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Stone marten (*Martes foina* Erxleben, 1777) use of different landscape types in the mountains of central Spain

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Previous studies on habitat selection by stone martens (*Martes foina*) indicate that they occupy a range of different habitats and geographical regions from forest and rocky areas to human environments (Libois and Waechter 1991). In most of central Europe, the stone marten is mainly associated with human environments (Waechter 1975; Skirnisson 1986; Libois and Waechter 1991; Herrmann 1994). In contrast, in central Spain (Mediterranean region), the species prefers forest to human enviromnents in forest-dominated landscapes (Virgós and Casanovas 1998). However, in such landscapes, stone martens may also occur in rocky areas (Heptner and Naumov 1974; Delibes 1983; Libois and Waechter 1991), which is thought to be their preferred habitat in most of the Mediterranean area (Waechter 1975; Delibes 1983). Stone marten preference for forest or rocky landscapes in Mediterranean landscapes, therefore, needs to be evaluated in the field.

In this study, we investigate the presence of stone martens in different landscape types in central Spain during winter, a very restricted season for marten species.

The study was carried out in the mountains of central Spain (Sierra de Guadarrama, 40°40′ N-3°51′ W, Madrid province) over 1 600 km^2. Fifteen relatively homogeneous 4 × 4-km patches (henceforth known as plots) were selected in terms of their rock and tree cover, vegetation formations, and predominant human usage. All plots were located between 1 100 and 1 350 m a. s. l. and were at least 2.5 km apart. The predominant vegetation is pine forest (especially Scots pine *Pinus sylvestris*) as the stone marten is known preferentially to select this forest type in the mountains of central Spain (Virgós and Casanovas 1998). The selected plots have a warm, semi-dry, Mediterranean climate with cool summers and moderately cold winters, with snow being not uncommon but not very persistent (Rivas-Martínez et al. 1987). Human land-use was similar between plots, the most important being weekend recreational use and forestry. Hunting is restricted, only being allowed in the study areas when wild boar *Sus scrofa* populations increase.

Plots were classified as rocky, forested or mosaic according to estimated tree and rock cover (Tab. 1). Thus, we assigned a plot to the forest category when tree cover in that plot was above 50% and rock cover under 10–15%. Similarly, we considered a plot to be located in a rocky landscape when rock cover was over 50% and tree cover under 10%. Landscapes with rock and tree cover not included in the intervals mentioned for rocky and forested landscapes were classified as mosaic.

The study was carried out from November to early March 1996 and 1997, the more restrictive season for martens (Buskirk et al. 1988; Libois and Waechter 1991). Stone marten scat was sampled by walking a series of routes along randomly selected tracks

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Table 1. Mean tree and rock cover, number of sampled sections and frequency of occurrence of scat in the different plots sampled in relation to defined landscape types.

Landscape type	Tree cover (%)	Rock cover (%)	Number of sampled sections	Scat frequency of occurrence
Rocky	5.6	76.4	16	0.06
Rocky	2.0	51.9	10	0.10
Rocky	0.4	50.0	12	0.08
Rocky	2.5	47.7	13	0
Rocky	0.8	54.4	16	0.06
Mosaic	19.4	62.1	15	0.27
Mosaic	49.2	29.1	13	0.31
Mosaic	21.1	45.0	10	0.70
Mosaic	57.2	21.2	16	0.62
Mosaic	52.0	43.0	9	0.44
Forested	57.3	8.9	11	0.64
Forested	45.8	9.9	16	0.19
Forested	74.8	1.2	16	0.06
Forested	50.9	9.1	11	0.45
Forested	66.2	12.5	16	0.06

and paths in the plots (Waechter 1975). In order to avoid potential differences in visibility, we sampled tracks of similar width and vegetation characteristics. Minimum and maximum distances travelled were 2.25 km and 4 km, respectively, along a 2 m-wide belt. Each route was divided into 250 m-long sections in which we recorded the presence or absence of stone marten scat and scat number (see Clevenger 1993 for similar procedures). Eight of the 15 plots were sampled in both winters to test for possible changes in occurrence patterns within plots between years. The remaining 7 plots were only sampled in the second winter. In addition to scat searches, we estimated both tree and rock cover along each route. Cover estimation of these variables was made at the midpoint of the 250 m sections on each route by visual inspection. The number of 250-m sections sampled per plot is given in table 1.

To study the distribution pattern between the different landscape types, a frequency of occurrence index was used, measured as the number of sections with scats divided by the total number of sections sampled for each plot. To evaluate the potential differences in the frequency of occurrence between the two years, we performed a Fisher exact test applied to a 2×2 contingency table with the number of sections with stone marten presence or absence as rows and the years as columns (Sokal and Rohlf 1981). Stone marten distribution pattern between the different landscapes was analysed using a fixed one-way ANOVA with the numbers of sections with scat (frequency of occurrence) as a response variable and landscape type (rocky, forested or mosaic) as the fixed factor. The frequency of occurrence values were logarithm-transformed to obtain data normality and homocedasticity prior to analyses.

The plots did not show significant differences in the frequency of occurrence values between the two study years (1: $p = 0.99$; 2: $p = 0.39$; 3: $p = 0.99$; 4: $p = 0.11$; 5: $p = 0.21$; 6: $p = 0.20$; 7: $p = 0.99$; 8: $p = 0.99$). Our results indicate that the distribution pattern was fairly constant at least for two consecutive years. Thus, only the data from the second winter with a larger sample were used in the subsequent analyses.

The different values of the frequency of occurrence index between landscape types were highly significant (Fig. 1). The Duncan post-hoc test shows that these differences are due to lower numbers of stone marten in rocky areas compared with mosaic and forested

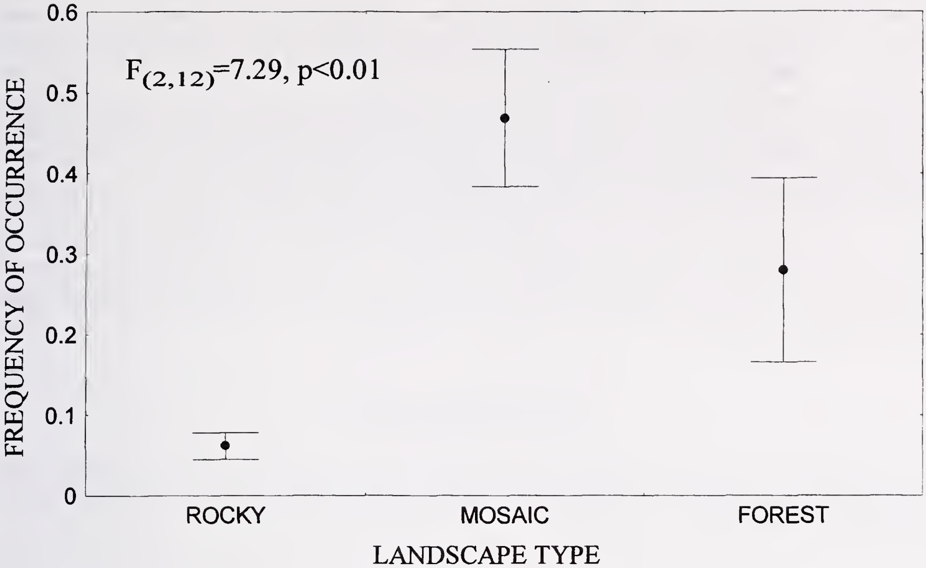

Fig. 1. Results of the one-way ANOVA with landscape type as a fixed factor (three levels) and number of sections in the transects with stone marten scat (frequency of occurrence) as response variables.

landscapes. No statistically significant differences occurred between the forested and mosaic landscapes ($p = 0.12$).

Research on stone marten habitat preferences has focused on radio-telemetry of several marked individuals within small areas (e. g. Skirnisson 1986; Herrmann 1994; Genovesi et al. 1996), where habitat selection was evaluated at individual levels (e. g. decision-making within home ranges). Our interest in habitat preferences at the population level makes comparisons with previous studies difficult and probably biased. However, several important points can be discussed regarding the results.

In contrast to previous studies (Libois and Waechter 1991), the stone marten shows a certain habitat choice in the mountains of central Spain (see also Virgós and Casanovas 1998). Thus, on a regional scale, the stone marten is found in greater numbers in the mosaics of forest-rocky areas than in mainly rocky landscapes without forests in contrast to earlier results in other areas (Heptner and Naumov 1974; Waechter 1975; Delibes 1983). We may suggest that, like other Martes species (Buskirk and Powell 1994), the stone marten presents a definite forest habitat preference when living in forest-dominated landscapes. In contrast, in non-forested landscapes, a habitat shift to open landscapes, such as rocky areas in some Mediterranean areas or buildings in central Europe (see discussion in Virgós and Casanovas 1998) would probably be advantageous for the species. Thus, in the non-forested but rocky areas of some Mediterranean regions (e. g. the Spanish plateau) the stone marten may occur in the rocky landscapes of hills or canyons.

The above-mentioned pattern could be explained by a combination of the mechanisms put forth to explain habitat selection in stone martens: food, predation risk, and shelter (Libois and Waechter 1991; Herrmann 1994; Thompson and Harestad 1994) despite the lack of quantitative estimates for them. We suggest that the low numbers in rocky landscapes could be explained by the high potential predation risk due to low tree cover and high numbers of eagle-owl (*Bubo bubo*), one of the most important predators on stone marten (Waechter 1975). Other predators such as red foxes and dogs are widespread and probably may affect stone marten numbers similarly in all landscape types. Therefore, they cannot produce the differences in abundace detected. Food availability (especially rodents, insects, and fleshy fruits) is probably as abundant in rocky landscapes as in forested or mosaic landscapes. Thus, rodents occur in similar numbers in the different landscape types, which are located at the same elevation and in similar scrub composition and cover, both being the main determinants of abundance and diversity of these taxa in mountains (Owen 1990; Alcántara 1992). Fleshy fruits are mainly located along small streams (Rivas-Martínez et al. 1987), which were very common in all the study plots. Shelters (rock holes or hollow trees) were widely available over all plots and landscape types. Therefore, these factors are probably less important than predation risk as a reason for the low numbers of stone marten in rocky areas. On the other hand, the pattern is consistent for the winter season, but the relative value of the different landscape types may change with season.

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References

Alcántara, M. (1992): Preferencias de hábitat de los micromamíferos de la Sierra de Guadarrama. Diss. thesis, Universidad Complutense, Madrid.

Buskirk, S. W.; Powell, R. A. (1994): Habitat ecology of Fishers and American martens. In: Martens, Sables and Fishers. Ed. by S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell. Ithaca: Cornell University Press. Pp. 283–296.

Buskirk, S. W.; Harlow, H. J.; Forrest, S. C. (1988): Temperature regulation in American marten (*Martes americana*) in winter. Nat. Geogr. Res. **4**, 208–218.

Clevenger, A. P. (1993): Sign surveys as an important tool in carnivore conservation research and management programmes. In: Seminar on the Management of Small Populations of Threatened Mammals. Sofia, Bulgaria: Council of Europe. Pp. 44–54.

Delibes, M. (1983): Interspecific competition and the habitat of the stone marten, *Martes foina* in Europe. Acta Zool. Fenn. **174**, 229–231.

Genovesi, P.; Secchi, M.; Boitani, L. (1996): Diet of the stone martens: an example of ecological flexibility. J. Zool. (London) **238**, 545–555.

Heptner, N. V.; Naumov, N. P. (1974): Die Säugetiere der Sowjetunion. Bd. II. Jena: Fischer Verlag.

Herrmann, M. (1994): Habitat use and spatial organization by the stone marten. In: Martens, Sables and Fishers. Ed. by S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell. Ithaca: Cornell University Press. Pp. 122–136

Libois, R.; Waechter, A. (1991): La Fouine (*Martes foina*). In: Encyclopédie des carnivores de France. Ed. by M. Artois and P. Delattre. Bohallard, Puceul: Societé Française pour l'Étude et Protection des Mammifères.

Owen, J. G. (1990): Patterns of mammalian species richness in relation to temperature, productivity and variance in elevation. J. Mammalogy **71**, 1–13.

Rivas-Martínez, S.; Fernández-González, F. A.; Sánchez-Mata, D. (1987): El Sistema Central: de la Sierra de Ayllón a Serra da Estrela. In: La vegetación de España. Ed. by M. Peinado and S. Rivas-Martínez. Madrid: Publ. Univ. Alcalá. Pp. 419–451.

Skirnisson, K. (1986): Untersuchungen zum Raum-Zeit-System freilebender Steinmarder (*Martes foina*). Beitr. Wildbiol. **6**, 1–200.

Sokal, R. R.; Rohlf, F. J. (1981): Biometry. 2nd ed. San Francisco: Freeman.

Thompson, I. D.; Harestad, A. S. (1994): Effects of logging on American martens, and models for habitat management. In: Martens, Sables and Fishers. Ed. by S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell. Ithaca: Cornell University Press. Pp. 355–367.

Virgós, E.; Casanovas, J. G. (1998): Distribution patterns of the stone marten (*Martes foina*) in Mediterranean mountains of central Spain. Z. Säugetierkunde **63**, 193–199.

Waechter, A. (1975): Écologie de la Fouine en Alsace. Rev. Ecol. (Terre Vie) **29**, 399–457.

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