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THE EUROPEAN BADGER (*MELES MELES*) DIET IN A MEDITERRANEAN AREA

ESTER DEL BOVE* AND ROBERTO ISOTTI°

* *Viale A. Ghisleri 9, 00176 Roma, Italy*
° *Via S. Maria della Speranza 11, 00139 Roma, Italy*

ABSTRACT - A study on food habits of the European badger (*Meles meles*) was carried out over a two year period (march 1996 - February 1998) in an area of ca 55 hectares in the Burano Lake Nature Reserve, central Italy. The badger's diet was determined by faecal analysis. The results, expressed as the frequency of occurrence, estimated volume (%) and percentage volume of each food item in the overall diet, showed that in this area the badger can be considered as a generalist, with fruit and insects as principal food items during the whole year, although some seasonal differences did occur.

Key words: badger, diet, Mediterranean, central Italy.

INTRODUCTION

The badger's *(Meles meles)* diet has been studied in several works carried out mainly in Great Britain (Kruuk and Parish, 1981, 1985; Mellgren and Roper, 1986; Neal and Cheesman, 1996). Some hypotheses have been formulated which suggest that food abundance, its dispersion in the environment, renewal capacity of the food resources, and the badger's food habits (Roper, 1994) are key factors in determining the kind of social and spatial organisation adopted by this Mustelidae in different habitats of its territory. In other words, food related factors seem to govern the "clan" like social organisation (Kruuk, 1978) of this species.

Further data are required to confirm these hypotheses, particularly regarding badgers food. These will add to the already existing data (Ciampalini and Lovari, 1985; Pigozzi, 1991, 1992). More specifically, data is needed concerning habitats where survival is particularly hard as in Mediterranean. The purpose of the present work is to throw light on these aspects.

METHODS

The study area, which cover about 55 ha of the Burano lake nature Reserve (Province of Grosseto) in southern Tuscany, about 130 km from Rome, is located along the Tyrrhenian coast and includes a brackish lake. The vegetation is mainly Mediterranean maquis, taxonomically defined as *Quercetea ilicis* which includes *Juniperus macrocarpaephoeniceae* and *Oleo-lentiscetum* (Pedrotti *et al.*, 1979), and is characterised by the alternation of dense maquis and fallow fields. The vegetation cover was estimated as follows: 25% *Juniperus* sp.; 30% *Quercus* sp.; 25% *Pistacia lentiscus* and *Rhamnus alaternus;* 10% *Pinus pinea;* 10% other species.

The climate in the study area is Mediterranean, characterised by rainy (745 mm mean/year) but warm autumns and winters, and hot and dry summers. The minimum mean temperature recorded during the study period at the Reserve's weather station was 9°C in February, with a maximum of 26°C in August.

During the research, 69 faeces samples were collected (March 1996 - February 1998), covering all the study area, and 7 dens were identified.

Faecal analysis was performed according to the procedure employed by Kruuk and Parish (1981), to which some changes were made mainly in the analysis and identification of

Table 1 - Diet of the European badger (n, faeces samples' number; ip, percentage of food items; vol, volume of food items in percentage; **AI=** (ip ar), where ar= mean volume occupied by a food item **in** the overall diet, in percentage).

Food items	spring (n= 16)			summer (n= 9)			autumn (n= 26)			winter (n= 18)			TOTAL (n= 69)			
	n	ip	vol	n	**ip**	vol	n	ip	vol	n	ip	vol	n	ip	vol	AI
VEGETABLE		56.69			27.35			37.60			50.73			42.98	41.06	
Juniperus oxycedrus	14	87.5		4	44.44		14	53.85		15	83.33		47	68.12		
Juniperus phoenicea	0	0		0	0		3	11.54		1	5.55		4	5.80		
Pistacia lentiscus	1	6.25		0	0		0	0		0	0		1	1.45		
Rhamnus alaternus	0	0		0	0		9	34.61		0	0		9	13.04		
Quercus suber	1	6.25		1	11.11		1	3.85		0	0		3	4.35		
Malus sylvatica	0	0		0	0		1	3.85		2	11.11		3	4.35		
Pinus pinea	0	0		4	44.44		0	0		0	0		4	5.80		
Rubus sp.	0	0		3	33.33		3	11.54		1	5.55		7	10.15		
Prunus sp.	0	0		1	11.11		3	11.54		0	0		4	5.80		
Vitis vinifera	0	0		0	0		2	7.69		0	0		2	2.90		
Poaceae sp.	0	0		1	11.11		2	7.69		0	0		3	4.35		
Avena sativa	0	0		0	0		2	7.69		0	0		2	2.90		
Setaria italica	0	0		0	0		0	0		1	5.55		1	1.45		
Plantago major	1	6.25		0	' 0		0	0		0	0		1	1.45		
Hyoscyamus niger albus	0	0		1	11.11		5	19.23		0	0		6	8.70		
grass	1	6.25		1	11.11		3	11.54		2	11.11		7	10.15		
vegetables unidentified	1	6.25		0	0		7	26.92		3	16.67		11	15.95		
ARTROPODA		32.10			47.67			43.92			14.36			34.51	36.00	
Coleoptera	3	18.75		0	0		4	15.40		2	11.11		9	13.04		
Scarabeoidea	1	6.25		0	0		0	0		0	0		1	1.45		
Entodon bidens punctatum	2	12.5		1	11.11		0	0		1	5.55		4	5.80		
Carabidae	2	12.5		6	66.67		10	38.46		1	5.55		19	27.54		
Scarites **sp.**	1	6.25		3	33.33		4	15.40		0	0		8	11.59		
Tenebrionidae	1	6.25		2	22.22		3	11.54		0	0		6	8.70		
Pimelia bipunctata papii	4	25		5	33.33		1	3.85		0	0		10	14.49		

Food items	spring (n= 16)			summer (n= 9)			autumn (n= 26)			winter (n= 18)			TOTAL (n= 69)			
	n	ip	vol	n	ip	vol	n	ip	vol	n	ip	vol	n	ip	vol	AI
Acndidae	1	6.25		7	77.78		14	53.85		3	16.67		25	36.23		
Gryllotalpidae	4	25		0	0		0	0		0	0		4	5.80		
Gryllidae	0	0		0	0		3	11.54		0	0		3	4.35		
Lepidoptera (larvae)	0	0		1	11.11		2	7.69		0	0		3	4.35		
Sphingidae	0	0		0	0		3	11.54		0	0		3	4.35		
Noctuidae	2	12.5		1	11.11		3	11.54		2	11.11		8	11.59		
Chilopoda	0	0		0	0		1	3.85		1	5.55		2	2.90		
Arachnida	0	0		0	0		1	3.85		0	0		1	1.45		
ANELLIDA AND MOLLUSCA		0.82			0.49			0.57			0.62			0.62	0.70	
***Hormogaster** redii*	2	12.5		2	22.22		6	23.10		3	16.67		13	18.84		
Gasteropoda	3	18.75		0	0		1	3.85		2	11.11		6	8.70		
VERTEBRATA		10.89			24.02			17.91			35.18			22.00	13.44	
REPTILIA																
Lacertidae	0	0		1	11.11		0	0		0	0		1	1.45		
AVES																
Galliformes	0	0		0	0		1	3.85		0	0		1	1.45		
Passeriformes	0	0		0	0		1	3.85		2	11.11		3	4.35		
Gruiformes	1	6.25		0	0		0	0		1	5.55		2	2.90		
Aves unidentified	1	6.25		1	11.11		3	11.54		4	22.22		9	13.04		
MAMMALIA																
Mus musculus	1	6.25		0	0		1	3.85		0	0		2	2.90		
***Apodemus** sylvaticus*	0	0		0	0		1	3.85		3	16.67		4	5.80		
***Rattus** rattus*	0	0		0	0		1	3.85		3	16.67		4	5.80		
***Rattus** norvegicus*	0	0		1	11.11		1	3.85		1	5.55		3	4.35		
Rodentia unidentified	0	0		1	11.11		2	7.69		1	5.55		4	5.80		
Lagomorpha	0	0		1	11.11		1	3.85		0	0		2	2.90		
Myocastor coypus	0	0		0	0		1	3.85		0	0		1	1.45		
Soncidae	0	0		0	0		1	3.85		0	0		1	1.45		
Erinaceus europaeus	0	0		1	11.11		1	3.85		0	0		2	2.90		
Mammalia unidentified	1	6.25		2	22.22		3	11.54		2	11.11		8	11.50		

earthworm chaete. Each sample was diluted with a 2% formaline solution, to check the possible presence of earthworm chaete. The material retained in the sieve was sorted into 7 categories: vegetables, insects, bones, feathers, hairs, Mollusca and non identifiable.

The methods of Bietolini (1993) and Teerink (1991) were utilised for mammal hair identification. The procedure of Day (1996) was used for feather identification, while bones were identified according to Chaline *et al.* (1974). The presence in the samples of hairs and feathers indicated mammals and birds. The estimated relative volume of food ingested was evaluated on a percent point scale (of volume: 0= absent, 1= <5%, 2= 5÷35%, 3= 35÷65%, 4= 65÷95%, 5= >95%). For earthworms, we considered the average presence of chaete in 10 sub-samples of 1 cm^2 of the 1.5ml sample (0, 1= 1+5chaete/area, 2= 6÷10 chaete, 3= 11÷20 chaete, 4= 21÷30 chaete, 5= 31÷40 chaete, 6= >40 chaete) (Raw, 1959). Quantification of vegetable matter ingested was done according to the number of seeds, while herbaceous material volume was reported directly (assuming it was not digested by the badger).

The highest number of elitra (both right and left; Harris *et al.*, 1991), of heads, wings and legs was considered for insects. The caterpillar and worm counts were carried out comparing the number of heads with that of the bodies (Harris *et al.*, 1991). The quantification carried out for Mollusca was very rough, owing to the scarcity of remains recovered.

The data were analysed according to:

- ip: percentage of samples of each food items;
- vol: percentage of volume of each food items (vegetables, Artropoda, Anellida, Mollusca, Reptilia, Aves and Mammalia);
- AI: the abundance index AI= (ip ar), where ar is the percentage of mean volume of each food in the overall diet. This index gives a general vision of the badger's diet (Kruuk and Kock, 1981; Mouches, 1981; Biancardi *et al.*, 1995).
- Levins' indexes were used to measure seasonal trophic niche breadth ($B = 1/\sum_{i=1}^{n} (P_i)^2$ and $BS = (B-1)/(N-1)$, where $P_i = N_i/N$ that is the total number of samples in which class "i" occurred/total number of samples and N is the number of the observed classes (Biancardi *et al.*, 1995).

The data were arranged in seasonal groups: spring (March-May), summer (June-August), autumn (September-November), winter (December-February). The χ^2 test (chi-square test) was used for testing differences in seasonal diets, while the Man-Whitney U test was used for testing differences in volume of food classes between seasons.

Results

The following food classes were found from the analysis of 69 samples: vegetables, arthropods, molluscs, anellida, reptiles, birds and mammals (Table 1). Vegetables and arthropods were present in all seasons and constituted the main food source. Their presence values were, in fact, 40.04% and 36.91% respectively (Table 1; Fig. 1).

Among vegetables, the commonest species was juniper berries (*Juniperus oxycedrus*), a typical Mediterranean maquis plant widespread in the study area and whose berries are available almost throughout the year. **A** decrease in exploitation of juniper berries was noted during the summer-autumn periods (Table 1), together with an increase of other vegetables that ripen in those seasons. Among these were *Rubus* sp. (ip 1997= 42.86%; vol 1997= 21.43%), *Prunus* sp. (vol 1996= 10%)and, to a lesser extent, Poaceae plants (ip 1997= 14.28%) in summer; *Rhamnus alaternus* (ip 1997= 40%; vol 1997= 23.5%) and *Hyoscyamus niger a.* (ip 1997= 27.78%; vol 1997= 14.02%) in autumn. The Abundance Index has the highest value among all the others food classes (AI= 41.06).

The insects found in the faeces belong to 3 orders: Coleoptera, Orthoptera and Lepidoptera (Table 1). As regards Coleoptera, the Carbidae family was more present than Tenebrionidae and Scarabeidae (Table 1). Among Orthoptera, the Acrididea family was more frequent than Gryllotalpidae and Gryllidae,

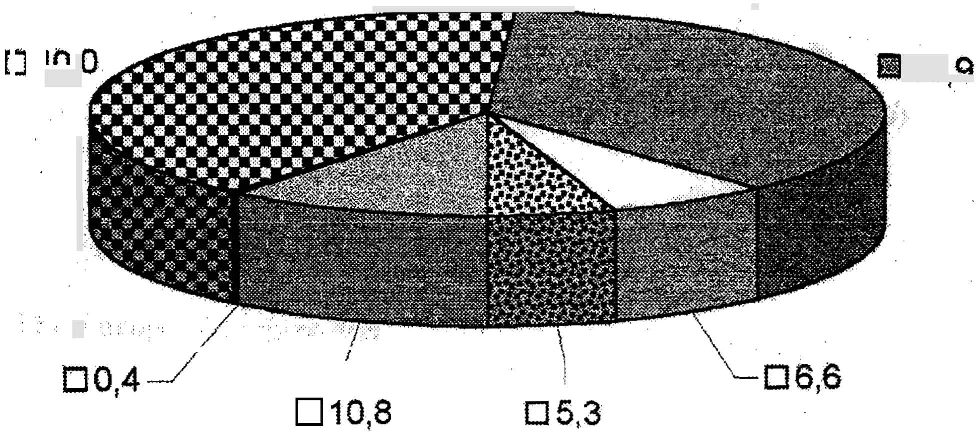

Figure 1 - The European badger diet (ip= percentage of samples of each food item).

Table 2 - Seasonal trophic niche breadth measured by means of the Levines' index (BS).

season	BS
spring	0.24
summer	0.36
autumn	*0.07*
winter	*0.20*

during all the seasons with the exception of spring 1996 and spring 1997 and of winter 1996/97 (Table 1). The Lepidoptera were mainly caterpillars belonging to the Noctuidae and Sphingidae families, and it was widespread only in autumn-winter periods, when in some samples a high percentage of volume was formed by caterpillar remains. Earthworms chaete were found in very small quantities and at very low frequencies (Table 1). This group had the second highest Abundance Index (AI= 36).

As far as Reptilia are concerned, only one remains of Lacertidae was found, in a sample collected during summer 1997 (Table 1).

Birds were often catalogued as unidentified Aves, owing to difficulty in identification of bone and feather remains. These animals were present at a low frequency in comparison to arthropods, vegetables and mammals (Table 1), with an Abundance Index **< 5%** and with percentage of volume values that, from season to season never exceeded 10%(Table 1). Mammals were present with greater frequency and Abundance Index than other vertebrates (Table 1; Fig.1). The maximum percentage of volume was reported in winter 1996/97 and during summer 1996, when it reached a value similar to that for vegetables, but lower than that for insects (Table 1). Mammals were represented mainly by rodent Muridae and Insectivores *(Erinaceus europaeus)*. Remains of nutria (*Myocastor coypus)*, hystrix (*Hystrix crisfata)*and Lagomorpha were found too. However, since they are rare, we can assume that these animals were not entirely ingested, and even than only occasionally. In fact the general presence of mammals in the badger's diet is very low compared to vegetables and insects.

Unidentifiable items which could not be recorded in other classes and/or non-food items (e.g., plastic) never rose higher than 2% in volume (Table 1).

The χ^2 test is significant (χ^2= 30.64, 9 d.f., p<0.01) when considering all categories in the different seasons. In particular, a significant difference is evident between observer and expected frequencies in insects and vegetable foods during summer (respectively insect: fe= 19.20; fo= 26.00 and vegetable foods: fe= 20.84; fo= 6.00), while no seasonal differences were detected for the other items. Similarly, vegetable matter in terms of mean ingested volume was higher in winter with respect to autumn (Mann-Whithney U: $z= 2.59$, $p<0.01$) and in summer with respect to spring (Mann-Whithney U: $z= 2.02$, $p<0.05$), while no seasonal differences were detected for the other food items.

The Levins trophic niche index values (BS), measured for the four seasons, are shown in Table 2. During summer, a greater niche breadth was reported because of the inclusion in the diet of items such as: arthropods (insects), *Rubus* sp., pine-nuts and *Prunus* sp. Spring follows, were the presence of gastropods and anellida was reported, although to a much lesser extent. Then came winter, during which the predation on arthropods was reduced and finally autumn, when *Rhamnus alaternus* and caterpillars were the preferred food.

Discussion

In Italy, the badger's food habits can vary from the typical situation of northern regions, where earthworms form a great part of the diet (Prigioni *et al.*, 1988; Canova and Rosa, 1993), to those situations in Mediterranean areas in central Tyrrenic Italy, where the badger prefers fruit and insects (Pigozzi, 1991). Nevertheless, these regional differences can not be considered univocal. In fact, some cases of frugivorous and insectivorous alimentary preferences were reported also in northern Italy (Kruuk and De Kock, 1981; Biancardi *et al.*, 1995).

The results of this study confirm the data of previous studies carried out in the Maremma Natural Park (Ciampalini and Lovari, 1985; Pigozzi, 1991, 1992), where a frugivorous-insectivorous diet was found. These results are clearly visible through the Abundance Index values that give an overall view of the kind of badger's diet. Nevertheless, there is an evident seasonal difference in percentage volume, which is more significant firstly for vegetables, followed by insects. It is interesting to note that Maremma Natural Park is only a few kilometres from the Burano Lake Nature Reserve, the site of our work. This fact could be explained as the habitat differences between the areas.

Among insects, the greater presence of Carabidae is probably explained by their nocturnal behaviour, that makes them easier for the badger to find, during its frequent twilight activity.

We also reported seasonal differences in the diet. Insects were increasingly used in summer with a consequent reduction vegetable matter consumption. This corresponds to a shift from a diet full of carbohydrates to one relatively richer in proteins, perhaps due to the need to recover weight after the reproductive period (Pigozzi, 1992; Neal and Cheesman, 1996). During winter, the increase volume percent of vertebrates in the diet could be correlated with the need to satisfy protein requirements, no longer supplied by insects that become rarer during this season. However, the low number of analysed samples could mean there was a bias in estimating the importance of vertebrates during summer and autumn.

The results concerning the trophic niche breadth seem to indicate that in the Burano Lake Natural Reserve area the badger prefers a diet, with definite frugivorous-insectivorous preferences, maintained throughout the year, even if there are some seasonal variations.

Therefore we can suppose that the badger is thus an adaptable animal that is able to take advantage of new available food resources and balance proteic and carbohydrate requirements, a view already expounded by Mellgren and Roper (1986).

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