FEEDING HABITS OF THE PINE MARTEN *MARTES MARTES* L., 1758, IN EUROPE: A REVIEW

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ABSTRACT – Twenty-nine studies on the diet of the pine marten *Martes tnartes* in Europe are reviewed. Feeding ecology of the mainland and island populations of the species is compared. Most of these studies are based on data collected during a single season; only a few were carried out over a whole year. It was found that the pine marten is a generalist predator and varies its diet according to local and seasonal food availability. The importance of different food items is discussed.

Key words: *Martes martes*, Diet, Europe.

RIASSUNTO – *Ecologia alimentare della martora* (Martes martes) *L., 1758, in Europa* – La dieta della rnartora *Martes martes* viene analizzata attraverso i risultati di 29 ricerche condotte in Europa. La descrizione dell'ecologia alimentare della specie è stata condotta confrontando le caratteristiche delle popolazioni continentali con quelle delle popolazioni insulari. La maggior parte degli studi è stata svolta nel corso di una sola stagione, soltanto pochi lavori si basano su dati raccolti durante un intero anno. La martora è un predatore generalista che varia la propria dieta in relazione alle disponibilità alimentari sia locali che stagionali. Viene analizzato il ruolo svolto dalle diverse categorie alimentari nella dieta del predatore.

Parole chiave: *Martes rnartes*, Dieta, Europa.

INTRODUCTION

The pine marten, *Martes nzartes* L., 1758, is distributed from the Boreal Zoogeographical Region to the Mediterranean area, where it occurs on the following islands: Minorca, Majorca, Corsica, Elba, Sardinia and Sicily (see Masseti in this volume).

A review is presented here of the available literature on the diet of this mustelid; in addition, the food habits of mainland and island populations are compared. Other parameters, such **as** sex and age related differences in the diet, food availability, relationships between the population dynamics of this species and that of small mammals, and the comparative feeding ecology of the pine marten and other sympatric carnivores, have not yet been sufficiently investigated and have not been included in this review.

Of the twenty-nine studies reviewed (see Tab. 1-4 for references), 5 are multi-year works, 4 report year-round data, and 12 describe winter diet; 19 are based on scat remains and 18 on stomach contents. The sample size is often small, less than fifty scats or stomachs in 7 studies. The methodologies applied are not always homogeneous thus not allowing an accurate comparison among results.

Data have been divided into 9 food categories: mammals, birds, eggs, amphibians, insects, other invertebrates, fruits, carrion and garbage. In order to standardize the results, data were expressed as frequency of occurrence, even if this parameter generally overestimates the importance of indigestible foods and

small food items (Reynolds & Aebischer, 1991). Only food categories with a percentage of occurrence ‡ 10% are listed in the tables.

In order to describe geographic variation in feeding habits 4 main climatic regions have been considered (Boreal, Atlantic, Central-European and Mediterranean according to Polunin and Walters, 1987), grouping the data from different studies.

BOREAL REGION

The available studies present data collected only during winter. The diet is based on mammals, which constitute from 37.2% to 81% of the total diet (Tab. 1). According to Pulliainen (1981), when various food supplies are abundant, voles and lemmings are the most important food; when these small mammals are not so abundant, other food items become dominant. Variation in feeding habits is reported from year to year. In Finland, the diet alternates among small mammals (voles, lemming and shrews) and berries (mostly *Vuccinium* sp.), mushrooms (mostly *Rhizopogon rubescens*) and reindeer carcasses (Pulliainen, 1981). In Sweden the pine marten shifts in successive winters from rodents (mainly *Sciurus vulgaris*) to insectivores (mostly represented by the genus *Sorex)* and cervid carrions (Storch et al., 1990). In Northern Russia the frequency of occurrence of squirrels reaches 50% in some years; in other cases it ranges from 0 to 20% (Yazan, 1970).

Considering the "birds" category, tetraonids constitute an important food item in Northern Russia (Yazan, 1970; Yurgenson, 1947).

Tab. 1 – Diet of the pine marten in Boreal Region (Material: sc = scat; st = stomach; ml = meal remains. Season: duration of the study; w = winter; sp = spring; sm = summer; at = autumn; y = year. Food categories: % occurrence ≥ 10%.m = mammals; b = birds; e = eggs; a = amphibians; iv = invertebrates; i = insects; fr = fruits; cr = carrion; gr = garbage.

AUTHOR	LOCALITY	MATERIAL (N)	SEASON	MAIN FOOD ITEM	OTHER
Yazan, 1970	N Russia	455 st 171 sc	7 w t sm	60 m small rodents 39.6 squirrel 11.7	24.6 b 22.5 fr
Yurgenson, 1947	N Russia	43 st males	1 w	67.3 m squirrel 48.8 voles 13.9	30.2 b
Pulliainen, 1970	N Finland	2700 sc	4 w	77.3 m voles + shrews 66.2	14.1 b 13.8 fr 10.6 cf
Nyholm, 1970	NE Finland	134 st	? w	37.2 m	20.8 b
Hoglund, 1960	Sweden	78 st	3 w	72.4 m squirrel 51.3 voles + shrews 21.1	18.4 b
Storch et al., 1990	S Sweden	94 sc	3W	73.3 m shrews 36.5 squirrel 28.5	32.2 cr 13.8 e 10.7 b
de Jounge, 1981	S Sweden	51 sc 32 ml	2 w	squirrel 56	

ATLANTIC REGION

Mammals are the dominant food in 3 of the studies based on annual data (Tab. 2). In the Cantabrian Mountains a strong predation on mice (mainly *Apodemus sylvaticus*) is reported by Clevenger (1993), in contrast to the above cited studies where voles show the highest frequency of occurrence. The high use of woodland rodents suggests that the Cantabrian marten prey less frequently in open habitats. In Ireland Coleoptera are an important food item throughout the year while Hymenoptera are eaten mostly in summer (Warner & O' Sullivan, 1982 in Clevenger, in press). Fruits such as *Sorbus aucuparia, Ilex aquifolium* and *Vaccinium myrtillus* were found in 69.5% of the scats collected over a year in the Western Cantabrian Mountains (Guitian Rivera & Callejo Rey, 1983).

Unusual preys of the pine marten are fishes, noted in Scotland (Lockie, 1961), and *Crocidura russula*, recorded by Clevenger (1993) in the Cantabrian Mountains.

Tab. 2 – Diet of the pine marten in Atlantic Region. See Tab. I for abbreviations.

AUTHOR	LOCALITY	MATERIAL (N)	SEASON	MAIN FOOD ITEM	OTHER
Lockie, 1961	Scotland	337 sc	2 y	37.6 m	22.7 i 17.2 fr
Warner & O' Sullivan, 1982	Ireland	609 sc	4Y	52 i	46 b 40 fr 31 m
Labrid, 1987	NW France	171 sc	1 y	59 m	57 fr 36 i 21 b
Mouches, 1983	NW France	11 St	?	66	19 fr 10 b
Clevenger, 1993	NW Spain	193 sc	I sp/sm/at	75.1 m wood mice 34.2 field voles 18.6	35.2 fr 32.1 i
Guitan Rivera & Callejo Rey, 1983	N Spain	1716 sc	5 y	69.5 fr	19.7 m
Braña & delCampo, 1982	N Spain	55 sc 20 st	3 at/w	77 fr	62 m 32 i 22 b
Garzon et al., 1980	N Spain	53 st	10 at/w	79 m wood mice 33 field voles 30	35 fr 34 i 30 b

CENTRAL-EUROPEAN REGION

The studies show large use of voles, generally represented by *Clethrionomys glareolus*, confirming this prey is the staple in the diet of the pine marten (Tab. 3). According to Marchesi & Mermod (1989), voles of low vegetation areas *(Microtus* and *Arvicola* **sp.)** are mostly preyed on in spring and summer, voles of wooded areas (C. *glareolus*) **in** winter and spring.

Fruits (mainly *Rosa* sp., *Sorbus aucuparia* and *S. aria)* represent the dominant food category in autumn (46%, Marchesi & Mermod, 1989). Insects, usually *Coleoptera*, are consumed mainly in summer, **24%** (Marchesi & Mermod, 1989).

Remains of reptiles and amphibians are not found very often in scats or stomach contents. In North-eastern Poland toads make up 11% of the pine marten's winter-early spring diet (Reig & Jedrzejewski, 1988).

Honey and fishes are uncommon food items of the marten's diet noted in Switzerland (Marchesi & Mermod, 1989) and in Eastern France (Baudvin et al., 1985).

The pine marten is occasionally a predator of owls ***(Strix** aluco, Asio otus* and *Aegolius funereus)*, eating essentially eggs and chicks (Baudvin et al., 1985; Marchesi & Mermod, 1989).

An example of inter/intraspecific necrophagy or cannibalism is discussed **by** Baud (1981) on the basis of remains of the genus *Martes* identified in the stomachs collected in Haute Savoie (France) in winter.

Tab. 3 – Diet of the pine marten in Central-European Regions. See Tab. 1 for abbreviations. Food categories: rod = rodents; lag = lagomorphs; Cl = *Clethrionomys.*

AUTHOR	LOCALITY	MATERIAL (N)	SEASON	MAIN FOOD ITEM	OTHER
Rzebik - Kowalska, 1972	Poland	89 st	? w	69.8 in voles 31.7 insectivores **14**	39.7 h 25.4 c
Reig & Jedrzejewski, 1988	NE Poland	62 sc	1 w/sp	> 90 **m** *Cl. glareolus* 43.5 *Apodemus* sp. 37	11.2 a 11.2 i
Baud, 1981	E France	22 st	1 w	78.8 m rod + lag 57.6 insectivores 15.2	21.2 b
Baudvin et al., 1985	E France	911 sc	5J6 y	68.4 fr *Sorbus* **sp** 58.9 Compositae 19.6	16.4m
Ansorge, 1989	S Germany	66 st	4 w	47 m voles 32	19 i 17h
Marchesi & Mermod, 1989	W Switzerland	823 sc 31 *st*	4 y	38 in voles 48.2 insectivores 24.2	30.5 fr 14.5 i
Agnelli & De Marinis, in this volume	NW Italy	9 st	**w**	50 **m**	33.3 fr 11.1 b

MEDITERRANEAN REGION

Fruits are the most important food item (93%) of the marten's annual diet in the Pyrenees Mountains (Tab. 4) (Ruiz-Olmo & Lopez-Martin, in press in Clevenger, in press). This also occurred in other 2 studies based on annual data in Europe (Guitian Rivera & Callejo Rey, 1983; Baudvin et al., 1985).

The feeding ecology of the insular populations has been studied only recently. Research has been carried out on the Balearic Islands (Majorca and Minorca) and on the Tuscan Archipelago (Elba).

Tab. **4** – Diet of the pine marten in Mediterranean Region. See Tab. 1 for abbreviations.

AUTHOR	LOCALITY	MATERIAL (N)	SEASON	MAIN FOOD ITEM	OTHER
Ruiz-Olmo & Lopcz-Martin, in press	NE Spain	445 sc	l y	93 fr *S. aucuparia* 70	39 m **33** i
Moreno et al., 1988	Balearics (Minorca)	35 sc	l sm	77.1 fr	60 iv 37 m 20 cr+gr
Moreno et al., 1988	Balearics (Minorca)	75 sc	l sm	54.7 iv	38.7 m **33.3** fr 24 b
Cheylan, 1984	Balearics (Minorca)	?	l sp	58 m	21 b 16 iv
Ruiz-Olmo & Nadal, 1991	Balearics (Minorca)	42 st	9 w	61.9 fr *Ficus carica* 42.9	45.2 b 38.4 **m**
Clevenger, 1993	Balearics (Minorca)	1180 sc	l y	44.1 i Coleopters 22.7	40.4 fr 38.7 **m** 33.3 fr
De Marinis & Masseti, 1993a	Tuscan Archipelago (Elba)	80 sc	l w	89.4 m **rats** 52.l wood mice 3l.9	

Only one study of the Mediterranean islands, includes all year-round data (Clevenger, 1993). Small mammals, birds, fruits and insects were the main dietary components. The predation on small mammals (*Rattus* **sp.** and ***Apodemus sylvaticus***) usually occurs between January and April; birds were mainly abundant in the spring, during hatching and fledgling time; insects (Coleoptera and Orthoptera) and fruits *(Ceratonia siliqua* and *Rubus ulmifolius*) were recorded from July to December (Clevenger, 1993).

Rats represented the dominant prey species (52.1%) in the winter diet of the marten on the island of Elba (De Marinis & Masseti, 1993a), while on Minorca rats form only 17.7% of the winter food (Clevenger, 1993).

Unusual predation on *Crocidura suaveolens* is noted on Minorca and Elba (Cheylan, 1984; Clevenger, 1993; De Marinis & Masseti, 1993a).

On Minorca herring gull (*Larus argentatus*) remains were also found in 37 scats of the pine marten; adult plumage appeared in 73%, while the rest were juveniles (Clevenger, 1993).

On Minorca uncommon food items include bats (Clevenger, 1993), crustaceans (Ruiz-Olmo & Nadal, 1991; Moreno et al., 1988) and honey (Ruiz-Olmo & Nadal, 1991).

DISCUSSION

Mammals represent the dominant food category as reported in most of the studies describing the diet of the European pine marten.

Forest-dwelling voles (*Clethrionomys* sp.) and field voles (*Microtus* sp.) are the main food items, showing that the pine marten occurs both in wooded and in open habitats.

Several authors observed a shift in the marten's diet between voles and squirrels depending on their relative abundance; both an increase in the squirrel population and a decrease in the vole population lead to an increased frequency of squirrels in the diet of the marten (Lindstrom, 1989). The squirrel does not seem to represent the most typical prey of the pine marten, in part because of the high energy needed to prey on this species.

Insectivores (*Sorex* sp., *Talpa* sp. and *Erinaceus* sp.) may also represent high percentages of the prey, although they are not a common feeding resource in the diet of carnivores.

Mice are reported to be an important food category in only a few studies. On the Mediterranean islands, the absence of voles, the most common continental mammalian prey of pine marten, determines the shift to mice. Rats, sporadically preyed upon on the continent, form 52.1% of the winter diet on the island of Elba, Tuscan Archipelago (De Marinis & Masseti, 1993a).

Diet varies seasonally: fruits, insects and birds are important during summer and autumn, mammals during winter and spring. Fruits (*Sorbus* sp. and *Vaccinium* sp.) are the most common food items; insect include mainly beetles and, less bees and grasshoppers. Passeriformes (mainly Turdidae and Corvidae) and Galliformes are commonly found in scats and stomachs of the pine marten.

Carrion and garbage is an alternative food in the diet of the pine marten, as for the other carnivores. On the Balearic islands, a high consumption of garbage has been recorded during summer, when the large number of tourists determines more refuse (Moreno et al., 1988). The occurrence of pine martens in urban areas of the island of Elba might also be related to the exploitation of this feeding resource (De Marinis & Masseti, 1993b).

Poultry and game species are rarely preyed on (Baudvin et al., 1985).

According to Clevenger (in press) no significant latitudinal trend is shown in the food selection.

The diet of the Minorcan population of the pine marten shows an almost completely balanced use of food resources compared to the mainland populations, probably due to reduced competition and increased food availability in the insular environment (Clevenger, 1993).

In conclusion, the pine marten is an opportunistic predator with a generalized diet. Although none of the reviewed studies analysed food selection in terms of availability, the diet of the pine marten appears to reflect local and seasonal food abundance.

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