Folia Zool. – 52(4): 367–377 (2003)

Feeding habits of stone martens in a Hungarian village and its surroundings

József LANSZKI

University of Kaposvár, Faculty of Animal Science, Ecological Research Group, P.O. Box 16, H-7401 Kaposvár, Hungary; lanszki@mail.atk.u-kaposvar.hu

Received 18 July 2002; Accepted 8 April 2003

A b s t r a c t . The feeding habits of the stone marten (*Martes foina*) were studied by scat analysis in a village (n = 423 samples) and its surrounding agricultural environment (n= 572), during a six-year study (three periods), in southwest Hungary. Birds (relative frequency 20%, mainly small perching birds) and plants (35%, mainly orchard fruit) were the most important foods for the martens living in the village. Small mammals (29%, mainly voles) and plants (34%, mainly fruit) were the main food resources for the stone martens living in the agricultural environment. With respect to diet composition environment-dependent difference proved significant, but intra-environment difference did not. In comparison with those living in the agricultural environment the stone martens studied living in the village consumed more frequently: 1) heavier prey (greater consumption of domestic animals), 2) arboreal prey (e.g. birds) and 3) prey associated with human settlements (e.g. house mouse, house sparrow, domestic animals).

Key words: *Martes foina*, diet analysis, agricultural environment, Hungary

Introduction

The stone marten, *Martes foina* (Erxleben, 1777) is a widely occurring predator (M i t c h e l l - J o n e s et al. 1999, H e l t a i 2002) which also occurs in human settlements. A number of other studies have analysed the diet composition of martens living in rural or agricultural environments: in temperate climate zones (G o s z c z y n s k i 1977, R a s m u s s e n & M a d s e n 1985, G o s z c z y n s k i 1986, T e s t e r 1986, L o d e 1994, P o s i l l i c o et al. 1995, P a n d o l f i et al. 1996); in Mediterranean areas (S e r a f i n i & L o v a r i 1993, B e r m e j o & G u i t i a n 2000); in habitats in forest and rocky areas of highland regions (D e l i b e s 1978, L u c h e r i n i & C r e m a 1993, B r a n g i 1995) and in forested rural areas (G e n o v e s i et al. 1996). Although the stone marten is a common species, the feeding behaviour of individuals of the species occurring in human settlements is an area of knowledge in which little research has been performed (e.g. in Denmark: R a s m u s s e n & M a d s e n 1985; in Italy: L u c h e r i n i & C r e m a 1993; in Switzerland: T e s t e r 1986; in the Czech Republic: H o l i š o v á & O b r t e l 1982; in Belorussia: S i d o r o v i c h 1997). There is little information available on the feeding habits of stone martens living in human settlements and agricultural environments in Hungary (T ó t h 1998, L a n s z k i et al. 1999).

A previous examination (T ó t h 1998) was performed in a large city (the environs of Budapest) where the food resources available were primarily associated with humans. Therefore, the present study was focussed on examining a small village where stone martens could choose between food items originating from natural sources and those connected with the human settlement.

The aim of the present study was to examine the feeding habits of the stone martens living in the village and its surrounding agricultural environment. The trophic niche overlap between stone martens living in different environments was also studied, and the frequency distribution of prey species (weight, zonation and environment association) was determined by means of scat analysis.

Study Area

The study was performed in the small village of Fonó in south-western Hungary. This settlement contains orchards with various fruit trees and domestic animals kept in house yards, e.g. poultry, rabbits, sheep, goats and honey bees. The climate is moderate and continental; in the period of the study mean (± s.e.) temperature ranged between 20.4±0.34 °C in summer and 1.5±0.37°C in winter, while mean annual rainfall was 648±35.2 mm. The four-storey mill building inhabited by the stone martens, which is approximately 100 years old (46°23' N, 17°57' E), is situated in the village. The first floor was used only for crop storage and the mill was abandoned in 1999. The samples were collected in the unfrequented loft of the building, where the martens had built their nest. The nearest wetland habitat (stream and reed area) and pasture were 100 m away from the mill, the forest and fish pond 600–650 metres away.

The environs of the village are essentially characterised by arable agricultural cultivation with a diversity of other habitats. Samples were also collected in this agricultural environment. The distribution of the different habitats in the sample collection area was as follows: plough land 27.9%, pasture with trees 4.9%, game field and weed communities 8.7%, wetland (reed, bulrush, sedge, meadow and willow) 23.0%, oak wood 28.4%, fish pond and fishing-related areas 7.1% (more detail: Lanszki et al. 1999).

Material and Methods

The samples derived from the previous two years of sample collection did not allow seasonal evaluation to be performed; only period-dependent analysis was possible. The diet composition of the martens living in the agricultural environment between 1992 and 1995 has been reported by Lanszki et al. (1999), while data for 1996 and 1997 have not yet been published. The distribution of the samples collected in the different habitats was as follows: plough land 15.4%, pasture with trees 5.2%, game field and weed communities 7.8%, wetland (reed, bulrush, sedge, meadow and willow) 9.0%, wood 49.6% and fishing-related areas 13.0%. The samples collected were divided into three groups relating to the periods studied (before 1993, i.e. 1992 and 1993; 1994–1995; 1996–1997, Table 1). These designations were adjusted with respect to sample collection in the village and its surrounding agricultural environment.

The taxa of the diet components were determined on the basis of bones, dentition, hair fibre and feather morphology (e.g. März 1972, Teerink 1991, Brown et al. 1993, and own reference collection) with a standard method for scat analysis (Jedrzejewska & Jedrzejewski 1998). Diet composition was calculated on the basis of the relative occurrence frequency of the items identified in the scats. Relative frequency according to category of the various items was expressed on the basis of the minimum individual value data obtained.

The ten categories used in the trophic niche calculations were 1: voles, 2: mice, 3: other rodents (dormice and unidentifiable rodents) and European hare, 4: insectivores and bats, 5: predatory mammals and animal carcasses (ungulates), 6: domestic animals, 7: birds, 8: other

vertebrates (reptiles, amphibians and fish), 9: invertebrates (arthropods and molluscs) and 10: plant matter. Non-food (generally indigestible) substances ingested and hair fibres swallowed by the stone martens while grooming were not included in the calculation.

Trophic niche breadth was calculated in accordance with Levins: $B = 1/\Sigma p_i^2$, where p_i is the relative frequency of a given taxon (K r e b s 1989). Niche overlap was calculated by means of the Renkonen index [$P_{jk} = [\Sigma n(\text{minimum } p_{ij}, p_{ik})]x100$], where P_{jk} = percentage overlap between the stone martens occurring in the two environments (*j* and *k*); p_{ij} and p_{ik} = proportion accounted for by the *i*th food taxon (i.e., resource) in the diet of the stone martens living in environments *j* and *k* (the minimum signifying that the smaller value should be used); n = the number of food taxa (of the ten categories listed above) (K r e b s 1989). The Kruskal-Wallis test was used to compare the diet composition of the martens in the three periods. The χ^2 test was applied for distribution analysis for the diet composition of the martens living in the different environments. Distribution of prey body weight was determined in accordance with C l e v e n g e r (1993), to create five categories (<15; 15–50; 51–100; 101–300; >300 g). Prey classification on the basis of zonation (characteristic level of occurrence or the physical stratification where a species is most active) was performed according to G i t t l e m a n ' s published data on predators (1985) (1: terrestrial and terrestrial but sometimes arboreal, 2: arboreal and arboreal but sometimes terrestrial, and 3: aquatic). Prey species were classified on the basis of their typical environment associations (1: human-linked, 2: wild, and 3: mixed). The SPSS 7.5 statistics program (G r e e n et al. 1997) was used for the processing of the data obtained.

Results

Diet composition of the stone martens

The proportion of small mammals in the diet of the stone martens living in the village varied over a range of low values (mean 13.4%) and ranged between 10.8 and 15.5% during the different periods (Table 1). Among the small mammals occurring, mice (primarily the house mouse, *Mus musculus*) were predominant, and Norway rat, *Rattus norvegicus* was also eaten. In addition to species associated with human settlements, the diet of the martens rarely also included other, characteristically wild-living small mammals, such as the water vole, *Arvicola terrestris* and the bank vole, *Clethrionomys glareolus*. No predator species or ungulates occurred in the diet. The stone martens living in the village consumed domestic animals, e.g. poultry, egg, rabbit, sheep, pig, goat or cow relatively often (14.6%, Table 1). Birds were the dominant prey taxon (mean 20.0%, ranging between 19.8–20.5%). The most important among the birds was the house sparrow, *Passer domesticus*, but sometimes swallow, *Hirundo rustica* and redstart, *Phoenicurus* spp. occurred as prey. Martens only rarely preyed on snakes, *Colubridae* and anurans, *Anura* spp. The frequency of consumption of invertebrates was high (mean 16.9%) and varied between 13.4 and 19.5% in the different periods (Table 1). The insects occurring most frequently in the diet were the wasps, *Vespidae* spp.; the honey bee, *Apis mellifera* also occurred, and the martens probably also ate honey (D e l i b e s 1978, S e r a f i n i & L o v a r i 1993). Plants, mainly garden fruits, were the dominant food (34.7%) of the martens; consumption of these varied between 26.0 and 43.3% in the different periods (Table 1). Of the fruits available, sweet cherry *Cerasus avium* and sour cherry *Cerasus vulgaris* were consumed in the largest proportions.

Table 1. Diet composition of stone martens living in the village of Fonó and in its surrounding agricultural environment in different periods in south-western Hungary. * one-shot sampling (see methods).

Food items	Diet of the stone martens					
	in village			in agricultural environment		
	1993*	1995*	1998*	1992–93	1994–95	1996–97
	Relative frequency of occurrence, %					
Small and medium-sized mammals	**10.8**	**14.0**	**15.5**	**14.2**	**36.8**	**33.4**
Bats Chiroptera and insectivores Soricidae	0.7		0.2		1.1	1.4
Red squirrel *Sciurus vulgaris*				0.6	0.3	0.2
Dormice Myoxidae		0.5	0.2	1.3	1.4	0.4
Field mice *Apodemus* spp.	1.0	0.5	3.0	2.9	6.7	9.4
Norway rat *Rattus norvegicus*		1.0	1.1		0.3	1.0
House mouse *Mus musculus*	5.4	9.0	5.8	1.0	1.7	
Muskrat *Ondatra zibethicus*				0.3	0.6	0.6
Water vole *Arvicola terrestris*			0.2			
Other voles Microtinae	1.5	2.5	3.4	6.8	23.0	17.1
Unidentified rodents	2.2	0.5	1.5	1.3	1.4	2.9
European hare *Lepus europaeus*					0.3	0.4
Species eaten as carrion	**0.0**	**0.0**	**0.0**	**1.9**	**0.6**	**3.3**
Badger *Meles meles*				0.3		
Wild boar *Sus scrofa*					0.3	
Deer Cervidae spp.				1.6	0.3	3.3
Domestic animals	**12.2**	**19.0**	**14.8**	**5.8**	**2.5**	**3.1**
Poultry	3.4	6.0	3.7	3.5	0.6	1.4
Eggs (poultry)	6.8	10.5	9.7	0.6	0.3	0.6
Other domestic animals	2.0	2.5	1.5	1.6	1.7	1.0
Birds	**20.0**	**20.5**	**19.8**	**10.0**	**12.1**	**11.8**
House sparrow *Passer domesticus*	10.8	7.0	7.5			
Other perching birds Passeriformes spp.	8.3	10.5	11.6	9.7	11.2	11.0
Pheasant *Phasianus colchicus*				0.3	0.0	0.2
Medium-sized birds		2.5	0.2		0.3	
Eggs	1.0	0.5	0.4		0.6	0.6
Reptiles and amphibians	**0.2**	**1.0**	**0.0**	**0.3**	**0.3**	**0.8**
Snakes Colubridae and snake eggs		0.5		0.3	0.3	0.6
Anurans Anura spp.	0.2	0.5				0.2
Fish	**0.0**	**0.0**	**0.0**	**0.6**	**0.0**	**0.2**
Invertebrates	**13.4**	**19.5**	**18.9**	**23.5**	**16.9**	**18.1**
Carabid beetles Carabidae spp.	2.4	3.5	3.2	9.0	6.2	12.4
Other beetles Coleoptera spp.	2.0	6.0	5.8	6.1	1.1	3.5
Orthopterans Orthoptera spp.		1.0	0.6	0.3		0.6
Hymenopterans Hymenoptera spp.	6.6	7.5	7.1		2.2	0.4
Other insects	2.4	1.5	1.8	7.4	7.0	1.2
Gastropods			0.4	0.6	0.3	
Plants	**43.3**	**26.0**	**31.0**	**43.5**	**30.9**	**29.3**
Grape *Vitis vinifera*	2.7	2.0	3.7	2.3	4.5	1.6
Cherry *Cerasus avium* and *C. vulgaris*	18.3	8.5	5.8	27.4	9.0	4.1
Blackthorn *Prunus spinosa*	0.7		0.4	0.3	1.1	10.6
Mulberry *Morus* spp.	13.9		0.2			
Other fruits	5.6	12.0	13.1	7.7	12.1	11.0
Seeds	0.7	1.5	3.4	1.6	1.1	1.6
Other plant matter	1.2	2.0	4.3	4.2	3.1	0.4
number of scats analysed	181	91	151	139	163	270
number of items	409	200	465	310	356	491
B index	3.77	5.11	4.89	3.75	4.91	5.59

The diet composition of stone martens living in the village did not differ significantly in the three periods studied (Kruskal-Wallis test: χ^2= 1.24, df= 2, P= 0.54, n= 30 and 10 food taxa).

The predominant prey species eaten by the martens living in the agricultural environment were small mammals (29.9%), the major species among these being voles, primarily the common vole, *Microtus arvalis* (Table 1). Bat (common pipistrelle, *Pipistrellus pipistrellus*), mole, *Talpa europaea*, red squirrel, *Sciurus vulgaris*, common dormouse, *Muscardinus avellanarius* and muskrat, *Ondatra zibethicus* were also eaten by the martens, while the European hare, *Lepus europaeus* represented a very small percentage (0.3%). Consumption of domestic animals (mainly poultry) ranged on a low level (mean 3.6%). Predation on birds was 11.4%, the difference between periods being insignificant (10.0–12.1%). The birds eaten most frequently were primarily small perching birds; however, consumption of pheasant *Phasianus colchicus* and moorhen *Gallinula chloropus* also occurred, but infrequently. Other vertebrates such as grass snake *Natrix natrix* and its eggs, and also various fish were identified rarely (0.5%) in the diet. Invertebrates were often consumed by stone martens (mean 19.2%), their ratio ranging between 16.9 and 23.5%. The insects eaten most frequently were carabid beetles *Carabidae*, but dung beetles *Geotrupes* and stag beetle *Lucanus cervus* were also important in the diet. The food source of primary importance to the martens living in the agricultural environment were various plants, accounting for one third of the diet (mean 33.6%); their frequency varied between 29.3 and 43.5%. The most important plants for the martens were the sweet cherry and the sour cherry, alongside the blackthorn *Prunus spinosa*.

The diet composition of the stone martens living in the agricultural environment did not differ significantly in the three periods studied (Kruskal-Wallis test: χ^2= 1.56, df= 2, P= 0.46, n= 30, 10 food taxa).

Table 2. Occurrence of indigestible substances ingested by stone martens living in the village of Fonó and in its surrounding agricultural landscape in different periods in south-western Hungary. * one-shot sampling (see methods)

Type of substance	Indigestible matter in the diet of stone martens					
	in village			in agricultural environment		
	1993*	1995*	1998*	1992–93	1994–95	1996–97
	Cases of occurrence					
Pieces of nylon/plastic		1	1			
Fishing line			2			
Plastic twine	3		2			
Pieces of rubber		4	8			
Condoms			1			
Salami skin		1	1			
Milk bags	1	1	1			
Imitation leather			1			
Aluminium foil		1	5		1	
Pieces of glass		1	1			
Thread		1	2			
Hemp yarn	7					
Paper	1	5	3		1	
Pieces of brick			2			
Cinders			1			
Pebbles			4	1	1	
number of items	12	15	35	1	3	-

Indigestible matter often occurred in the diet of the stone martens living in the village and rarely in that of those living in the agricultural environment. A great diversity of refuse was eaten by the martens in the village, the most frequently occurring substances being various kinds of rubber (Table 2). The difference in frequency of refuse eating between the village martens and those living in the agricultural environment was significant (χ^2= 53.79, df= 1, P< 0.001, n= 2297).

Trophic niche breadth, overlap and diet similarity

The samples for the stone martens living in the village contained 50 prey and 23 plant taxa, while the samples for those in the agricultural environment contained 68 and 18 taxa respectively. Trophic niche breadth for the diet of the martens living in the village varied between 3.77 and 5.11 in the different periods; for those living in the agricultural environment, the variation was between 3.75 and 5.59 (Table 1). Trophic niche overlap between the stone martens living in the village and those living in its surrounding agricultural habitat was high, ranging from 80 to 85%. Independently of high overlap, there were significant differences in diet composition between the martens living in the different environments in the three periods studied (Table 1).

As plant consumption was found to reach similar values in the two environments (Table 1), further evaluation was based on prey species.

Environment-dependent differences between the martens

With respect to the weight of prey species eaten, predation by the stone martens living in the village and the agricultural landscape differed significantly (χ^2= 85.71, df= 4, P<0.001, n= 1469). Half of the prey items were in the 15–50 gramme weight category (47.3 and 55.1%, in the village and in the agricultural landscape, respectively); however, weight was also important where prey weighed below 15 g (26.9 and 31.1% resp.) and above 50 g (25.8 and 13.8% resp.) (Fig. 1).

Prey distribution for the martens living in the various environments also differed (χ^2= 32.10, df= 2, P<0.001, n= 1469) with respect to the characteristic zonation of the prey species consumed. The stone martens typically hunted on terrestrial prey (68.4 and 81.0%, resp.); however, relatively frequently (30.9 and 17.2% resp.) individuals living in the village chose prey species living in bushes, under the eaves of buildings, or in trees (Fig. 2).

A substantial difference between the stone martens living in the village and in the agricultural landscape was also observed (χ^2= 472.25, df= 2, P<0.001, n= 1469) with respect to distribution of the characteristic place of occurrence (i.e. association) of the various prey species. The diet of the martens living in the agricultural environment consisted mainly of wild prey, while those hunting in the village essentially consumed prey (49.9%) associated with human settlements also containing a small proportion (10.0%) of wild prey (Fig. 3). Samples collected in the agricultural environment showed an inverse proportion (9.5 and 58.4%, resp.).

Discussion

On the basis of this examination it can be established that the feeding habits of the stone martens living in the village and its surrounding agricultural environment were similar from only a few aspects; however, significant differences were observed with respect to environment (Tester 1986).

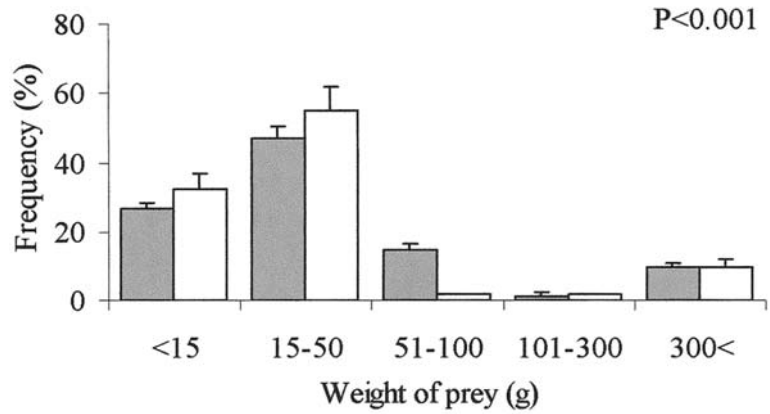

Fig. 1. Distribution frequency (mean±s.e.) of prey species in the diet of stone martens living in the village of Fonó (shaded bars) and its surrounding agricultural environment (open bars) on the basis of prey weight.

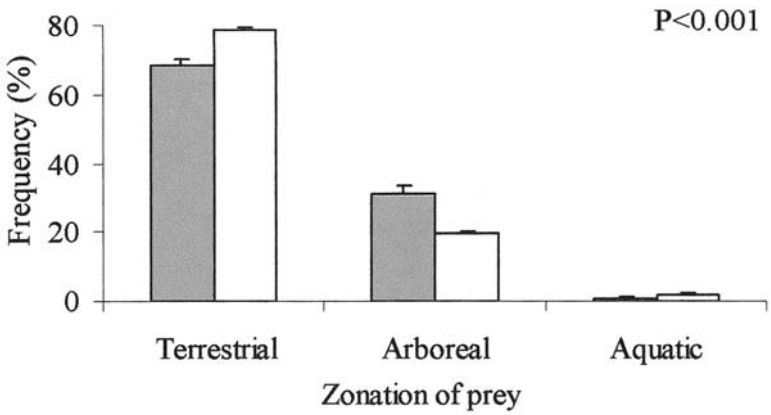

Fig. 2. Distribution frequency (mean±s.e.) of prey species in the diet of stone martens living in the village of Fonó (shaded bars) and its surrounding agricultural environment (open bars) on the basis of prey zonation.

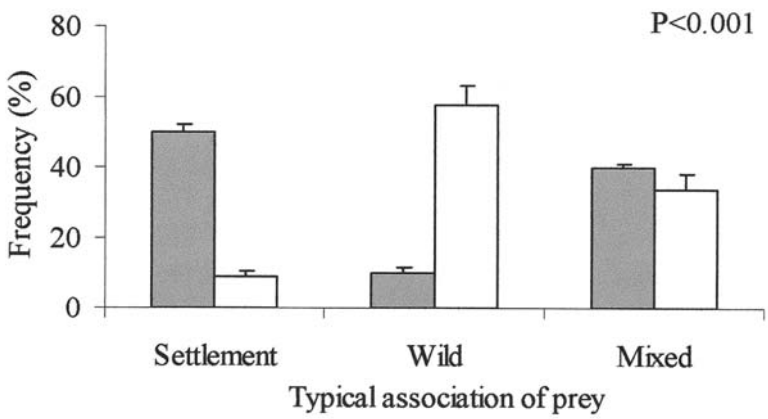

Fig. 3. Distribution frequency (mean±s.e.) of prey species in the diet of stone martens living in the village of Fonó (shaded bars) and its surrounding agricultural environment (open bars) on the basis of habitat association of prey.

Trophic opportunism (Waechter 1975, Delibes 1978, Holišová & Obrtel 1982, Goszczynski 1986, Rasmussen & Madsen 1985, Mitchell-Jones et al. 1999) was characteristic of the stone martens, irrespective of their environment. This observation was supported by the variety of food sources consumed, wide niche and relatively balanced diet composition. The trophic niche overlap between martens living in the different environments was high. This was, supported by the fact that the food sources eaten by the martens contained relatively great amounts of plant matter; this proved independent of the environment inhabited. Plant matter also includes garden and wild fruit species, these being important for martens (Pandolfi et al. 1996). Stone martens also play a role in the dispersal of seeds (Herrera 1998), thus helping to broaden their own variety of available food sources. The frequency with which plants were eaten by the stone martens was found to be similar, independently of the environment, in all three periods. According to Delibes (1978), Serafini & Lovari (1993), Brangi (1995), Pandolfi et al. (1996) and Lanszki et al. (1999), stone martens eat fruit throughout the year, even in winter.

Environment-dependent difference proved significant in the case of prey (or carrion) consumption; that is, the diet of the martens living in the village and its surrounding agricultural environment was found to differ in all three periods. Diet composition was similar in consecutive periods; only small differences were observed with respect to environment. This means that period-dependent (inter-habitat) differences were not apparent; the martens utilised the food resources available to similar degrees. This supports Tester's statement (1986) that intra-habitat variability of diet is higher than inter-habitat variability.

The importance of environmental resources was marked by differences in the consumption rates of certain prey species. In human settlements not only garden fruit but also domestic animals and their slaughter remains, in addition to certain rodents and birds such as the house mouse, the Norway rat, the house sparrow etc. (Holišová & Obrtel 1982, Rasmussen & Madsen 1985, Lucerini & Crema 1993, Sidorovich 1997, Tóth 1998), can be classified as potential food resources associated with human activity; these occurred less frequently in the diet of the stone martens living outside the village.

Consumption of small mammals varies largely in relation to geographical area. Lower ratios have been recorded in a sub-Mediterranean area (Brangi 1995), but in rural areas in western and northern Europe (Rasmussen & Madsen 1985, Goszczynski 1986, Lodé 1994) studies have found higher degrees of predation on small mammals by stone martens. In this study the stone martens living in the village consumed half as many small mammals (13.4%) as those living in the agricultural environment (29.3%), where small terrestrial mammals are the most important prey items in the diet of martens, as has been reported in other studies (Delibes 1978, Rasmussen & Madsen 1985, Goszczynski 1986, Serafini & Lovari 1993). The martens living in the village preyed mainly on mouse species, while those living in the agricultural environment preyed mainly on voles.

As with studies performed in parallel in human settlements and agricultural environments (Rasmussen & Madsen 1985, Tester 1986), greater consumption of domestic animals and birds was recorded in the village. However, such high consumption of domestic animals (mean 14.6%) had not been reported previously. Presumably customs of animal keeping differ: poultry was kept in every yard in the village studied. Environment-

dependent difference proved insignificant with respect to predation of other vertebrates and invertebrates. Examination of the consumption of indigestible objects derived from rubbish revealed a large difference between the stone martens living in the different environments: higher frequency was recorded in the village, while consumption was much lower in the more natural and agricultural areas, as has been observed in other studies (e.g. Rasmussen & Madsen 1985, Lucerini & Crema 1993, Serafini & Lovari 1993, Tóth 1998). The martens living in the village typically took their food from rubbish more frequently.

This study did not include radio tracking; therefore it can only be postulated that there was no particularly great overlap between the ranges of the village martens and those living in the agricultural environment (Rasmussen & Madsen 1985, Genovesi et al. 1997). This may be corroborated by the results of the diet analysis performed (i.e., consumption of wild prey species and fruit and those found in association with human settlement), or by radio telemetry studies performed in villages, on farmland and in forests (summarised by Herrmann 1994).

With respect to consumption of indigestible matter (probably originating from rubbish) great differences were observed between the martens hunting in the different environments (Table 2), as in the findings of other studies (Rasmussen & Madsen 1985, Lucerini & Crema 1993, Tóth 1998).

However, hunted prey of 15 to 50 g weight was important in the diet of the martens living in the village and of those living in the agricultural environment; this category consisted mostly of rodents and perching birds. The martens in the village ate heavier prey, due to the higher frequency of domestic animal consumption, compared to the martens living in the agricultural environment. In the agricultural environments small terrestrial mammals between 15 and 50 g were the major prey in the diet of the martens, as has been found in other studies (Delibes 1978, Rasmussen & Madsen 1985, Goszczynski 1986, Serafini & Lovari 1993). House mouse and Norway rat occurred in the diet of the martens living in the agricultural environment, but in smaller proportions than with the martens living in the village. The badger, *Meles meles* occurring in the diet of the martens living in the agricultural environment could, in all probability, have been eaten as carrion (Delibes 1978, Jedrzejewska & Jedrzejewski 1998, Brangi 1995, Lanszki et al. 1999), as could the wild boar, *Sus scrofa* and the various species of deer (red deer, *Cervus elaphus* and roe deer, *Capreolus capreolus*). The latter benefit from a higher density of potential food items and from the presence of prey species which are easier to catch, e.g. domestic animals, pigeon, house mouse and sparrow (Holišová & Obrtel 1982, Rasmussen & Madsen 1985, Lucerini & Crema 1993, Sidorovich 1997, Tóth 1998); these species account for the greater part of their prey. The task of carrying prey of greater weight (above 300 g) – chiefly domestic animals – to the nest or feeding place presents no obstacle to predation for the marten.

The stone martens living in the village preyed on more arboreal species and fewer terrestrial prey species than those living in the agricultural environment (Fig. 2). This may be connected with the greater predation on birds observed in the village, where house sparrow living under the eaves of buildings or in stacks was the main prey preference. Despite the proximity of aquatic habitats, the martens rarely preyed on vertebrates associated with water, e.g. water vole, fish, certain birds, reptiles and amphibians (Delibes 1978, Holišová & Obrtel 1982, Rasmussen & Madsen 1985, Serafini & Lovari 1993, Lodé 1994, Sidorovich 1997). However, these

food resources were available for the martens, particularly in the agricultural habitat studied; 21% of the samples were collected on wetlands or in areas related to fishing, but prey species associated with water did not play a significant role in the diet.

The environment-dependent difference was also important with respect to the association of the prey species either to human or to wild habitats. The stone martens living in the village more frequently consumed prey species associated with humans, e. g. domestic animals, house mouse and house sparrow (and food derived from rubbish), which occasionally caused conflict (Mitchell-Jones et al. 1999); in contrast, those living in the agricultural environment ate predominantly wild prey species (voles, small game and forest rodents).

In addition to partial shared utilisation of some food resources, characteristic environment-dependent differences were also observed; these provide evidence of the particular adaptability of the stone marten.

Acknowledgements

I am grateful to S. Körmendi and two anonymous referees for advice in the composition of the manuscript, and also to D.L. Moss and to A. Szabó for their help in the English proofreading. This work was supported by the Hungarian Fund for Scientific Research (OTKA, F 23057) and the Bolyai scholarship.

LITERATURE

BERMEJO T. & GUITIAN, J. 2000: Fruit consumption by foxes and martens in NW Spain in autumn: A comparison of natural and agricultural areas. *Folia Zool. 49: 89–92*.

BRANGI A. 1995: Seasonal changes of trophic niche overlap in the stone marten (*Martes foina*) and the red fox (*Vulpes vulpes*) in a mountainous area of the Northern Appenines (Italy). *Hystrix 7: 113–118.*

BROWN R., FERGUSON J., LAWRENCE M. & LEES D. 1993: Federn, Spuren & Zeichen der Vögel Europas: Ein Feldführer. *Aula-Verlag, Wiesbaden.*

CLEVENGER A.P. 1993: Pine marten (*Martes martes* Linné, 1758) comparative feeding ecology in an island and mainland population of Spain. *Z. Säugetierk. 58: 212–224*.

DELIBES M. 1978: Feeding habits of the stone marten, *Martes foina* (Erxleben, 1777), in northern Burgos, Spain. *Z. Säugetierkd. 43: 282–288*.

GENOVESI P., SECCHI M. & BOITANI L. 1996: Diet of stone marten: an example of ecological flexibility. *J. Zool. Lond. 238: 545–555*.

GENOVESI P., SINIBALDI I. & BOITANI L. 1997: Spacing patterns and territoriality of the stone marten. *Can. J. Zool. 75: 1966–1971*.

GITTLEMAN J.L. 1985: Carnivore body size: ecological and taxonomic correlates. *Oecologia 67: 540–554*.

GOSZCZYNSKI J. 1977: Connections between predatory birds and mammals and their prey. *Acta Theriol. 22: 399–430*.

GOSZCZYNSKI J. 1986: Diet of foxes and martens in central Poland. *Acta Theriol. 31: 491–506*.

GREEN S.B., SALKIND N.J. & AKEY T.M. 1997: Using SPSS for Windows: analyzing and understanding data. *Prentice Hall, New Jersey*.

HELTAI M. 2002: The status and distribution of mammal predators in Hungary. *Doctoral thesis, St. Stephen Univ., Gödöllő, Hungary*.

HOLIŠOVÁ V. & OBRTEL R. 1982: Scat analytical data on the diet of urban stone martens, *Martes foina* (Mustelidae, Mammalia). *Folia Zool. 31: 21–30*.

HERRERA C.M. 1989: Frugivory and seed dispersal by carnivorous mammals, and associated fruit characteristics, in undisturbed Mediterranean habitats. *Oikos 55: 250–262*.

HERRMANN M. 1994: Habitat use and spatial organization by the stone marten. In: Buskirk S.W., Harestad A.S., Raphael M.G. & Powell R.A. (eds), Martens, sables and fishers biology and conservation. *Cornell University Press, Ithaca, London*.

JEDRZEJEWSKA B. & JEDRZEJEWSKI W. 1998: Predation in vertebrate communities. The Bialowieza Primeval Forest as a Case Study. *Springer-Verlag, Berlin, Heidelberg, New York*.

KREBS C.J. 1989: Ecological methodology. *Harper Collins Publishers, New York*.

LANSZKI J., KÖRMENDI S., HANCZ C. & ZALEWSKI A. 1999: Feeding habits and trophic niche overlap in a Carnivora community of Hungary. *Acta Theriol. 44: 429–442*.

LODE T. 1994: Feeding habits of the stone marten *Martes foina* and environmental factors in western France. *Z. Säugetierkd. 59: 189–191*.

LUCHERINI M. & CREMA G. 1993: Diet of urban stone martens in Italy. *Mammalia 57: 274–277*.

MÄRZ R. 1972: Gewöll- und Rupfungskunde. *Akademie Verlag, Berlin*.

MITCHELL-JONES A.J., AMORI G., BOGDANOWICZ W., KRYŠTUFEK B., REIJNDERS P.J.H., SPITZENBERGER F., STUBBE M., THISSEN J.B.M., VOHRALÍK V. & ZIMA J. 1999: The Atlas of European Mammals. *T & AD Poyser Ltd. London*.

PANDOLFI M., MARINIS DE A.M. & PETROV I. 1996: Fruits as a winter feeding resource in the diet of stone marten (*Martes foina*) in east-central Italy. *Z. Säugetierkd. 61: 215–220.*

POSILLICO M., SERAFINI P. & LOVARI S. 1995: Activity patterns of the stone marten *Martes foina* Erxleben, 1777, in relation to some environmental factors. *Hystrix 7: 79–97*.

RASMUSSEN A.M. & MADSEN A.B. 1985: The diet of the stone marten *Martes foina* in Denmark. *Natura Jutlandica 8: 141–144*.

SERAFINI P. & LOVARI S. 1993: Food habits and trophic niche overlap of the red fox and the stone marten in a Mediterranean rural area. *Acta Theriol. 38: 233–244*.

SIDOROVICH V. 1997: Mustelids in Belarus. *Zolotoy uley publisher, Minsk*.

TEERINK B.J. 1991: Hair of West-European mammals. *Cambridge University Press, Cambridge*.

TESTER U. 1986: Vergleichende Nahrungsuntersuchung beim Steinmarder *Martes foina* (Erxleben, 1777) in groβstädtischem und ländlichem Habitat. *Säugetierk. Mitt. 33: 37–52.*

TÓTH A.M. 1998: Data to the diet of the urban stone marten (*Martes foina* Erxleben) in Budapest. *Opusc. Zool., Budapest, XXXI: 113–118*.

WAECHTER A. 1975: Ecologie de la fouine en Alsace. *Terre et Vie 29: 399–457*.