

Dietary Overlap among Seasons and Habitats of Red fox and Stone Marten in Central Greece

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Abstract

The dietary overlap of red fox (*Vulpes vulpes*) and stone marten (*Martes foina*) were studied in Central Greece in period 2003 - 2005. 219 red fox stomachs and 106 stone marten stomachs were laboratorially analyzed and the various prey items that participated in the diet of the two animals were determined. The prey species were classified depending on their origin in six diet groups (mammals, birds, plants, arthropods, reptiles – amphibians and others). The samples were collected from regions where hunting is practised and in regions where hunting is not practised and they were classified per season and habitat (shrubs, agriculture, oaks). Each carnivore had significant seasonal differences in its consumption of the six food categories (chi-square test, p -value=0,000). Niche overlap of red fox and marten was high for all seasons (>49,5%) and for all 3 habitats (>68,7%).

Keywords: Diet, overlap, red fox, stone marten.

Introduction

Dietary analysis is a frequent first step in studying an animal's ecology because diet directly reflects resource use and can provide insight into habitat utilization and competitive interactions (Litvaitis 2000). For carnivores, the availability and utilization of various food resources are important factors affecting population viability (Fuller and Sievert 2001). Additionally, competitive interactions among carnivore species are common and can have major impacts upon their ecology and management

(Palomares and Caro 1999, Creel et al. 2001). Such interactions usually favour the larger competitor and can result in decreased fitness for the subordinate competitor due to direct mortality, reduced access or exclusion from preferred resources, and reduced foraging and reproductive efficiency (Johnson et al. 1996, Palomares and Caro 1999, Creel et al. 2001). Therefore, understanding such interactions can be critical when conservation of the subordinate competitor is a management goal.

The primary objective of this work was to describe seasonal trends in the food habits of red fox (*Vulpes vulpes*) and stone marten (*Martes foina*) in central Greece. A secondary objective was to compare the red fox diet to that of the other generalist carnivore in the region, stone marten. An analysis of the seasonal food habits of these two sympatric species is an important step toward their effective management.

Red foxes are generally characterized as opportunistic predators and scavengers that eat a wide variety of foods depending on seasonal availability. Small and medium-sized mammals dominate the diet, with birds, insects, fruit, carrion, garbage and other foods important seasonally (Ables 1975, Lloyd 1980, Samuel and Nelson 1982, Lariviere and Pasitschniak-Arts 1996, Verts and Carraway 1998, Nowak 1999). The red fox diet has been extensively studied in a variety of countries and habitats (Ables 1975, Lockie, 1977 Lariviere and Pasitschniak-Arts 1996), and also in Greece (Papageorgiou et al. 1986, Papageorgiou et al. 1988, Vlachos et al. 2007). Previous studies showed that red fox eat predominantly rodents and lagomorphs, along with a wide variety of other vertebrate, invertebrate and plant foods as seasonally available.

Martin (1994) reviewed 22 dietary studies of marten. Mammalian preys were the primary dietary component for marten across their range. Birds, insects, and vegetation frequently occurred in scats but generally at low volumes. She concluded that marten were opportunistic generalists, taking foods as seasonally available in the environment. A recent study of marten found that they ate primarily sciurids, other rodents and birds, with insects and fruit consumed in summer and autumn (Zielinski and Duncan 2004). Although stone marten and red fox ranges largely coincide in Greece, their potential competitive interactions have not been examined.

Materials and Methods

Carnivore stomachs were collected from spring 2003 through winter 2005 while performing laboratorial analyses. 219 red fox stomachs and 106 stone marten stomachs were analyzed and the various prey items that participated in the diet of the two animals were determined. The prey species were classified depending on their origin in six diet groups (mammals, birds, plants, arthropods, reptiles – amphibians and others). The samples were collected from regions in Central Greece where hunting is practiced and in regions where hunting is not practiced and they were classified per season and habitat (shrubs, agriculture, oaks).

Two χ^2 tests were used to compare dietary trends among seasons and among carnivore species. Differences were considered significant if $p \leq 0,05$. Each carnivore's dietary niche breadth was quantified using the Pianka's (1973) niche overlap index:

$$L = \frac{\sum_{i=1}^S p_{iA} p_{iK}}{\sqrt{p_{iA}^2 p_{iK}^2}}$$

where p_{iA} and p_{iK} represent the proportion of food item i in the diets of species A (red fox) and K (stone marten) respectively.

Dietary overlap between the pair of carnivores was calculated via Renkonen's percentage overlap equation (Krebs 1989):

$$R = \sum_{i=1}^S \min(p_{iA}, p_{iK}) 100$$

where R represents the percentage overlap between species A and K , and p_{iA} and p_{iK} represent the proportion of food item i in the diet of species A and K , respectively.

Results

Seasonal Occurrence

Plants, arthropods and mammals dominated the diet of the two carnivores in all seasons. The carnivores took birds and reptiles – amphibians at a low level, accounting for less than 11% of the food items for any season. Manmade items were more common in the red fox diet than for the other carnivore. Each carnivore had significant seasonal differences in its consumption of the six food categories (red fox: $\chi^2 = 270,189$, $df=15$, $p = 0,000$; stone marten: $\chi^2 = 249,010$, $df=15$, $p\text{-value} = 0,000$) (Table 1).

Table 1: Frequency of occurrence (absolute and %) of diet groups used by red fox and stone marten, split to season.

Diet group	Spring		Summer		Autumn		Winter	
	Red fox	Stone marten	Red fox	Stone marten	Red fox	Stone marten	Red fox	Stone marten
Mammals	77 (17,11)	13 (10,92)	57 (27,94)	6 (2,80)	87 (22,48)	4 (3,03)	71 (24,07)	4 (1,79)
Aves	11 (2,44)	7 (5,88)	4 (1,96)	8 (3,74)	14 (3,62)	1 (0,76)	14 (4,75)	7 (3,13)
Plants	80 (17,78)	5 (4,20)	56 (27,45)	163 (76,17)	206 (53,23)	76 (57,58)	64 (21,69)	109 (48,66)
Arthropoda	234 (52,00)	59 (49,58)	62 (30,39)	33 (15,42)	55 (14,21)	41 (31,06)	113 (38,31)	99 (44,20)
Reptilia-Amphibia	12 (2,67)	6 (5,04)	5 (2,45)	4 (1,87)	2 (0,52)	3 (2,27)	5 (1,69)	0 (0,00)
Others	36 (8,00)	29 (24,37)	20 (9,80)	0 (0,00)	23 (5,94)	7 (5,30)	28 (9,49)	5 (2,23)
Number of stomachs	61	33	40	31	58	16	60	26

Niche Breadth and Overlap

Dietary niche breadth varied by season. Niche breadth for the two carnivores showed a general pattern of being widest in spring and narrowest in summer. Percent overlap among carnivore pair ranged from 49,50% to 77,82% depending on the season. Both the Pianka and Renkonen indices revealed that the overlap between red fox and stone marten was high. Overlap was >49,50% in all seasons, indicating that overlap was actually food categories used by the two species (Table 2). Niche overlap of red fox and marten was high (>0,8) for all 3 habitats and showed virtually no significant variation.

Table 2: Season and habitat overlap of red fox and stone marten.

Index	Season			
	Spring	Summer	Autumn	Winter
Pianka's index	0,923	0,672	0,916	0,837
Percentage overlap (Renkonen's index)	77,82%	49,51%	77,05%	67,14%
Index	Habitat			
	Shrubs	Agriculture	Oaks	
Pianka's index	0,840	0,832	0,948	
Percentage overlap (Renkonen's index)	68,86%	70,62%	82,33%	

Discussion

Diet Content

With a few notable exceptions, the dietary patterns of red fox and stone marten in central Greece were similar to those described in dozens of other studies of these species. Plants, arthropods and mammals dominated their diets in all seasons. The presence of reptiles – amphibians and birds usually represented a low percentage. Garbage and manmade items varied by season and species. Birds and reptiles – amphibians were seasonally common in the carnivores' diets but usually accounted for a small proportion. Consumption of birds and reptiles – amphibians by red fox is likely opportunistic and much of it may represent scavenging. The two carnivores ate manmade foods, although these rarely accounted for less than 10% of the food items, except during spring for stone marten (24,37%) (Table 1). However, human-associated foods often contain few indigestible items that would appear in the analyses, so their consumption may be underestimated in this study.

Niche Breadth and Overlap

Red fox and stone marten had relatively wide trophic niches, reflecting their consumption mammals, birds, plants, arthropods, reptiles – amphibians and manmade items, and consistent with their reputations as opportunistic generalists. Trophic niche varied consistently by season for the two species, being narrowest in summer and widest in spring. Findings of other studies showed that, in summer, the trophic niche overlap of these carnivores tends to be greater than in the other seasons (Serafini and Sandro 1993, Baltrūnaitė 2002). In those findings, the different climbing ability of these carnivores may partly have determined food selection: in summer, apples and pears can be found also on the ground where foxes can take them, but sorb-apples and wild plums are still on trees, where only martens may get access to them. Dietary overlap between two species was high, indicating that they used many of the same foods during the same season. Moreover, overlap across two species was > 49,5% in all seasons (Table 2). This overlap is again consistent with the scenario of two opportunistic generalists eating seasonally available foods.

Extensive dietary overlap is not in itself evidence of competition between two species. Niche overlap is not necessarily indicative of, or even correlated to, interspecific competition (Wiens 1977). Extensive overlap may indicate a high potential for competition or merely a superabundant resource. Likewise, low overlap may indicate a low potential for competition or complete competitive exclusion (Colwell and Futuyma 1971, Litvaitis and Anderson 1996). In a variable environment, truly limiting resource availability sufficient to spur competition may occur only infrequently, perhaps not for generations (Wiens 1977). If resources are extremely scarce, potential competitors may have to take what is available, resulting in increased niche overlap (Wiens 1993). Lastly, competition may also manifest itself along other resource axes such as habitat utilization or activity pattern as opposed to diet (Wiens 1993).

However, interspecific intolerance may exist between red fox and stone marten. Red fox may occasionally kill marten (Thompson 1994), and the risk of such predation may contribute to stone marten avoidance of open areas (Brainerd et al. 1994, Thompson and Harestad 1994). Despite the dietary overlap between these two carnivores, the seasonal abundance of most of their foods may reduce competition pressure. However, during the snowy months agonistic interactions between red fox and stone marten may be common.

The results are consistent with the characterization of red fox and stone marten as opportunistic predators and scavengers whose dietary patterns reflect the availability of food items (Ables 1975, Samuel and Nelson 1982, Storch et al. 1990, Martin 1994, Sidorovich et al. 2000, Padial et al. 2002). The absence of a usual critical food resource may require red foxes in particular to rely upon other sources for food.

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