

FOOD HABITS AND TROPHIC NICHE OVERLAP OF THE RED FOX, EUROPEAN WILD CAT AND COMMON GENET IN THE PENEDA-GERÊS NATIONAL PARK

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ABSTRACT

The preliminary results of studies on food niches of predators in a mountain habitat are presented. The diet of *Vulpes vulpes*, *Felis silvestris* and *Genetta genetta* was determined by scat analyses. Data was collected from a study area located in the Peneda-Gerês National Park from January to December at altitudes ranging from 800m to 1250m in open and wooded areas, dominated by *Quercus robur* and *Quercus pyrenaica*. Results are expressed as frequency of occurrence, and consumed biomass was estimated. Trophic diversity of predators was evaluated and their diet overlap measured. The comparison of the diets of the three carnivores showed two different feeding strategies: (i) high consumption of Rodents and Lagomorphs by red fox and wild cat; (ii) high consumption of Rodents (with a great predominance of *Apodemus sylvaticus*) and Insectivores by genet. To explain this pattern of resource exploitation we discuss two hypothesis based on abundance of feeding resources and space use by predators.

Key words: Diet, *Felis silvestris*, *Genetta genetta*, niche overlap, *Vulpes vulpes*.

RESUMEN

Hábitos alimentarios y solapamiento trófico de zorro, gato montés y gineta en el Parque Nacional de Peneda-Gerês

Se presentan los resultados preliminares de un estudio sobre la dieta del zorro, gato montés y gineta en un hábitat montañoso, mediante análisis de excrementos. Las muestras fueron recogidas en el Parque Nacional de Peneda-Gerês entre Enero y Diciembre, a una altitud de entre 800 y 1250 m, en áreas abiertas y boscosas, de *Quercus robur* y *Quercus pyrenaica*. Los resultados se expresan en forma de frecuencia de aparición y se estima la biomasa consumida. Por otro lado, se calcula la diversidad trófica de los predadores y el solapamiento de sus dietas. La comparación de las dietas de los tres carnívoros muestra la existencia de dos estrategias tróficas distintas: i) zorros y gatos monteses consumen principalmente roedores y lagomorfos; ii) la gineta consume principalmente roedores (sobre todo *Apodemus sylvaticus*) e insectívoros. Para explicar el patrón detectado se discuten dos hipótesis basadas en la abundancia de recursos tróficos y en el uso del espacio por los predadores.

Palabras clave: Dieta, *Felis silvestris*, *Genetta genetta*, nicho trófico, *Vulpes vulpes*.

INTRODUCTION

Diet studies increase our understanding on feeding resources available to a predator, the predatory capability of the species, and the limitations their environment places on their choices (Clevenger 1995).

In this paper we present preliminary results on the diet of three predators, red fox (*Vulpes vulpes* Linnaeus, 1758), wild cat (*Felis silvestris* Schreber, 1777) and common genet (*Genetta genetta* Linnaeus, 1758). This study is part of a wider project aiming the study of the relationship between medium sized carnivores and their preys in the National Park of Peneda-Gerês.

The trophic ecology of these three predators has been studied throughout Europe including the Iberian Peninsula. Red fox is a well-known generalist predator with opportunistic feeding habits reported (Amores 1975, Goszczynski 1986, Macdonald 1987). Wild cat is considered a carnivore species specialised in rodents and lagomorphs (Stahl 1986, Sarmiento 1996, Gil-Sánchez et al. 1999). Finally genet has been pointed out as an efficient predator on rodents, in particular *Apodemus sylvaticus* (Delibes 1974, Palomares and Delibes 1991, Gomes 1998). However, in the Peneda-Gerês National Park there are only a few studies about these predators (Pinto 1978, Gomes 1989, 1998), and none of these works make comparisons between predators diets.

With this paper, we pretend to estimate the degree of trophic niche overlap between the three species and contribute to a better knowledge of the carnivore role.

STUDY AREA

This study was carried out in a mountain area of about 3000ha in the region of Montalegre, in Peneda-Gerês National Park, Northeast Portugal, in altitude, ranging 800m and 1250m. The area is very heterogeneous, characterised by a mosaic pattern of patches of oakwood (*Quercus pyrenaica* and *Quercus robur*) interspersed with shrubland dominated by *Erica cinerea* and *Genista* sp, pastures, cereal fields and abandoned fields covered by *Genista* sp. and *Cytisus* sp. This mosaic pattern provides an important diversity of habitats for a wide small mammal community that supports a great number of predators in the area.

METHODS

Between January and December of 1999 a total of 232 scats were collected (102 of red fox, 56 of wild cat and 74 of common genet). The methodology of scat analysis was based on the methods described by Putman (1984) and Reynolds and Aebischer

(1991). Faeces were washed in a sieve (0,36 mm mesh) under a jet of water and the macroscopic portion was separated in fur, bones, feathers, scales, seeds, remains of insects and non-energetic material. The food items were dried and weighed. The considered prey items were: small mammals (rodents and insectivores), lagomorphs, birds, reptiles, arthropods, carrion and fruits. Amphibian remains were found in only one scat of genet, and were not considered in the analysis. Mammal remains were identified to the species level by using teeth (Blanco 1998) and hairs (Teerink 1991).

Results are expressed as frequency of occurrence. The consumed biomass of mammalian prey was also estimated multiplying the dry weight of the food items by a coefficient of digestibility, i.e. the ratio of fresh weight of a given prey to the dry weight of its remains in scats. Coefficients were taken from works of Lockie (1959), Goszczynski (1974), Yoneda (1982), Palomares and Delibes, (1991), Sarmiento (1996) and are listed in Table 1. We were unable to find appropriated correction factors in literature for some prey consumed by red fox (reptiles) and wild cat (fruits, arthropods and carrion). In these cases we used for red fox the coefficients given for wild cat and vice-versa. We think that this is a reasonable assumption taking in account the similar weights of these predators and the resemblance between the coefficients for the other categories. When more than one mammal item were present in a scat, the relative proportion of each one in the diet was assumed equal to the proportions of teeth from the different mammals found.

TABLE 1
Conversion factors used to estimate the biomass of food eaten by red fox, wild cat and genet
Factores de transformación utilizados para calcular la biomasa consumida por el zorro, el gato montés y la genet

	<i>Vulpes vulpes</i>	<i>Felis silvestris</i>	<i>Genetta genetta</i>
Small mammals	23 (a) (b)	23,6 (d)	9 (e)
Lagomorphs	43 (a)	37,7 (d)	12,5 (e)
Birds	45 (a)	42,2 (d)	7,5 (e)
Reptiles	40.7 (f)	40,7 (d)	19,8 (e)
Arthropods	5 (c)	5 (g)	10 (e)
Fruits	14 (c)	14 (g)	24 (e)
Carrion	118 (b) (c)	118 (g)	—

Sources of data: (a) - Lockie (1959); (b) - Goszczynski (1974); (c) - Yoneda (1982); (d) - Sarmiento (1996); (e) - Palomares and Delibes (1991); (f) - the same as for wild cat; (g) - the same as for red fox

Diet diversity was calculated using the standardised Levins index (B_{sta}) (Colwell and Futuyma 1971) applied to the percentage of biomass consumed of the main food categories (rodents, insectivores, lagomorphs, birds, reptiles, arthropods, fruits and carrion). The Levins index formula is:

$$B = 1 / \sum p_i^2$$

where p_i is the frequency of each food category consumed (Levins 1968). The standardised Levins index formula is:

$$B_{sta} = B - 1 / B_{max} - 1$$

where B is the Levins index and B_{max} is the total number of food categories recognised (lowest niche breadth = 0; greatest niche breadth = 1).

Trophic niche overlap was measured using percentage of biomass consumed of food items through Pianka's index ($O_{jk} = p_{ij} p_{ik} / \sum p_{ij}^2 \sum p_{ik}^2$, where p_i is the percentage of prey item "i" in the diet of species "j" and "k") (Pianka 1973). Pianka's index varies between 0 (total separation) and 1 (total overlap). Food niche overlap was calculated at two levels: (a) – considering the major prey groups (rodents, insectivores, lagomorphs, birds, reptiles, arthropods, fruits and carrion); (b) – considering rodents and insectivores at the specific level (*Apodemus sylvaticus*, *Microtus lusitanicus*, *Microtus agrestis*, *Arvicola sapidus*, *Eliomys quercinus*, *Crociodura russula*, *Talpa occidentalis*, *Sorex granarius*, *Sorex minutus* and *Neomys anomalus*).

RESULTS

Diet composition

In the red fox diet, small mammals were the most important prey consumed both by occurrence (65,7%) and biomass (40%). Rodents, especially *Apodemus sylvaticus* and *Microtus lusitanicus*, were by far more important than insectivores. Arthropods, lagomorphs and fruits represented a good supplementary food resource by this order of importance in terms of frequency. However, when we consider the percentage of biomass consumed, only Lagomorphs accounted for a substantial portion (25%) of the overall diet. Birds and Carrion were also explored but with less importance. Reptiles were minor dietary components (Table 2).

Small mammals were the main food item of the wild cat diet, occurring in 78,6% of the total scat samples and representing 56,5% of the consumed biomass. Predation on rodents was heavy (67,9% appearances in scats and 48,6% as consumed biomass). Predation on *Microtus lusitanicus* was particularly important. This rodent appeared

in almost half of the total scat sample and represented a quarter of the overall diet as biomass. Insectivores appeared in 21,4% of scats but in terms of biomass they were much less important (7,9% of consumed biomass). Lagomorphs and arthropods were frequently found (21,4% and 25%, respectively) but only the first category had a significant meaning in terms of biomass consumed (26,4%). Predation on the other prey groups was of minor importance (Table 2).

TABLE 2

Frequency of occurrence (F.O.) and percentage of biomass (P.B.) of each prey species consumed by red fox, wild cat and common genet

Frecuencia de aparición (F.O.) y porcentaje de biomasa (P.B.) consumida de cada especie de presa por el zorro, el gato montés y la gínetta

Food categories	<i>Vulpes vulpes</i> n=102		<i>Felis silvestris</i> n=56		<i>Genetta genetta</i> n=74	
	F.O.	P.B.	F.O.	P.B.	F.O.	P.B.
Small mammals	65,7	40,0	78,6	56,5	92,0	78,0
Rodentia	56,9	31,4	67,9	48,6	79,7	54,4
<i>Apodemus sylvaticus</i>	20,6	11,2	28,6	12,2	60,8	34,0
<i>Microtus lusitanicus</i>	23,5	13,2	48,2	25,0	21,7	12,0
<i>Microtus agrestis</i>	14,7	7,0	19,6	11,4	13,5	7,0
<i>Arvicola sapidus</i>	-	-	-	-	1,4	1,0
<i>Eliomys quercinus</i>	-	-	-	-	1,4	0,4
Insectivora	10,8	6,9	21,4	7,9	46,0	23,6
<i>Crociodura russula</i>	2,0	1,0	8,9	2,8	5,4	1,1
<i>Talpa occidentalis</i>	8,8	5,9	8,9	2,9	2,7	1,2
<i>Sorex granarius</i>	-	-	5,4	1,0	13,5	7,0
<i>Sorex minutus</i>	-	-	1,8	0,4	12,2	6,7
<i>Neomys anomalus</i>	-	-	-	-	13,5	6,1
<i>Insectivora not.id.</i>	-	-	1,8	0,8	2,7	1,5
Lagomorphs	19,6	25,0	21,4	26,4	2,7	2,1
Birds	10,8	10,0	3,6	3,8	12,2	5,6
Reptiles	7,8	2,5	14,3	4,3	16,2	5,8
Fruits	17,7	7,0	5,4	0,4	10,8	6,4
Arthropods	27,5	4,5	25,0	1,3	4,1	2,1
Carrion	2,9	11,0	5,4	7,3	-	0
B		4,84		3,12		2,70
Bsta		0,55		0,30		0,24

In the genet diet, small mammals stood out as the dominant component appearing in 92% of the analysed scats and representing 78% of the total biomass consumed. Among small mammals, rodents were by far the most consumed group, appearing in nearly 80% of scats and representing more than a half of the overall diet as biomass. A strong preference for *Apodemus sylvaticus* was verified appearing in 60,8% of the scat samples and representing 34% of ingested biomass. Insectivores were an important secondary food resource (46% of occurrences in scats and 23,6% as biomass). The other classes of prey were minor components of diet (Table 2).

Diet diversity and trophic niche overlap

Taking in account the major food categories considered, the diet diversity of the three predators was relatively low (Table 2) due to an intensive exploitation of mammalian prey. Nevertheless red fox diet was more diversified ($B_{sta} = 0,55$) than wild cat ($B_{sta} = 0,30$) and genet ($B_{sta} = 0,24$) due to a higher consumption of secondary prey groups.

Niche overlap among these predators was extensive due to the preponderance of mammalian prey in their diets. This is particularly evident in the case of red fox and wild cat as a result of the exploration of the same prey groups (Rodents and Lagomorphs). When rodents and insectivores were considered to the specific level, niche overlap between genet and the other two carnivores diminished considerably reflecting different prey choices at this level (Table 3).

TABLE 3

Food niche overlap (O) expressed as Pianka' s index between red fox, wild cat and common genet; (a) - calculated based on frequencies of the major prey groups. (b) - calculated when the class of mammals was considered to the specific level

Solapamiento de las dietas entre zorro, gato montés y gineta através del índice de Pianka (a) – los calculos fueron efectuados basandose en las frecuencias de los grupos principales de presas. (b) calculos efectuados cuando lo grupo de los mamíferos es considerado a nivel específico

	Overlap	
	O (a)	O (b)
Red fox/Wild cat	0,96	0,91
Wild cat/Genet	0,86	0,56
Genet/Red fox	0,78	0,54

DISCUSSION

The results here presented agree in general with the ones reported by other authors for each predator. In the case of the red fox, many studies refer this carnivore as a generalist and opportunistic predator (Goszczynski 1974, Amores 1975, Goszczynski 1986, Macdonald 1987). In this work a predominance of rodents in its diet was verified. However this is related probably with their high availability in the environment. Lagomorphs were an important secondary prey group, accounting for a quarter of the total consumed biomass. The consumption of fruits and insects in substantial portions (as occurrences) confirms the tendency to a generalist feeding behaviour.

The observations reported in this paper support other studies describing rodents and lagomorphs as predominant food resources for wild cat (Stahl 1986, Kozena 1990, Gil-Sánchez 1998). Of particular interest is the study carried out by Sarmiento (1996) in the Serra da Malcata Nature Reserve, East of Portugal, that described the same pattern of exploitation of rodents as primary prey and lagomorphs as secondary. In the south of Spain the diet of wild cat is also similar to that found in this study (Gil-Sánchez, 1998 and Gil-Sánchez et al. 1999). However, in these two studies rabbits were the primary prey and rodents were the secondary prey. This variation may be explained by the higher lagomorph abundance in that region (Blanco and Villafuerte 1993).

Virgós et al. (1999) reviewed the literature on the genet diet in order to study the trophic pattern in different regions of this species range, however, this review didn't include data on Portuguese populations. These authors showed two general patterns of diet: (i) locations where small mammals are the most important prey; (ii) locations where arthropods and other groups are more important than small mammals in occurrences. The trophic pattern reported in this work was based on the consumption of small mammals, especially *Apodemus sylvaticus*, closely similar to the first pattern described by Virgós et al. (1999). Other authors (Delibes 1974, Palomares and Delibes 1991, Gomes 1998) also verified the predominance of *Apodemus sylvaticus* in the genet's diet. Gomes (1998) studied the diet, and space use by this carnivore in Northwestern Portugal and explained this pattern as the consequence of the commonness of this rodent in the same vegetal formation where genets usually move. In fact, the sympatry between these two species is suggested by the distribution of genet's latrines and data on small mammal captures. Insectivores were also important secondary food resources, which demonstrates the capacity of genets to exploit another food resources when they are available. This is in agreement with the hypothesis on the generalist/opportunistic character of this species (Delibes 1974, Virgós et al. 1999).

The pattern of resource partitioning between species is based on an intensive use of mammals, especially rodents. This intense use of rodents as food resource reflects a high degree of niche overlap. The dependence of the small and median-sized carnivores of rodent populations is well documented (Jedrezejewski et al. 1989, Lodé 1991, Jedrezejewska and Jedrezejewski, 1998 and Lanskzi et al. 1999). Although relative prey abundance was not quantified for this study, our data on captures of small mammals and counts of surface signs indicate that rodents are available to predators in high quantities in our study area (Carvalho and Gomes unpub. data).

The predators studied in this work showed two basic different feeding strategies: (i) high consumption of rodents and lagomorphs by red fox and wild cat; (ii) high consumption of rodents (with a great predominance of *Apodemus sylvaticus*) and insectivores by genet. To explain this pattern of resource exploitation we suggest two hypothesis.

A different use of space by each predator could be a reasonable explanation for the different feeding patterns. While genet makes use of wooded areas and surrounding fields in the border of wooded patches (Gomes 1998), red fox and wild cat can explore larger areas including woods and openfield areas (Macedo pers. com.). In fact, genet preys heavily on *Apodemus sylvaticus*, that can be found in higher densities in closed areas (woods and abandoned fields), while red fox and wild cat take more advantage from species that live in more open areas, *Microtus lusitanicus* and lagomorphs (Gomes 1998).

Another explanation is the different body size between genet and the other two carnivores. In fact, red fox and wild cat are much heavier than genet. This has important consequences in the ability to catch heavier preys like lagomorphs and satisfy their higher energetic needs. Jedrezejewska and Jedrezejewski (1998) found a positive relationship between body masses of the temperate forest's predators and the mean weights of their prey.

Niche overlap between red fox and wild cat was very extensive. However, we can note some slight differences that could be more pronounced if the total scat sample were greater. Red fox diet diversity was higher due to a greater consumption of secondary food items, especially birds and fruits, and the predominance of rodents in the felid's diet.

These results are only preliminary and the small sample size didn't allow an analysis of seasonal variation of diet. Nevertheless, it is reasonable to expect that the seasonal dynamics of niches occurs in result of seasonal changes in prey abundance making more evident the differences between these carnivores.

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