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SEASONAL CHANGES OF TROPHIC NICHE OVERLAP IN THE STONE MARTEN (*MARTES FOINA*) AND THE RED FOX (*VULPES VULPES*) IN A MOUNTAINOUS AREA OF THE NORTHERN APENNINES (N-ITALY)

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ABSTRACT – Between 1989 and 1991, 284 scats of stone marten (*Martes foina*) and 642 scats of red fox (*Vulpes vulpes*) were collected in a 280 km² mountainous area in the northern Apennines. The scats were analyzed to identify differences between the two species' diets. The prey were grouped in 6 food categories: Fruits, Other Vegetables, Small Mammals, Other Vertebrates, Invertebrates and Garbage. Annual trophic niche was wider in the Red fox (0.62) than in the stone marten (0.53). We also found a large overlap between the two species with some small differences: Other Vertebrates, Small Mammals and Other Vegetables were more used by the Red fox, while Fruits were more used by the stone marten.

Key words: Stone marten, Red fox, Diet overlap, N-Italy.

RIASSUNTO – *Variazioni stagionali della sovrapposizione di nicchia trofica della faina* (Martes foina) *e della volpe* (Vulpes vulpes) *in un'area montana degli Appennini settentrionali* – Tra il 1989 e il 1991 sono state raccolte 284 feci di faina (*Martes foina*) e 642 feci di volpe (*Vulpes vulpes*) in un'area montuosa di 280 km² situata nell'Appennino settentrionale. Le feci sono state analizzate per evidenziare le eventuali differenze nella dieta delle due specie. Le singole prede sono state raggruppate in 6 categorie alimentari: Frutta, Altri Vegetali, Micromammiferi, Altri Vertebrati, Invertebrati, Rifiuti. L'ampiezza annuale della dieta è risultata maggiore nella Volpe (0,62) che non nella Faina (0,53). E' stata trovata inoltre una larga sovrapposizione tra le due specie con alcune differenze nell'uso degli Altri Vertebrati, dei Micromamrniferi e degli Altri Vegetali che è maggiore nella Volpe e della Frutta, maggiore nella Faina.

Parole chiave: Faina, Volpe, Sovrapposizione della dieta, Italia settentrionale

INTRODUCTION

The red fox (*Vulpes vulpes*) and the stone marten (*Martes foina*) are opportunistic predators that in the Mediterranean area feed on the same food sources, in particular small mammals, Rosaceae fruits and insects (Delibes, 1978; Pozio & Gradoni, 1981; Prigioni et al., 1988; Calisti et al., 1990; Rosa et al., 1991; Lucherini & Crema, 1993; Serafini & Lovari, 1993). In our study area these sources are widely available but subject to seasonality, because of the annual climatic cycle. This could affect their use by two sympatric species like those in question. Moreover the presence of other carnivores, in particular the wolf (*Canis lupus*), could also affect the use of these sources. Particularly in winter, when there is a general scarcity of food sources this species may compete with the red fox and the stone marten (Meriggi et al., 1991) making these sources less available. The wolf also abandons some large prey not completely consumed and these remains can then be available to the smaller carnivores.

The aim of this study is to investigate if, in these particular conditions, the trophic niches of two species differ or overlap completely.

STUDY AREA

The study area (280 km²) was located in a mountainous zone of the Northern Apennines between 800 and 1700 m a.s.l. (in Pavia, Piacenza, Genoa and Alessandria provinces). The climate was submediterranean; the annual mean temperature was 8°C and the total annual precipitation 1700 mm. Mixed woods were 23.9% of the whole study area, beech woods 32%, conifer reafforestations 2.8%, pasture 26%, shrubs 8.3% and crops 7%. Grazing was free and calves were born on pastures. Wild boars (*Sus scrofa*) were abundant while roe deer (*Capreolus capreolus*) and fallow deer (*Dama dama*) were occasionally present.

METHODS

Scats were collected from December 1989 to December 1992 on transects representative of the habitats of the study area (n=30; 181 kmj. They were preserved in PVC bags at -20°C and then washed in water over 3 sieves with decreasing meshes (0.5 to 0.1 mmj. The prey were identified from undigested remains using personal collections and atlases (Brunner & Coman, 1974; Debrot et al., 1982).

The proportion of prey as eaten was assessed for each scat (Kruuk & Parish, 1981) and each prey was assigned to one of the following percentage volumetric classes: <1%; 1-5%; 6-25%; 26-50%; 51-75%; 76-95%; >95%. All prey were assigned to one of **6** food categories: Fruits, Other Vegetables, Small Mammals, Other Vertebrates, Invertebrates, Garbage. The "Other Vertebrates" category was further divided into three subcategories: Birds and Reptiles, Medium size mammals and Large mammals. The latter, almost exclusively wild boar, represented 27.2 % of the Other Vertebrates; both red fox and stone marten probably ate them as carrion and did not directly attack these prey.

The mean percentage volume and the frequency of occurrence of each category were calculated. The seasonal variations in the use of food categories (winter = December-February; spring = March-May; summer = June-August; autumn = Scptcmbcr-November) and between the two species were analyzed by Kruskall-Wallis and Mann-Whitney U tests for mean percentage volumes. We also calculated the C index of trophic niche overlap on proportion of occurrcncc (Horn, 1966; Goszczynski 1986) and the B index of trophic niche breadth on mean percentage volumes (Feisinger et al., 1981).

RESULTS

Stone marten and red fox diet showed seasonal variations in the use of some food categories (Tab. 1 and 2). Significant differences were found in stone martens for Other Vegetables and Other Vertebrates, in Red fox for Fruits, Small Mammals and Invertebrates. Fruits was the most important food source for both species in all seasons.

Tab. 1 – Stone marten. Comparison of mean percentage volumes of food categories in different seasons (Kruskall Wallis test, P = significance level, N.S. = not significance).

FOOD CATEGORIES	WINTER N = 55	SPRING N = 80	SUMMER N = 63	AUTUMN N = 84	P
Fruits	69.1	38.7	36.3	56.7	0.00
Other vegetables	0.1	8.8	3.3	0.8	0.0009
Small mammals	22.3	26.2	21.2	8.3	N.S.
Other vertebrates	0.3	11.3	15.4	11.5	0.0436
Invertebrates	1.6	18.4	16.1	16.2	0.00
Garbage	3.6	0.2	0.1	1.1	N.S.

Tab. 2 – Red fox. Comparison of mean percentage volumes of food categories in different seasons (Kruskall Wallis test, P = significance level, N.S. = not significance).

FOOD CATEGORIES	WINTER N = 190	SPRING N = 194	SUMMER N = 104	AUTUMN N = 146	P
Fruits	63.2	32.1	31.8	45.1	0.00
Other vegetables	3.3	3.1	4.2	4.4	N.S.
Small mammals	10.0	30.6	14.3	15.8	0.00
Other vertebrates	15.0	16.0	17.2	16.9	N.S.
Invertebrates	3.3	12.1	25.2	11.3	0.00
Garbage	2.2	1.4	0.02	1.0	N.S.

When the annual diet of the two species is compared (Tab. 3) only the Other Vertebrates differ in use. The comparison of data for each season showed significant differences in winter for Other Vegetables (P=0.01) and Other Vertebrates (P=0.002), and in autumn for Other Vegetables (P=0.003), Small Mammals (P=0.028) and Other Vertebrates (P=0.046).

C index values showed that the trophic niche overlap between the two species was almost complete without seasonal variations (Tab. 4). B index values were very similar for the two species with the highest recorded in summer and the lowest in winter (Tab. 4).

Tab. 3 – Comparison of mean percentage volume of food items in the two species (Seasons pooled, Mann-Whitney U test, P = significance level, N.S. = not significance).

FOOD CATEGORIES	STONE MARTEN N = 284	RED FOX N = 642	P
Fruits	49.7	44.3	N.S.
Other vegetables	3.5	3.6	N.S.
Small mammals	19.0	18.5	N.S.
Other vertebrates	10.1	16.2	0.001
Invertebrates	13.9	11.3	N.S.
Garbage	1.1	1.3	N.S.

Tab. 4 – Index values of trophic niche breadth and C index values of trophic niche overlap in the two species and in the different seasons.

	STONE MARTEN B	RED FOX B	C
Whole year	0.53	0.62	0.99
Winter	0.31	0.38	0.97
Spring	0.61	0.70	0.97

A comparison between the mean percentage volumes of the two species was effected for the subcategories of "Other Vertebrates". The red fox ate significantly more Large mammals than the stone marten in all seasons except winter (Tab. 5).

Tub. 5 – Mean percentage volumes of vertebrates in the two species in different seasons and significance of differences (Mann-Whitney U test, N.S. = not significance, M = *Martes foina*, F = *Vulpes vulpes*).

FOOD CATEGORIES	WINTER		SPRING		SUMMER		AUTUMN		WHOLE YEAR	
	M	F	M	F	M	F	M	F	M	F
Medium size mammals	0.3	8.4	7.7	10.9	10.6	8.8	**10.1**	8.4	7.6	9.2
	N.S.		**N.S.**		N.S.		N.S.		N.S.	
Large mammals	0.0	4.1	0.5	5.2	1.6	6.4	0.0	6.2	0.5	5.4
	N.S.		P = 0.017		P = 0.02		P = 0.002		P = 0.00	
Reptiles and birds	0.0	2.5	2.7	0.3	2.8	1.9	0.4	2.2	1.5	1.7
	N.S.		N.S.		**N.S.**		N.S.		N.S.	

Tab. 6 – Mean percentage volumes of fruits in the two spccics and significance of differences (Seasons pooled, Mann-Whitney U test, P = significance level).

FRUIT SPECIES	STONE MARTEN N = 284	RED FOX N = 642	P
Nuts	0.6	1.3	0.0232
Apples	9.9	9.2	0.0387
Grapes	0.0	0.6	0.0205
Raspberries	0.7	0.0	0.0091
Bilberries	1.0	0.0	0.0001

With regard to the use of fruit species, the red fox selected nuts and grapes and the stone marten apples, raspberries and bilberries (Tab. 6); apart from apples these fruits were marginal in the diet of these carnivores, while the most important fruit species (in order *Kosa* sp. fruits, cherries and pears) are not clearly selected and cannot therefore separate the species.

The average number of prey specimens per scat was 2.3 for red foxes (S.D. = 1.22; min-max = 1-7) and 1.7 for stone martens (S.D. = 0.87; min-max = 1-6): this difference was highly significant (t = 6.69; d.f. = 924; P = 0.0000). This result was confirmed by the Chi-square test on the percentages of scats with one prey specimen in the red fox (one prey 29.8%; more than one prey 70.2%) and the stone marten (one prey 47.5%; more than one prey 52.5%) which was highly significant ($\chi^2 = 26.53$; P = 0.00).

DISCUSSION

In our study area the diet of the red fox and the stone marten was principally based on fruits even if no particular fruit species seems to be clearly avoided or preferred by either of the carnivores. On the contrary, in central and northern Europe the most used food source was small and medium size mammals. These prey occurred more frequently in the diet of the two species while fruits were scarcer and less important (Englund, 1965; Macdonald, 1977; Kolb & Hewson, 1979; Chotolchu, 1980; Rasmussen & Madsen, 1985; Libois, 1991; Romanowski & Lesinski, 1991).

The stone marten used its food sources independently of their seasonal availability; the animal fraction of stone marten diet was mainly represented by small mammals, which being consumed independently of their seasonal availability were therefore looked for actively.

On the other hand, red fox diet followed resource seasonality, and in fact this carnivore ate most fruits, insects and small mammals when they are most available; this therefore indicated typical opportunistic behaviour. The animal fraction of its diet was represented by small and large mammals. These latter were probably consumed as carrion made available by the wolf or by man (there is much hunting pressure on the population of wild ungulates and in particular on wild boar) Jedrzejewski et al. (1989) suggest that the large predators like wolf and lynx *(Lynx lynx)* support the generalist predators in that they constantly supply the unconsumed remains of their kills. Extensive scavenging of carrion seems therefore to be an ancestral feeding habit of the red fox.

The greater number of scats with only one prey specimen in the stone marten was probably due to the lower value of niche breadth as compared to the red fox: the two species have different behaviour in looking for food sources and the red fox has greater energetic requirements due to its greater dimensions. So, in conditions of shortage of preferred food sources the red fox could shift towards other prey types more than stone marten, in order to make up the temporary food shortage.

As a consequence competition between the two species could take place in conditions of food shortage and this would favour the red fox, as has been demonstrated in other studies (Goszczynski, 1986; Thompson & Colgan, 1987; Jedrzejewski et al., 1989).

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