

# Trophic niche overlap of three carnivores in a mountain area north of Varese (Lombardy – Italy)

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## Abstract

The diet and trophic niche overlap of three species of carnivores, the Eurasian Badger *Meles meles*, the Red Fox *Vulpes vulpes* and the Pine Marten *Martes martes*, were analysed in an area of the Italian Prealps (Alto Luinese, Varese, Lombardy).

The composition differed, but the three diets were characterized by a relevant frequency of occurrence of fruits, which was the main cause of the high overlap among the three trophic niches. However, the higher values of the Horn's and Pianka indices were reached between badgers and foxes, and between foxes and martens. The volume in total diet of fruits and vegetables progressively decreased changing from badger to fox and then to marten, and the same occurred for the volume in total diet of invertebrates (insects and earthworms). The fraction of vertebrate preys, on the other hand, progressively increased from the lower value in badger diet to the higher in marten one, passing through the intermediate value in fox diet.

Key-words: *Meles meles*, *Vulpes vulpes*, *Martes martes*, diet, trophic niche overlap, Italy

## Introduction

Numerous data concerning the diet of three species of carnivores living in the Alto Luinese area (the northernmost area of the town of Luino, in the Province of Varese, Lombardy, Italy)- the Red Fox (*Vulpes vulpes*), the Eurasian Badger (*Meles meles*) and the Pine Marten (*Martes martes*)- have been collected over more than ten years of research (Biancardi *et al.*, 1995; Biancardi & Rinetti, 2002; Campanozzi, 2001). Red Foxes are the most widely present carnivores in Lombardy (Vigorita *et al.*, 2001), where they live both on the plains and on hills and mountains up to 3,000 m a.s.l. Eurasian Badgers are also extensively present in our region as well as in the research area (Biancardi & Rinetti, 1998; Vigorita *et al.*, 2001). On the other hand, Pine Martens, which have been located in the northern part of the Lombard territory, are in general not frequently reported below 1,000 m of altitude (Vigorita *et al.*, 2001). However, in the "Alto Luinese" area they are present also at a lower altitude (Biancardi & Rinetti, 2002). This work, which is the result of long years of research, compares the diet and the trophic niche of these three carnivores in order to define the relationship between the use of the trophic resources available throughout the year and the use of the habitat and, as a result, the distribution of these three species in the study area.

## Material and Methods

The territory of the "Comunità Montana Valli del Luinese"- a consortium of municipalities of the Luinese vales- extends over 180 km<sup>2</sup> between the east coast of Lake Maggiore and the Swiss border. Luino is the main town in this area (46°00'N, 08°77'E) of the province of Varese. The altitude ranges between 200 and 1,600 m a.s.l. (Mt. Lema being the highest peak) with a sub-coast temperate climate (Mennella, 1967) and average temperatures between +2.8°C in January and +20.9°C in July. Rainfall is copious,

above all in spring and late summer, averaging 1,469 mm per year (Spinedi, 1992).

Large broad-leaved woods are common in this study area where Sweet Chestnuts (*Castanea sativa*) have replaced the climax (*Quercus-betuletum insubricum*) association also as a result of human intervention. Pubescent Oaks (*Quercus pubescens*) are also present on drier slopes while Beeches (*Fagus sylvatica*) prevail on colder slopes and more humid vales. The only conifers are present due to limited reforestation actions dating back to the 1960s and 1970s, while the higher vegetation areas consist of meadows and pastures on which sheep breeding has now been abandoned.

The diet of the three species under observation has been established by the analysis of samples of faeces (Biancardi *et al.*, 1995; Biancardi & Rinetti, 2002; Campanozzi, 2001). Quantitative (volumetric fractions) and qualitative (frequency) data have been obtained on the various components of the diet. Volumetric estimates have been obtained through the method proposed by Kruuk & Parish (1981). The affinity of the different diets has been tested with Spearman's rank correlation coefficient, by grouping the components in nine great food categories used in the reference works (Biancardi *et al.*, 1995; Biancardi & Rinetti, 2002; Campanozzi, 2001). On the other hand, the indices of the trophic niche overlap of Horn and Pianka have been calculated according to Krebs's (1989) indications, with a higher level of details and taking into consideration the differences between the components of the diet inside the food categories.

## Results and discussion

Table 1 shows the frequencies and the volumetric percentages of the various food categories. The analysis of these figures clearly shows the importance of fruits in all the three species considered. For Eurasian Badgers and Red Foxes fruits were the most important category, both as frequency of occurrence and volume, while for Pine Martens fruits followed the most important category of mammals. The Eurasian Badger diet was distinguished by only limited predation on Vertebrata and, vice versa, by a large component of Arthropoda together with fruits. In the Red Fox diet, on the other hand, mammals came second in abundance. The differences between frequencies and volumetric percentages were statistically significant except for one category, the vegetable one, which included (excluding fruits and cereals) grassy material, roots, seeds, etc. Also the predation on reptiles between Red Foxes and Pine Martens and the one on birds between Red Foxes and Eurasian Badgers did not show statistically significant differences.

The highest and most meaningful values of the Spearman's rank correlation coefficient were obtained by comparing the diets of Eurasian Badgers and Red Foxes, and those of Red Foxes and Pine Martens, while there was no correlation between the diets of Eurasian Badgers and Pine Martens (Table 2).

Differences appeared in a detailed analysis of the components of the diet, such as the presence of medium-large size

Table 1. Frequency of Occurrence (FO) and estimated Volume (V) of the food categories in the diet of Eurasian Badger, Red Fox and Pine Marten

	Eurasian Badger		Red Fox		Pine Marten	
	FO%	V%	FO%	V%	FO%	V%
<b>Fruits</b>	95.0	64.2	72.2	51.9	58.8	21.0
<b>Cereals</b>	4.6	3.0	-	-	-	-
<b>Other Vegetables</b>	56.4	5.1	48.1	11.5	41.2	2.2
<b>Arthropods</b>	82.6	22.4	27.8	8.5	39.2	3.7
<b>Earthworms</b>	24.3	-	13.9	0.7	-	-
<b>Mammalians</b>	5.1	1.4	42.7	24.4	91.9	53.8
<b>Birds</b>	10.6	3.7	9.1	2.1	49.3	14.2
<b>Reptiles</b>	-	-	5.0	0.7	5.4	0.9
<b>Other food</b>	2.3	0.1	2.0	0.5	8.8	3.2

mammals (ungulates) only in Red Fox diet or the absence of earthworms in Pine Marten diet. However, there were also interesting analogies. For a correct interpretation of the data collected, we need to point out that, together with a seasonal presence of cherries, figs, grapes and currants, chestnuts were always present from the “Fruits” category, as a resource in the diet of these three species of carnivores. This reflects the availability of this fruit nearly all year round, since it can be preserved in the litter. It is worth remembering that although chestnuts contain a great quantity of glucides in the form of starch, they have a high content in proteins and lipids, which confer a high energetic contribution. In the Eurasian Badger diet, chestnuts, which were present throughout the year except in August, was the main trophic resource with an annual frequency of occurrence FO = 76.2% (Biancardi *et al.*, 1995). Chestnuts appeared in the Red Fox diet especially in the winter and spring months (annual FO = 20.5%, spring FO = 38.4%) (Campanozzi, 2001). Finally, chestnuts were frequently eaten by Pine Martens in the cold months (annual FO = 11.5%, winter FO = 33.3%) (Biancardi & Rinetti, 2002). Therefore, chestnuts represent a reliable and good quality trophic resource for Eurasian Badgers, Red Foxes and Pine Martens in the “Alto Luinese” area, thanks to their unbroken availability throughout the year.

The niche overlap indices, which took into consideration also the differences inside the nine food categories, showed a relevant overlap between the Eurasian Badger and the Red Fox and between the Red Fox and the Pine Marten trophic niches, while

there is little overlap between the Eurasian Badger and the Pine Marten (Table 3). Actually, this result points to a sort of “gradient” between a diet based on vegetables and Invertebrata, with a small rate of Vertebrata (Eurasian Badgers), and one in which the rates of vegetables and Invertebrata are reduced and the Vertebrata rate increases (Red Foxes) up to a diet with little contribution of vegetables and Invertebrata and a larger rate of Vertebrata (Pine Martens), as shown in Fig.1.

This mid-position of the Red Fox seems not to be universal: in some regions, for example, Red Foxes fed almost exclusively on small mammals, Lagomorpha and birds. In these cases Red Foxes can appear less generalist than *Martes* sp. (Goszczyński, 1986). Compared with the variability of the range of the trophic niche of Red Foxes (Cantini, 1991), Pine Martens generally present a more fixed and typically carnivore-oriented food spectrum (De Marinis & Masseti, 1995; Marchesi & Mermod 1989).

Also the Eurasian Badger diet can become more “specialized” in some areas: in these cases the staple food consists of earthworms or, in some cases, of cereals (Kruuk, 1989). Some situations can therefore occur in which Eurasian Badgers and Red Foxes present very little overlap of trophic niches as they are concentrated on different trophic resources (Canova & Rosa, 1993; Kauhala *et al.*, 1998) or, vice versa, there can be situations of high trophic niche overlap in which, as in this research work, both species show a more generalist propension (Ciampalini & Lovari, 1985).

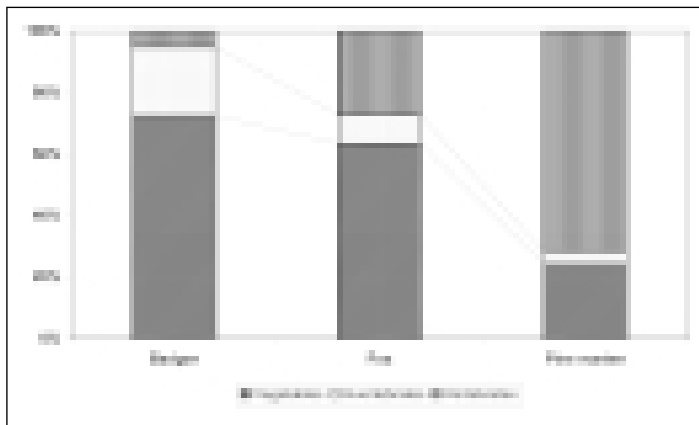
Table 2. Spearman rank correlation coefficient ( $r_s$ ) for the relationship between the Frequencies of Occurrence (FO) and the estimated Volumes (V) of the diet of Eurasian Badger, Red Fox and Pine marten. ( $p$  = significance level; \* = significant values)

	FO		V	
	$r_s$	p	$r_s$	p
<b>Eurasian Badger vs. Pine marten</b>	0.41	0.273	0.51	0.198
<b>Eurasian Badger vs. Red Fox</b>	0.80	0.010 *	0.61	0.079
<b>Red Fox vs. Pine marten</b>	0.70	0.052	0.76	0.028 *

Table 3. Trophic Niche Overlap: Horn’s Index and Pianka Index

	Horn’s	Pianka
<b>Eurasian Badger vs. Pine marten</b>	0.53	0.32
<b>Eurasian Badger vs. Red Fox</b>	0.80	0.76
<b>Red Fox vs. Pine marten</b>	0.79	0.67

Fig. 1. Volume percentage of vegetables, invertebrates and vertebrates in total diet of Eurasian Badger, Red Fox and Pine Marten.



Having considered all this, we can conclude that, in our study area, Eurasian Badgers, Red Foxes and Pine Martens share a lot of food resources, which they however use in different ways. The original aspect of this trophic behaviour is represented by the extensive exploitation of the “Fruits” category, which is not generally associated in literature with an Alpine and Pre-alpine environment. This choice is certainly to be related to the peculiar environmental and anthropic conditions of the “Insubrica Region”. In fact, the mild climate due to the presence of Lake Maggiore, which mitigates its degree of continentality and favours mild winters and fresh summers, enables the growth of fruit trees. Moreover, the desertion of the typically traditional agricultural activities of a mountain region and the ongoing depopulation have created an opportunity for the exploitation of this resource, which is easily available both in chestnut woods and in formerly tilled land as well as in small tilled patches of land near hamlets.

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