 2006; Krawczyk et al. 2016). Stoat and riparian species like Eurasian otter, American mink are thought to prefer human settlements less (Carss 1995). However, when food resources are highly available, otters could use fish farms areas. Home ranges for red fox are established as 20-30 km$^2$ (Goszczyński 2002), for female polecat as 0.1 – over 2 km$^2$, and for male polecat as 0.2 – 12 km$^2$ (home range changes in seasons; Brzeziński & Romanowski, 1997).

The objectives of our study were to show the different types of garbage in the diet of carnivores, and the interspecific variability in the amount of garbage remains in the carnivores' diet, along with a variation within the single species according to a distance to human settlements. In accordance with the above facts about opportunistic species, we predict that the specimens with home ranges closer to human settlements should often use the anthropogenic food like garbage dump, and it should be manifested by increased occurrence of garbage items in scats.

## 1. MATERIALS AND METHODS

The study was carried out in the Wielkopolska region, near the town of Odolanów (51°34'N, 17°40'E) in western Poland. The study area (220 km$^2$) is characterized by extensive farmland with a mosaic of arable fields, meadows, wasteland and scrub. There are also many natural and artificial streams. Forests, mainly coniferous, occupy only a small percentage of the study area. Our scope of research was the administrative part of the Odolanów, Sulmierzyce and Przygodzice district, which are characterized as urban-rural with mean density as 77,9 humans/km$^2$. One garbage dump is localized in the study area. A large part of garbage produced by households were kitchen waste – 17% at rural and 26% at urban areas, which gave 231 tons of kitchen waste in Odolanów district in 2006 (GUS; Szyszkowski 2008).

Scats of surveyed species were collected from 2006 to 2010 and analyzed following the standard procedures. The scats were identified according to shape, size and place where the faeces were found (for details see Romanowski 1998). They were collected and placed into plastic bags and stored for later analysis. Later on, faeces were soaked in water, crumbled and examined for macroscopic remains identified using a light microscope (for details see Jędrzejewska & Jędrzejewski 1998). The contribution of garbage was expressed as the percentage of scats in which they occurred. We separated scats in a warm season (April-November) and a cold season (December-March) to undertake seasonal comparisons. The details of collected sample size are shown in Table 1.

Because human food waste is very well digested in scats, we have used each indigestible, anthropogenic origin element found in faeces (e.g., glass, plastic, rubber) as an indication of this kind of food in the diet. To test the relationship between distance to settlements and garbage presence in scats, these were tested using a generalized linear model with a binominal distribution and logit-link function. We also computed the odds ratio to show how the probability of garbage items' presence changed per unit change in relation to the distance to nearest buildings from the place where scat was found. We did not do this analysis for Eurasian otter, stoat and American mink, stone marten because of the small sample size of garbage in their diet.

The significance was accepted at $p < 0.05$. The whole statistical analysis were done by STATISTICA 8.0v software (StatSoft Inc. 2007)

## 2. RESULTS

The examination of scats revealed the occurrence of garbage of 12 different types in the carnivores' diet (Table 1). Plastic occurred in the scats of five of seven species, and for four species, it was the most frequent garbage. Glass was the most often type of garbage found in the diet of Eurasian otter. The analysis of stoat faeces revealed the presence of only one type of garbage – wool, which was found only once.

For red fox and polecat, we found that the probability of finding the garbage item in scat decreased if the distance to settlements increased (Table 2, Figure 1). The odds ratio shows that with every 100 m increase in the distance to settlements, the chance to find a garbage item decreased by 15% for red fox and by 19% for polecat.

## 3. DISCUSSION

Our survey suggests continuous gradient in the garbage consumption. From the most synanthropized species – red fox, which had the most numerous garbage in the diet, to American mink, which did not consumed garbage at all (Gołdyn et al. 2003; Zabala et al. 2005; Goszczyński et al. 2007). On the other hand, the Eurasian otter, American mink and stoat did not show signs of synathropization. The analysis showed that red fox and polecat, whose scats were found closer to human settlements, probably used garbage as an easily accessible food source. The main source of garbage for these animals

*Table 1. Types of garbage in diets of Carnivora species in the study area.*

| Garbage item | raccoon dog (*Nyctereutes procyonoides*) | | red fox (*Vulpes vulpes*) | | marten (*Martes* sp.) | | polecat (*Mustela putorius*) | | stoat (*Mustela erminea*) | Eurasian otter (*Lutra lutra*) | American mink (*Neovison vison*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | N | N |
| Plastic | 6 | 60 | 15 | 33.3 | 4 | 50.0 | 10 | 32.3 | | 1 | |
| Aluminium foil | | | | | 1 | 12.5 | 7 | 22.6 | | 1 | |
| Styrofoam | | | 13 | 29.0 | | | 2 | 6.5 | | | |
| Paper | 1 | 10 | 6 | 13.3 | 1 | 12.5 | 4 | 12.9 | | | |
| Buckshot | | | | | | | 1 | 3.2 | | | |
| Lime | | | | | 1 | 12.5 | 2 | 6.4 | | | |
| Paint | | | | | | | 2 | 6.4 | | | |
| Wool | 1 | 10 | 1 | 2.2 | | | 2 | 6.5 | 1 | | |
| Hemp twine | | | | | | | 1 | 3.2 | | | |
| Glass | 2 | 20 | 4 | 8.9 | | | | | | 2 | |
| Rubber | | | 1 | 2.2 | | | | | | | |
| Sponge | | | 1 | 2.2 | 1 | 12.5 | | | | | |
| Unidentified | | | 4 | 8.9 | | | | | | | |
| Total number of garbage | | 10 | | 45 | | 8 | | 31 | 1 | 4 | 0 |
| Total garbage occurrence | | 8.8 | | 4.8 | | 4.3 | | 2.5 | 1.7 | 0.2 | 0 |
| Total number of scats | | 215 | | 936 | | 161 | | 1068 | 59 | 2269 | 115 |

*Table 2. The results of generalised linear models showing the relationship between the presence of garbage item in the scats of two species and the distance to buildings from the place where the scat was found.*

| Model | Term | Coefficient | Standard Error | Wald Chi--square | p-value | Odds ratio |
|---|---|---|---|---|---|---|
| red fox (*Vulpes vulpes*) | intercept | -1.9364 | 0.3692 | | | |
| | distance to buildings | -0.0015 | 0.0005 | 8.9135 | <0.01 | 0.9985 |
| polecat (*Mustela putorius*) | intercept | -2.6452 | 0.2852 | | | |
| | distance to buildings | -0.0019 | 0.0005 | 13.9582 | <0.001 | 0.9981 |

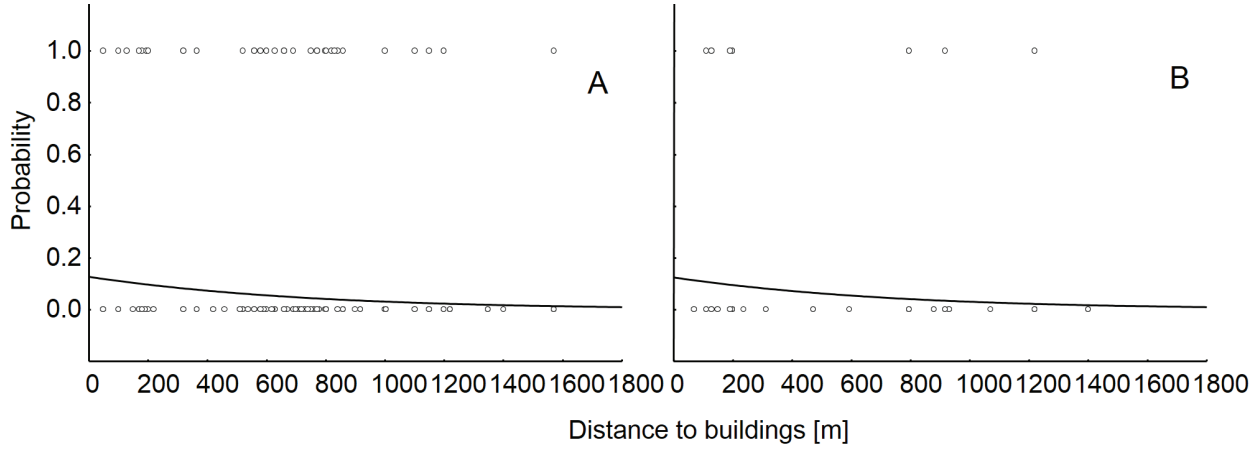


*Figure 1. The negative relationships between probability of finding the garbage item in the scats of red fox Vulpes vulpes (A) and polecat Mustela putorius (B) with the distance to nearest buildings from place where the scat was found.*

could be small garbage dumps and containers found in farmyards or gardens, or even some rubbish near roads (Ditchkoff et al. 2006). The most frequent garbage items found in the diet of surveyed species was plastic. Probably during the foraging of rubbish dumps, animals tear plastic bags to get the remains of human food and accidentally eat it. Human garbage often constitutes a food source which is more calorific and richer in carbohydrates, lipids and proteins than most natural food items (Peirce and Van Daele 2006). They are available all year round and independent of the environmental conditions (Panek and Bresiński 2002; Gołdyn et al. 2003). Peirce and Van Daele (2006) have shown that eating garbage may provide earlier maturation, higher growth rates, and gain some calorific benefit. However, foraging close to human settlements may be risky, because many of the carnivorous species are regarded as pests, and are persecuted because of the possibility of being poisoned (Birks 1998; Dip et al. 2003). There is also a possible risk of damage to or blockage of the digestive track (Sadove & Morreale 1990). Staying in the human neighbourhood may also increase road mortality (Ditchkoff et al. 2006). It should be noted that signs of poultry consumption found as feather remains in scats could also be an evidence of synanthropization. A paper from the study area shows that the occurrence of poultry remains in scats increases in territories of red fox closer to human settlements (Jankowiak et al. 2008).

We assessed the relative contribution of garbage to carnivores' diet by quantifying the proportion of scats with non-digestible garbage remains (e.g., rubber, plastic and glass). However, the relative contribution of digestible material may be underestimated because human food waste can be completely digested and its remains cannot be found (Litviatis 2000). Nevertheless, it is this kind of material that truly forms a part of the diet (i.e., not the non-digestible items, such as rubber or plastic that do not contribute nutrients nor energy to whom ingested it, thus by definition do not form part of the diet) and will contribute to carnivores' fitness in the form of human-mediated subsiding. We assumed according to Cavallini and Volpi (1996) survey that there is a relationship between digestible and non-digestible material.

The input of nutrients from human food waste can positively benefit the population density (Fedriani et al. 2001; Bino 2010; Oro et al. 2013; Tryjanowski et al. 2015). On the other hand, feeding on garbage could be a result of high population densities, as due stronger competition, the carnivores are forced to forage closer to human settlements (Contesse et al. 2004). However, the ability to adapt to this unusual habitat, gaining some benefits and avoiding risks arising from the human proximity, could be important factors determining the development of these populations. The subject of this study covers an important ecological issue, due to the invasion of natural wastes by human settlements and activities.

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