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SEASONAL VARIATION IN THE FOOD HABITS OF BADGERS IN AN ALPINE VALLEY

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ABSTRACT – The seasonal variation in diet and trophic niche breadth of the European badger *(Meles meles)* have been studied in a high-elevation Alpine ecosystem from March 1990 to October 1991. The analysis of 76 faecal samples showed that Orthoptera, Coleoptera, insect larvae (mainly Coleoptera and Lepidoptera), earthworms and small mammals were the main food items. Both inter- and intra-year differences in food habits were detected. These differences seem primarily related to variations in food availability.

Key words: *Meles meles*, Food habits, Italian Alps.

RIASSUNTO – *Variazione stagionale dell'alimentazione del tasso in una valle alpina* – La variazione stagionale della dieta e dell'ampiezza di nicchia trofica del tasso *(Meles meles)* è stata studiata in un ecosistema alpino di alta quota tra marzo 1990 e ottobre 1991. L'analisi di 76 campioni fecali ha mostrato che ortotteri, coleotteri, larve di insetti (principalmente coleotteri e lepidotteri), lombrichi e micromammiferi sono state le categorie principali della dieta del tasso. Nell'alimentazione Sono state rilevate differenze sia stagionali che annuali. Queste differenze Sono apparse essenzialmente connesse a variazioni delle disponibilità trofiche.

Parole chiave: *Meles meles*, Alimentazione, Alpi.

INTRODUCTION

The food habits of the badger *Meles meles* have been studied in a variety of habitats (for reviews: Neal, 1986; Henry et al., 1988; Kruuk, 1989). On the basis of the findings on badger foraging behaviour in Scotland, this species has been described as an "earthworm specialist" (Kruuk & Parish, 1981; Kruuk & Parish, 1985). More recently, however, the data collected on badger diet in central-southern Europe (e.g. Kruuk & De Kock, 1981; Ciampalini & Lovari, 1985; Pigozzi, 1988; Lambert, 1990; Rodriguez & Delibes, 1992) suggested that the species may be better defined as opportunistic feeder (Shepherdson et al., 1990).

In Europe, the altitudinal limit of badger geographical range is reported to be around 1600-1700 m a.s.l. (Henry et al., 1988) and never above tree-line (Macdonald & Barrett 1993). Several studies were conducted on this carnivore in the Alpine region (e.g. Kruuk & De Kock, 1981; Lups et al., 1987; Rinetti, 1987), but only one of them (Rinetti, 1987) examined badger diet in the highest part of its altitudinal distribution. The results of this research showed that, during summer, in the Gran Paradiso National Park, Coleoptera composed the bulk of badger diet, followed by small mammals.

Montane ecosystems are strongly seasonal in terms of climate and food availability. If badger foraging behaviour is opportunistic, we may expect that, in the Alps, seasonal changes in the diet of this carnivore occur, reflecting variations in food availability.

The aim of this paper is to present a picture of the seasonal variation of the badger trophic niche in a typical Alpine ecosystem at the upper limit of its altitudinal range in Europe.

STUDY AREA

The study area is located in the Western Italian Alps, about 80 km west of Torino, and coincides with the lowest part of the Troncea valley, which is partially comprised in the Val Troncea Natural Park boundaries. Throughout the study period, the whole valley was frequently explored as a part of another research project (Lucherini & Crema, in press), but it resultes that the study area was the only part of the valley attended by badgers. Altitude ranges from 1560 m to 2500 m a.s.l. Vegetation and climate are typically Alpine. Precipitation peaked in spring (a total of 1250 mm) and autumn (1420 mm), while winter was characterised by 4-6 months of permanent snow cover and low temperatures (x = -2.5°C). For a more detailed picture of the climate see Lucherini & Crema (in press). Tree line lies at about 2000-2100m. Larch (*Larix decidua*) forests and pastures are prevalent. The-bottom of the valley is occupied by a small river and a dirty road. Two tiny villages (inhabited exclusively during summer) lie inside of the study area. Tourists visit the valley mainly from May to August and during Christmas holidays.

METHODS

Faecal samples were collected monthly from March 1990 to October 1991 at altitudes from 1560 to 2050 m a.s.l. On a total of 25 excursions on foot or ski 76 faeces were found. Scats were mainly collected in small (2-3 samples) latrines. They were analysed as described in Kruuk & Parish (1981) and Ciampalini & Lovari (1985). Results are expressed as seasonal percentage of occurrence (number of occurrence of each food, when present,/total number of occurrences x 100) (Cavallini & Lovari, 1991), percent frequency of occurrence (number of occurrence of each food/number of faeces x 100), and percentage of volume (estimated volume of each food/total estimated volume x 100) (Kruuk & Parish, 1981). In winter 1990, no scats were found. In this season, the harsh climate is likely to limit badger external activity (Fowler & Racey, 1988). Furthermore, frequent snow falls may prevent faecal collections by rapidly covering tracks and scats (Patalano & Lovari, 1993).

To compare the niche breadth among seasons, we calculated a standardized index of trophic niche breadth (B_{sta}) (Colwell & Futuyma, 1971). The index has the formula: $B_{sta} = B-1/B_{max}-1$, where B is the Levin's index of niche breadth (Levins, 1968) and B_{max} is the total number of food categories recognized (N = 17; Tabs. 1-2). B_{sta} values can range between 0 (minimum niche breadth) and 1 (maximum niche breadth).

Differences between seasonal diets were tested with a chi-square test on the occurrences. For these comparisons, we combined related food categories to insure that expected frequencies were not too small (Siegel & Castellan, 1989). The Mann-Whitney U-test (Siegel & Castellan, 1989) was used to test the seasonal differences in volumes of single food categories. In this comparison, sample sizes are the number of scats in each season.

RESULTS

In Troncea valley, invertebrates (mainly insects) were by far the most important category in all seasons (Fig. 1; see also Tabs. 1-2). This predominance was clearer in 1991, when invertebrates reached 93% of the total volume, than 1990. Vertebrates constituted about 20% in volume in summer 1990 and in spring 1991, whereas their values never reached 15% in the other seasons (Fig. 1). Plants (see below) represented a considerable part of the diet exclusively in autumn 1990.

Insect (adults and larvae) showed a large seasonal variation in badger diet (Tabs. 1-2). Orthoptera were present in all scats in autumn of both 1990 and 1991, but they were scarce in summer and absent in spring, when insect larvae (mainly Coleoptera and Lepidoptera) reached the highest values. Coleoptera were found in all seasons but their peak was in summer 1990, when they represented almost 50% of the volume of the

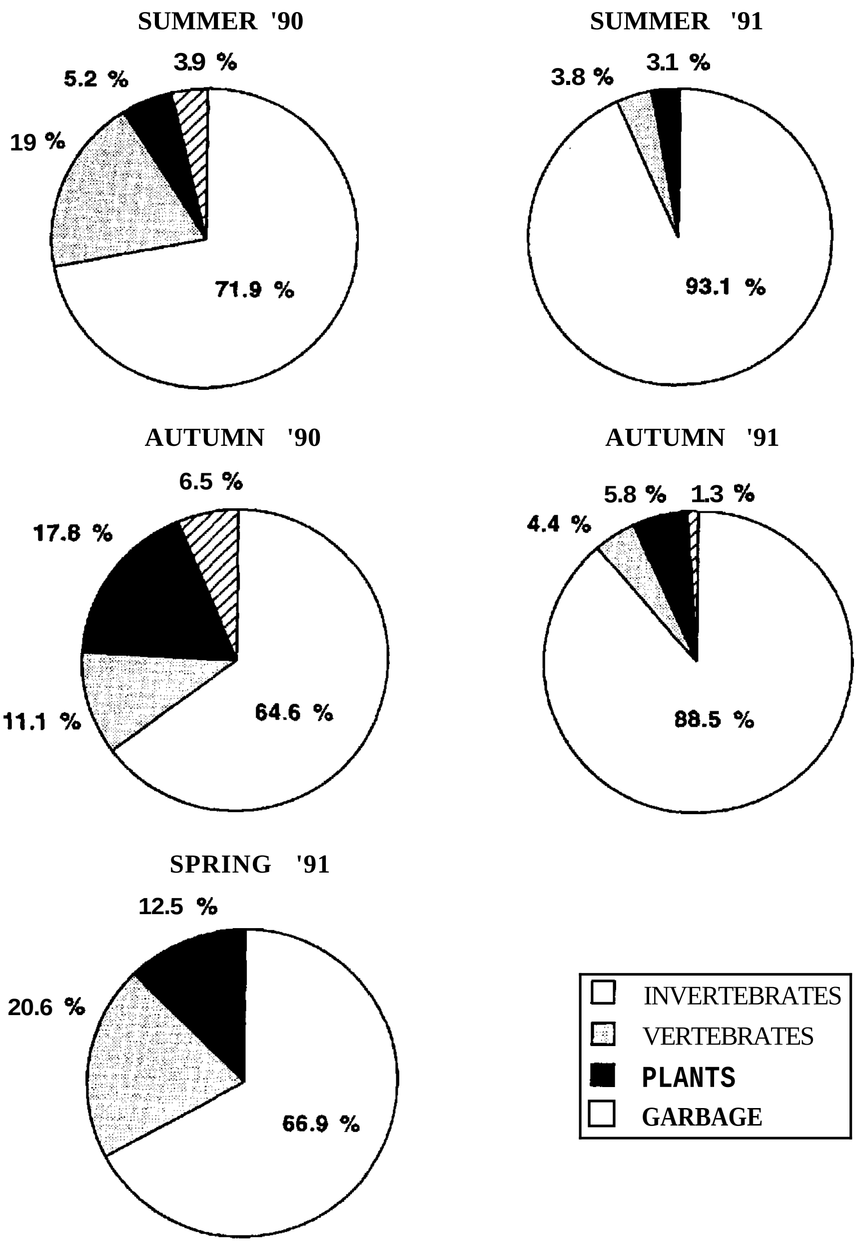

Fig. 1 – Seasonal variation (percent volume) of the main food categories in the badger diet in Troncea Valley.

diet. Earthworms had an important role in spring and summer 1991, but they were eaten, in variable amounts, in **all** seasons. Small mammals were the only other food item constantly present in the diet, but they accounted for more than 10% of total volume only in spring. Other food items (e.g. fruits, birds, garbage) were seldom consumed by badgers in the Troncea valley.

Tab. 1 – Seasonal diet composition of thc badger in 1990 (summer: n = 12; autumn: n = 24 faecal samples). B_{sta}: standardizcd trophic niche breadth index (see text). %O. = percentage of occurrence; %F.O. = pcrccnt frequency of occurrence; %V. = percentage of volume.

	Slimmer 1990			Autumn 1990		
	%O.	%F.O	%V.	%O.	%F.O.	%V.
Coleoptera	24.0	100.0	48.8	13.4	45.8	9.2
Orthoptera	12.0	*50.0*	8.1	29.3	100.0	37.6
Dermaptera				1.2	4.2	0.I
Coleoptera larvae	8.0	33.3	6.7	4.9	16.7	6.0
Lepidoptcra larvae	10.0	41.7	5.1	11.0	37.5	7.2
Earthworms	4.0	16.7	4.2	7.3	25.0	4.5
Other invertebrates	2.0	8.3	0.2			
Small mammals	6.0	25.0	9.1	3.7	12.5	5.4
Birds	6.0	25.0	9.1	4.9	16.7	5.7
Rubus sp. (Fruits)				1.2	4.2	1.5
Rosa sp. (Fruits)				1.2	4.2	0.6
Other fruits				1.2	4.2	0.6
Other plant matter	22.0	91.7	5.0	17.1	58.3	15.1
Garbage	6.0	25.0	3.7	4.9	16.7	6.5
B_{sta}	0.36		0.17	0.33		0.26

Tab. 2 – Seasonal diet composition of the badger in 1991 (spring: n = 14; summer: n = 14; autumn: n = 12 faecal samples). B_{sta}: standardizcd trophic niche breadth index (see text). %O. = percentage of occurrence; %F.O. = percent frequency of occurrence; %V. = percentage of volume.

	Spring 1991			Summer 1991			Autumn 1991		
	%O.	%F.O.	%V.	%O.	%F.O.	%V.	%O.	%F.O.	%V.
Coleoptera	14.C	50.0	7.0	15.6	50.0	9.3	2.9	8.3	0.2
Orthoptcra				13.3	42.9	29.2	34.2	100.0	69.8
Dermaptera	4.2	14.3	5.0				2.9	8.3	0.2
Coleoptera larvae	12.5	42.9	20.0	4.4	14.3	1.3			
Lepidoptera larvae	18.7	64.3	17.6	15.6	50.0	26.7			
Diptera larvae				2.2	7.1	0.2	20.0	58.3	1.5
Earthworms	22.8	78.6	17.3	22.2	71.4	22.4	8.6	25.0	9.7
Other invertebrates				6.8	21.4	4.0	2.9	8.3	7.1
Small Mammals	8.3	28.6	14.9	2.2	7.1	2.7	5.6	16.7	4.4
Ungulates	2.I	7.1	5.7						
Birds				2.2	7.1	1.1			
Amelarichier ovalis (Fruits)	4.2	14.3	3.6						
Rubus sp. (Fruits)									
Rosa sp. (Fruits)	6.3	21.4	8.4						
Other Fruits				2.2	7.1	0.2			
Other plant matter	6.3	21.4	7.5	13.3	42.9	2.9	20.0	58.3	5.8
Garbage							4.6	8.3	1.3
B_{sta}	0.38		0.36	0.38		0.22	0.23		0.05

A difference in diet composition was not detected between summer 1990 and summer 1991 and between the two autumns. Nevertheless, at least for some food categories, the inter-year variation is apparently strong (Tabb. 1-2). We tested this difference on volumes. Coleoptera were eaten in larger quantities in 1990 than 1991, both in summer ($m = 11$, $n = 14$, $Z = 3.6$, $P = 0.0004$) and autumn ($m = 24$, $n = 12$, $Z = 1.96$, $P = 0.05$). Conversely, Orthoptera seemed to be more important in 1990 than 1991, although the difference was significant only for autumn ($m = 24$, $n = 12$, $Z = 2.58$, $P = 0.001$).

No difference was found in the diet composition comparing summer and autumn 1990, and spring and summer 1991. The only significant seasonal difference was detected between summer and autumn 1991 ($\chi^2 = 9.6$, d.f. = 4, $P = 0.048$). In both years, however, the variation in consumption between summer and autumn was significant for Coleoptera (1990: $m = 11$, $n = 24$, $Z = 3.99$, $P = 0.0001$; 1991: $m = 14$, $n = 12$, $Z = 1.98$, $P = 0.048$) and Orthoptera (1990: $m = 11$, $n = 24$, $Z = 3.1$, $P = 0.002$; 1991: $m = 14$, $n = 12$, $Z = 2.78$, $P = 0.006$). No difference was found between spring and summer. The volume in the diet of the other categories tested (i.e. insect larvae, earthworms and small mammals) did not vary from season to season).

In the two seasons of 1990, the trophic niche size measured on occurrences appeared similar, whereas that measured on volumes resulted larger in autumn (Tab. 1). In the following year, the trophic niche showed a clearer pattern, narrowing progressively from spring to autumn (Tab. 2).

DISCUSSION

Our data show that the badger in the Alps doesn't behave as an "earthworm specialist" (sensu Kruuk & Parish, 1981; Kruuk & Parish, 1985), supporting the conclusion of Shepherdson et al. (1990), that earthworms consumption, like that of other food resources, is determined by its availability. Earthworms are scarcely available when temperature goes below zero and soil humidity is low (Kruuk & Parish, 1985; Lambert, 1990). Hence, in our high-elevation study area, climate likely makes earthworm availability not constant and large enough to allow badgers to rely mainly on this food item for their nutritional requirements.

In the Alps, badger diet apparently comprises most of the potential sources of food present in the study area. Invertebrates, however, were by far the most important food category. This result probably reflects both the relatively great availability of invertebrates in our study area (as suggested by the scarce presence in the diet of other potential food items, e.g. fruits) and the feeding behaviour of the badger, determined by its morphological adaptation, for this food item (Henry et al., 1988).

Our results are consistent with those reported by Rinetti (1987) for the Gran Paradiso National Park: in summer, insects were the staple of the diet as in the present study. The main difference lies in the importance of Orthoptera. In Troncea valley, Orthoptera were frequently present in the scats of both summers, whereas in those collected in the Gran Paradiso National Park they were completely absent. A similar discrepancy between the two same areas was found in fox diet (Lucherini &

Crema in press). Hence, it is very likely that the difference in Orthoptera consumption is mainly related to a spatial variation of food availability.

The apparent seasonal variation in diet composition showed by the results of the faecal analysis was confirmed only partially by the statistical elaboration of the data. This may be due to our small sample size and the ensuing grouping of categories necessary to correctly apply the chi-square test. Nevertheless, among the five main food categories, two (Orthoptera and Coleoptera) were eaten in different amounts in different seasons. In montane ecosystems seasonal changes in climate are usually very pronounced and larger than inter-years differences (Patalano & Lovari, 1993). Climate change determines variations in food availability (Cavallini & Lovari, 1991), which in turn are the main causes of temporal variation in the feeding habits of badgers (Kruuk & Parish, 1985; Lambert, 1990). Hence, it could be expected that, in our study area, the inter-seasonal difference in diet would be larger than that between years. For summer and autumn, this hypothesis seems to be confirmed. The main differences in the diet were found between summer and autumn of the same year. Our data failed to show a difference between spring and summer, but the wide discrepancy in the values of some important categories (e.g. Orthoptera and Coleoptera larvae) suggests caution in the interpretation of these results.

The maximum trophic niche breadth of the badger occurred in spring and was connected more to a relatively balanced consumption of the different food items than to the presence of numerous "secondary" categories in the diet. Also this spring increase is presumably in relation to availability variations.

Our study provides a first insight on badger food habits at the upper limit of its altitudinal range in Europe and strongly suggests that also in such extreme conditions, like in most of badger range (Shepherdson et al., 1990), the foraging behaviour of this mustelid is opportunistic. More data, however, are needed to evaluate the relationship between the seasonal variation in badger diet and food availability in the Alps.

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