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USE OF TROPHIC RESOURCES AND FOREST HABITATS BY THE GENUS *MARTES* IN ADAMELLO-BRENTA PARK (CENTRAL ITALIAN ALPS)

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ABSTRACT – Habitat use and diet of genus *Martes* (*M. martes* and *M. foina)* were studied in alpine forest habitat (Adamello-Brenta Park, Central Italian Alps) from July 1991 to September 1992. Marten scats were looked for along 3 transects representative of 5 forest habitats in order to analyse seasonal variations in habitat selection. The food habits were studied analysing 225 scats collected along the transects. Both percentage frequency of occurrence and relative percentage frequency (Fr%) of the different food items were calculated. Arthropods (Fr% = 50.0%), mainly insects (Coleoptera and Hymenoptera), were the staple in the diet of martens and were mostly consumed in spring and in summer. The other main food categories were vegetables (Fr% = 25.9%), mainly Rosaceae fruits, with a peak in autumn/winter, and mammals (Fr% = 10.5), especially small rodents, regularly preyed on throughout the year with a peak in winter. Carrion (marmots and ungulates) and partly insects (Orthoptera and Hymenoptera) were a fairly important food resource in the winter and at the beginning of the spring. All year round *Martes* selected coppice forest and mixed high forest, where presumably a major availability of the main food resources used by both species occurred.

Key words: ***Martes,*** Habitat selection, Diet, Alpine forest habitat, Central Italian Alps.

RIASSUNTO – *Uso delle risorse trofiche e degli ambienti forestali da parte del genere* Martes *nel Parco Adamello-Brenta (Alpi Centrali)* – L'uso dell'habitat e la dieta del genere *Martes (M. martes* e *M. foina*) sono stati studiati in ambienti forestali del Parco Adamello-Brenta nel periodo luglio 1991-settembre 1992. Il numero di feci di *Martes* è stato rilevato in 3 transetti rappresentativi di 5 ambienti forestali, al fine di valutare le variazioni stagionali nell'uso dell'habitat. Le abitudini alimentari sono state investigate mediante analisi di 225 feci raccolte lungo i transetti di campionamento. I dati sulla dieta sono stati espressi come frequenza percentuale e frequenza relativa percentuale (Fr%) delle diverse componenti alimentari rilevate. Gli Artropodi (Fr% = 50,0%), rappresentati principalmente da insetti (Colcotteri e Imenotteri), erano la categoria alimentare dominante ed erano utilizzati soprattutto in primavera e estate. Le altre fonti alimentari più importanti erano i vegetali (Fr% = 25.9%), in particolare frutti di Rosaceae, maggiormente consumati in autunno/inverno, e i mammiferi (Fr% = 10,5%), soprattutto piccoli roditori, predati tutto l'anno e specialmente in inverno. Le carogne (marmotta e ungulati) e in parte gli insetti (Ortotteri e Imenotteri) erano una fonte alimentare non trascurabile in inverno e all'inizio della primavera. Per l'intero arco dell'anno *Martes* selezionava i boschi cedui a latifoglie e misti di fustaie, dove presumibilmente più abbondanti erano le risorse alimentari maggiormente utilizzate dalle specie.

Parole chiave: *Martes,* Uso dell'habitat, Dieta, Ambiente forestale alpino, Alpi centrali

INTRODUCTION

The stone marten (*Martes foina*) and the pine marten (*Martes martes*) are sympatric species on a large part of the Italian Alps (see Pedrini et al. in this volume). For this reason studying separately ecological aspects of both species using their signs of presence is a problem still unsolved. This problem occurred also in our study area which is characterized mainly by forest habitats. Nevertheless, there was a certain habitat segregation between the two species: the pine marten seemed to be restricted to forest habitats, the stone martens to agricultural land, urban areas and woods of the valley bottom (Pedrini et al, in this volume). In this respect, our data could be ascribed more to pine martens than to stone martens.

The knowledge about the food habits of *Martes* is very poor in the Italian alpine range (Cantini, 1991), and no information is available on the habitat use. These ecological aspects were investigated in the present work, promoted by Adamello-Brenta Park within a wider research on the distribution and status of mustelids in this park and surrounding areas.

STUDY AREA

The study area (27 km^2) was located in the middle-low stretch of the Tovel valley between 600 and 1600 m a.s.l. This valley runs in the northern part of the Brenta mountain group (Trento province) and its morphology is due to glacial erosion in the upper stretch and to fluvial erosion of the Trisenda stream in the middle-lower course.

At low altitude the valley was covered by thermophil woods of *Quercus pubescens, Fraxinus ornus* and *Ostrya carpinifolia,* followed by mixed woods of *Fagus sylvaticus* and conifers. At middle altitude a forest of *Pinus sylvestris* occurred on detritus of a wide post-glacial landslide. At 1000 m a.s.l. mixed high forests of *Picea abies* and *Abies alba* was dominant, beyond 1200 m a.s.l. monospecific forests of *P. abies*, interspersed with *Pinus mugo* (Tomasi, 1973), was present.

The clime was characterized by low temperatures in autumn/winter (Fig. 1). During the study period the annual mean temperature was about 4.7 °C with a minimum of -20.6 °C in February and a maximum of 27.6 °C in August. The snowy precipitation occurred mainly in December-March, but severe snowfalls were also recorded in April (about 1000 mm in 1992). The snowy cover lasted from December to May.

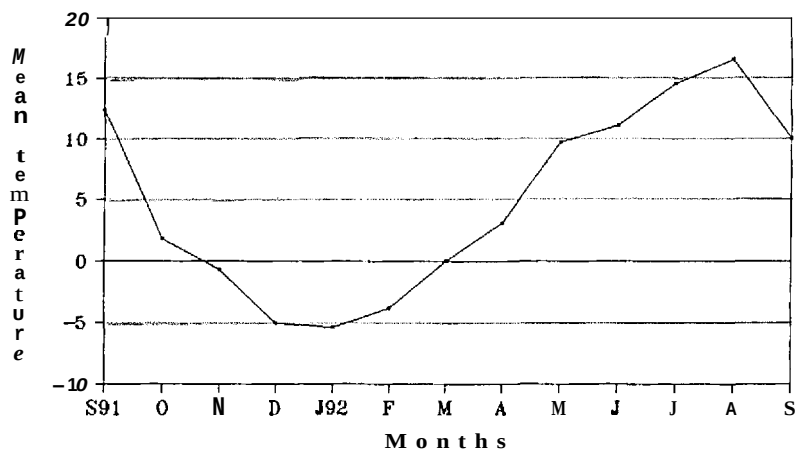

Fig. 1 – Mean monthly variation of temperature (°C) in the study area throughout the research period (the values of July and August 1991 were not reported because unavailable).

Built-up areas mainly occurred in the bottom of the Tovel valley and around the Tovel lake; tourism was much developed in summer.

All four Italian tetraonid species occurred in the study area; in addition, some pairs of the golden eagle (*Aquila chrysaetos*) and the eagle owl (*Bubo bubo*) were regularly nesting. The roe deer (*Capreolus capreolus*) and chamois (*Rupicapra r. rupicapra*) were present with fairly good populations, while the red deer (*Cervus elaphus*), recently appeared, was restricted in number. Besides the stone marten and pine marten, carnivores were represented by the stoat (*Mustela erminea*), weasel (M. *nivalis*), bear (*Ursus arctos*) and lynx (*Lynx lynx*), this last recently appeared.

METHODS

The study was conducted from July 1991 to September 1992. Marten scats were searched during fortnightly excursions along 3 transects (12.36 km in total length recorded by tape measure) coinciding with forest roads and footpaths, representative of 5 forest habitats (Tab. 1). These habitats, defined on the basis of physiognomic, structural and silvicultural parameters, were drawn from the vegetation map of the Adamello-Brenta Park (Venanzoni in prep.).

Tab. 1 – Distribution of the transects investigated in each forest habitat.

HABITATS	LENGTH IN KM
Coppice forest	2.76
Mixed high forest	2.92
Red fir forest	4.42
Shrub forest	1.21
Pine forest	0.95

Habitat selection was analyzed by the following index (Robel et al., 1970):

$$PI_i = \frac{OPUi}{SHR_i}$$

where OPU_i is the observed proportion of use for the ith habitat calculated as number of marten scats recorded in each habitat over the total number of scats, and $SHRi$ is the ratio between the surface of each habitat and the surface of the study area. When $PI < 1$ the habitat is avoided, when $PI = 1$ the habitat is used in proportion to the availability, and when $PI > 1$ the habitat is selected.

A total of 225 scats (139 in 1991 and 86 in 1992) was collected along the transects. The annual variation of the diet was analyzed at bi-monthly intervals on the basis of the following sample sizes: January-February = 20, March-April = 17, May-June = 23, July-August = 45, September-October = 81, November-December = 39. Scats were stored in polythene bags at -20° C and then analysed. They were thawed and washed in water over 3 sieves with decreasing meshes (0.5 to 0.1 mm) Different food remains in the scats were considered to identify the prey: seeds and epicarp for plants, wings, legs and cuticule parts for arthropods, shell for molluscs, vertebra for amphibians, scales for reptiles, feathers for birds, hair and mandibles for mammals. Feathers and hairs were soaked for 3-4 hrs. in ethylic alcohol to take the grease off and then identified under binocular microscope using the identification keys by Day (1966), Brom (1986) and Debrot et al. (1982). At this purpose, personal collections of feathers and hairs were used too.

According to Prigioni & Tacchi (1991), the results were expressed as:

a) percentage frequency of occurrence, F% = (number of scats containing a specific food item on the total number of examined scats) x 100;

b) relative percentage of frequency, Fr% = (number of times that the same item occurs on the total number of recorded items) x 100.

Annual and bi-monthly diet breadth was estimated by the B index (Feinsiger et al., 1981):

$$B = \frac{I}{R \, E \, pi'}$$

where p_i is the proportion of use of the $_i$th item (Fr%) and R is the item number (21 in this case, see Appendix). B varies from 1/R (use of one item only) to 1 when all items are equally used.

The correlation between different food items in the diet was tested by the Spearman rank correlation coefficient (r_s) (Siegel, 1956) using Fr% calculated for each month (N = 15).

RESULTS

HABITAT SELECTION

Coppice forest and mixed high forest were selected all year round, while shrub forest and pine forest only in spring and in autumn respectively; red fir forest was always avoided (Tab. 2).

Tab. 2 – Seasonal variation of the habitat preference index (PI). The number of signs of presence (scats) is shown in parenthesis.

HABITAT	WINTER (35)	SPRING (111)	SUMMER (52)	AUTUMN (27)
Coppice forest	1.4	2.1	2.4	1.4
Mixed high forest	2.0	I.2	1.3	1.9
Red fir forest	0.6	0.3	0.3	0.2
Shrub forest	0.3	1.0	0.4	0.8
Pine forest	0.0	0.0	0.2	1.4

DIET

The overall diet of martens included 65 prey items, grouped in 21 main food categories (Appendix 1). Arthropods (Fr% = 50%), mainly Coleoptera and Hymenoptera, were the staple of the marten diet, followed by vegetables (Fr% = 25.9%), mostly Rosaceae fruits (Tab. 3). Within Vertebrates, mammals, especially small rodents (Fr% = 8.6%), were the most eaten item, birds (Fr% = 4.3%) were used to a lesser extent, and amphibians and reptiles were occasionally preyed on. Garbage was a negligible food resource, while carrion, represented by ungulates and marmots, was fairly used.

Tab. 3 – Composition of the marten diet expressed as percentage frequency (F%) and relative percentage frequency (Fr%). N = number of scats containing a specific taxon; n = number of prey items in each taxon; total examined scats: 225; total number of prey items: 578).

	N	n	F%	Fr%
VEGETABLES	131	150	58.2	25.9
Rosaceae	96	102	42.7	17.6
Ericaceae	17	18	7.5	3.1
Other vegetable matter	30	30	13.3	5.2
ARTHROPODS	148	289	65.8	50.0
Coleoptera	65	83	28.9	14.3
Hymenoptera	91	99	40.4	17.1
Orthoptera	48	48	21.3	8.3
Other insects	12	12	5.3	2.1
Undetermined insect larvae	28	2s	12.4	4.8
Other arthropods	19	19	8.4	3.3
MOLLUSCS	1	1	0.4	0.2
AMPHIBIANS	4	4	1.8	0.7
REPTILES	3	3	1.3	0.5
BIRDS	22	25	9.8	4.3
Passeriformes	15	15	6.7	2.6
Other birds	10	10	4.4	1.7
MAMMALS	59	61	26.2	10.5
Lagomorphs	1	1	0.4	0.2
Insectivores	8	8	3.5	1.4
Small rodents	50	50	22.2	8.6
Carnivores	1	1	0.4	0.2
CARRION	38	38	16.9	6.6
GARBAGE	6	6	2.7	1.0

The annual variation of the marten diet is shown in Fig, 2. Vegetables were eaten all year round with peaks in autumn and winter; in these seasons *Sorbus aria* and *Rubus idaeus* (Rosaceae) were the main food items. On the other hand *Vacciniunz* species (Ericaceae) were irregularly used. The consumption of insects was substantially opposite to that of vegetables: peaks occurred in spring and summer and were mainly due to Coleoptera (*Carabus, Pterostichus* and *Geotrupes)* and Hymenoptera (*Vespa silvestrix, V. saxonica* and Apinae). Orthoptera, exclusively *Gryllus campestris*, occurred mostly in late summer and autumn; they were also eaten in winter together with Hymenoptera when all the other arthropods were not used. Mammals, almost exclusively small rodents (Muridae, Arvicolidae and Gliridae), were regularly preyed on throughout the year with a peak in winter, while birds occurred mostly in spring. Carrion and garbage were mainly used in winter and spring.

The use of mammals and carrion was negatively correlated with Rosaceae and Coleoptera respectively. On the other hand birds were positively correlated with three different food items (Tab. 4). The diet breadth (annual value: 0.42) showed a bi-modal pattern with peaks in spring and in late summer/beginning autumn (Fig. 3).

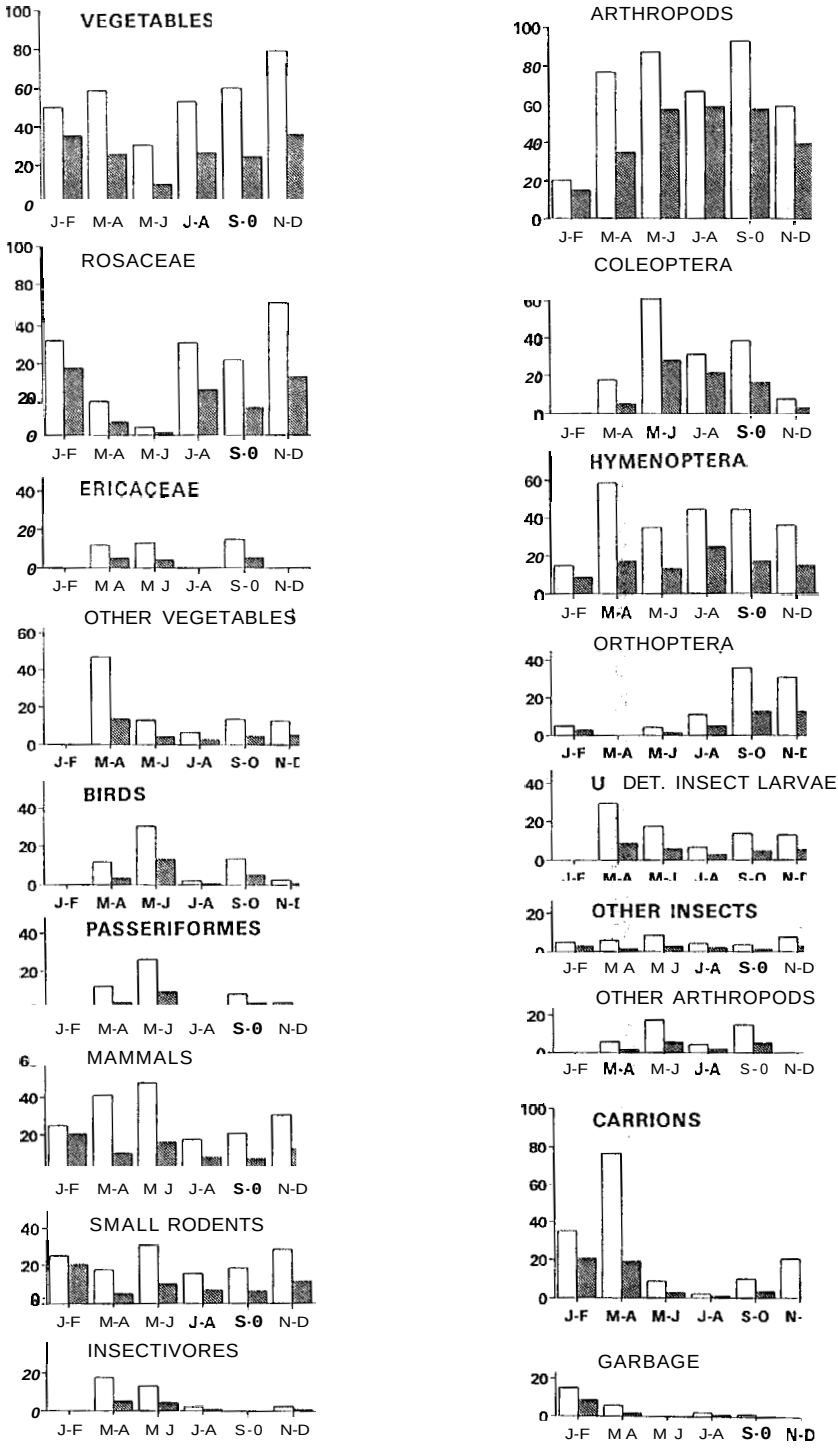

Fig. 2 - Bi-monthly distribution of F% (white histogram bars) and Fr% (dotted histogram bars) of the main prey items in the marten diet throughout the year.

Tab. 4 – Significant correlation (r_s) between relative percentage frequencies (Fr%) of different food items.

FOOD ITEMS	r_s	SIGNIFICANCE LEVEL
Amphibians-Molluscs	0.73	0.01
Birds-Vegetables	0.59	0.05
Birds-Insect larvae	0.58	0.05
Birds-Other Arthropods	0.66	0.03
Mammals-Rosaceae	-0.66	0.03
Carrion-Coleoptera	-0.81	0.007

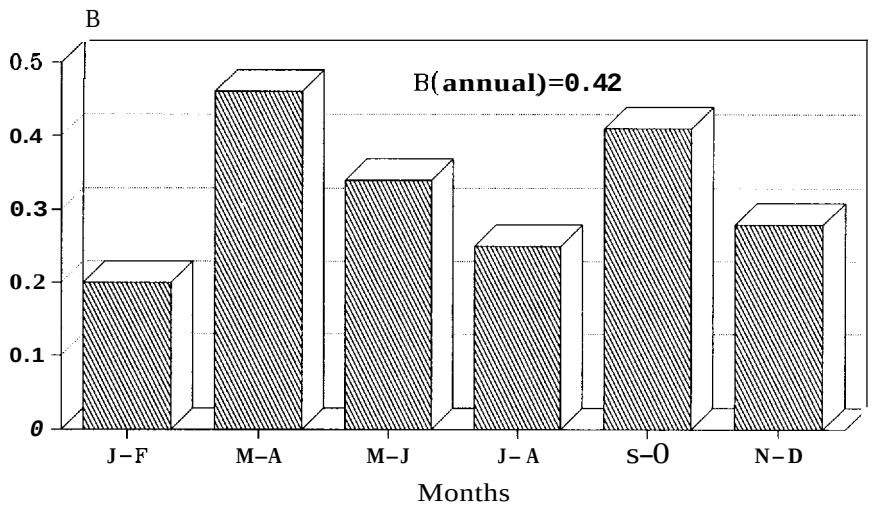

Fig. 3 - Variation of the trophic niche breadth (B) throughout the year.

DISCUSSION

The habitat use and the feeding habits of carnivores are mainly affected by abundance, dispersion and availability of food resources (e.g. Macdonald, 1981; Doncaster et al., 1990; Balharey, 1993). In our study, insects, Rosaceae fruits and small rodents were the main resources influencing the feeding behaviour and the habitat selection of martens. The high use of insects from the late spring to the beginning of autumn was not surprising, because it agreed with their seasonal abundance and availability. On the other hand, in autumn/winter Orthoptera and Hymenoptera seemed to be actively looked for by martens in their wintering sites (e.g. rotten wood, foliage, musk, little caves).

The consumption of Rosaceae fruits seemed to be more influenced by the climatic annual pattern and by the duration of the snowy cover than by their seasonal availability. Indeed, for example, *Sorbus uriu* fruits (an important food item in spring and winter) fructified in late summer but could be preserved for the winter/spring period by the low temperature or under the snow. In this period martens consumed also ungulates (mainly roe deer and chamois) as carrion. Also this food resource could be maintained for a long time under the snow and could become available in late spring after thawing.

The consumption of the marmot as carrion could be surprising, because this rodent did not occur in the study area. Martens probably ate it as food remains of the eagle which nests (with one pair) in the study area.

Among birds, Passeriformes were the most preyed on with a peak coinciding with their breeding period.

In a valley of central Italian Alps with environmental characteristics similar to those of our study area, Cantini (1991) found that the annual diet of the genus *Martes* was based on mammals (mainly rodents, F% = 46.8), birds (mostly Passeriformes, F% = 7.3) and vegetables (F% = 40.0), mainly Rosaceae and Ericaceae fruits, while insects (F% = 1.6) were a negligible food item. This pattern substantially differs from that recorded by us, mainly in the use of insects. Such difference could depend on the availability of this resource. Nevertheless it may be suggested that different strategies in the exploitation of available food resources by martens exist between the two study areas.

We found a narrow annual trophic niche breadth. This result seems to confirm that martens are opportunistic carnivores and tend to use the most available or easily accessible food resources. Although we have no data on the availability in the different forest habitats of the main food resources consumed by martens, it is presumable that these resources are more abundant in coppice forest and in mixed high forest. Hence these habitats are selected by martens all year round.

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Appendix 1 – Food species and items identified by analysis of scat martens. Food categories used to estimate the trophic niche breadth are given prominence in bold.

VEGETABLES

Rosaceae
Rosa canina
Prunus avium
Pirus communis
Malus communis
Sorbus aria
Amelanchier ovalis
Rubus idaeus

Ericaceae
Vuccinium vitis iduea
Vaccinium myrtillus

Other vegetable matter
Viscum album
Vitis vinifera
Undetermined vegetables

ARTROPODS

Coleoptera
Carabus granulatus
Pterostichus metallicus
Pterostichus multipunctatus
Undetermined Carabidae
Geotrupes alpinus
Undetermined *Geotrupes*
Undetermined Scarabeoidae
Otiorrhynchus ligustici
Undetermined *Otiorrhynchus*
Undetermined Curculionidae
Undetermined Cerambicidac
Undetermined Byrridae
undetermined Coleoptera larvae
Undetermined Coleoptera

Hymenoptera
Vespa silvestris
Vespa saxonica
Undetermined *Vespa*
Undetermined Apinac
Undetermined Formicidae
Mutilla europuea
Undetermined Hymenoptera larvae
Undetermined Hymenoptera

Orthoptera
Gryllus campestris
Undetermined Lepidoptera
Undetermined Insects

Other Insects
Forcicula sp.

Undetermined Insect larvae

Other artropods
Scorpionoidea
Lithobius forficatus
Undetermined *Lithobius*

MOLLUSCS

Gasteropoda

AMPHIBIANS

Anura

REPTILES

Podarcis muralis
Ophidia

BIRDS

Passeriformes

Other birds
Piciformes
Undetermined birds
Undctcrmined eggs

MAMMALS

Lagomorphs
Lepus sp.

Insectivores
Sorex sp.

Undetermined Chiroptera

Small rodents
Clethrionomys glareolus
Apodemus sp.
Microtus nivalis
Microtus sp.
Muscardiniis avellanarius
Eliomys quercinus
Undetermined rodents

Carnivores
Felis domesticus

CARRION

Murmotu marmota
Capreolus capreolus
Undetermined Cervidae
Rupicapra r. rupicapra

GARBAGE