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# HABITAT REQUIREMENTS OF THE STONE MARTEN *(MARTES FOINA)* ON THE TYRRHENIAN SLOPES OF THE NORTHERN APENNINES

ORESTE SACCHI & ALBERTO MERIGGI

*Dipartimento di Biologia Animale, Università di Pavia, Piazza Botta 9, 27100 Pavia, Italy*

ABSTRACT – Habitat requirements of stone martens (*Martes foina*) were studied in southern slope of northern Apennines (Genoa province, NW Italy) in autumn 1992. One hundred two sample areas each of 1 km² were randomly selected in the different habitat types of the region. In each sample area the presence and abundance of the species were assessed by looking for the signs as scats and tracks along 1 km transects. Twenty five habitat variables were then measured by aerial photographs at 1:10 000 scale. The proportion of signs in the different habitat types was also calculated. The influence of habitat variables on presence-absence and abundance of stone martens was studied by discriminant function and correlation analyses; besides habitat selection was analyzed by $x^2$ test and Bonferroni simultaneous confidence intervals. The density of isolated houses, the wood fragmentation index, the percentage of Mediterranean shrubs and that of conifer forests were the habitat variables that mainly contributed to the discrimination of the squares with stone marten signs from those without signs. The abundance index averaged 0.8 signs per km (SE = 0.15; min-max = 0 - 1i) and was positively correlated to the density of isolated houses (r = 0.392; P = 0.0) and to the percentage of culiivated areas (r = 0.221; P = 0.025); a negative correlation with altitude was found (r = - 0.221; **P** = 0.025). Stone martens selected shrubs and avoided deciduous forest and pastures.

Key words: *Martesfoina,* Habitat selection, Habitat variables, Italy.

RIASSUNTO – *Preferenze ambientali della faina* (Martes foina) *nel versante tirrenico dell'Appennino settentrionale* – Nell'autunno 1992 sono state studiate le preferenze ambientali della faina *(Martesfoina)* nell'Appennino settentrionale in provincia di Genova. Sono stati esaminati 102 quadrati campione, ognuno con superficie di 1 km², distribuiti in maniera casuale. Per ogni area campione sono state misurate, da fotografie aeree in scala 1:10.000, 25 variabili ambientali ed è stato percorso un transetto di 1 Km dove venivano ricercati i segni di prcscnza della specie quali orme e feci. L'influenza delle variabili ambientali su prcscnza-assenza della specie e sull'abbondanza dei segni rilevati è stata studiata utilizzando le analisi di funzione discriminante e di correlazione rispettivamente; in aggiunta, l'uso dell'habitat è stato analizzato tramite il test del $x^2$ e gli intervalli fiduciali di Bonferroni. La densità delle case isolate, l'indice di frammentazione dei boschi, la percentuale di arbusteti mediterranei e i boschi di conifere erano le variabili ambientali che contribuivano in misura maggiore alla discriminazione delle aree campione con segni di presenza della faina da quelle in cui la specie non era accertata. L'indice di abbondanza, media = 0,8 segni per Km (ES = 0,15; rnin-max = 0-1 i) è risultato correlato positivamente con la densità di case isolate (r = 0,392; **P** = 0,0) e con la percentuale di zone coltivate (r = 0,221; P = 0,025): una correlazione negativa è invece risultata con l'altitudine ( r = - 0,221; P =

0,025). Dall'analisi dell'uso dell'habitai risulta che la faina seleziona gli arbusteti, mentre sembra evitare le estese superfici boscatc di latifoglie e i pascoli.

Parolc chiave: *Martes foina*, Selezione dell'habitat, Variabili ambientali, Italia

## INTRODUCTION

The stone marten *(Martes foina)* is considered to be an adaptable predator (Libois, 1991); it mainly occurs in rocky habitats and forests and neighbouring areas. In central Europe the species seems to be closely linked to densely inhabited zones and is rarely found in large and homogeneous forests where the pine marten *(Martes martes)* occurs (Delibes, 1983). In Alsace, Waechter (1975) recorded the presence of stone martens only around villages (95.2 % of captures were within 500 m of human settlements); this is also true in Denmark, in Western Germany and in Czechoslovakia (Delibes, 1983). Competition between the stone marten and the pine marten may explain this pattern of habitat occupancy. In fact the stone marten is a synanthropic species where it coexists with the pine marten. Another hypothesis that may explain this behaviour is this species' preference for warm and rocky habitats; thus houses would be a good replacement for rocky cliffs.

In some countries such as Pakistan (Robert, 1977), the former USSR (Novikov, 1962), Spain (Delibes, 1978) and in southern Europe stone martens are less closely linked to inhabited areas and can be found in both woody and rocky habitats (Waechter, 1975; Delibes, 1983; Libois, 1991).

The aim of this study was to identify the habitat variables that determine the presence and abundance of the stone marten and to analyse patterns of habitat selection in a region where the pine marten did not occur.

## STUDY AREA AND METHODS

The study was carricd out in 1992 on 102 sample squares of 1 $km^2$, randomly distributed on thc Tyrrhcnian slopes of the northern Apennines in Genoa province (Northern Italy).

Landscape use and structure were very heterogeneous because of the wide altitudinal range (0 - 1650 m a.s.l.) and of tlic presence of several small valleys. It was possible to distinguish three zones in the study area: a) the coastal zone, b) the hilly zone and c) the mountain zone. The climate was Mcditcrranean type; precipitation averaged 1600 mm/year and the mean annual temperature was 8 °C.

In each sample squarc wc looked for stone marten tracks and scats along a transect of minimum lcngth 1 km, and measured 25 habitat variables on aerial photographs at a scalc of 1:10 000 (Tab. 1). Broad-leaved forests averaged 52.8 % of the sample, conifer forests 6.3 %, shrubs 3.2 %, pasture 27.7 % and cultivatcd areas 10 % . For each square we calculated an abundance indcx of ihc stone marten expressed as number of signs/km.

We used Discriminant Function Analysis (DFA, stepwise procedurc and Wilks' method) to differentiate the squarcs with and without signs of stone martens and to identify the most important habitat variables discriminating the two types of squares. All thc variables were tested by one-way ANOVA to vcrify the existence of significant differences between squares with and without stonc martens signs. We performed correlation analyses between thc abundance index and the values of the habitat variablcs in each square to evidence the relationships between abundance and any variables.

Tab. i - Average values of the habitat variables measured in the sample squares (N = 102: 1-15 variables expressed as percentage, 22-25 in m: SE = Standard Error).

| HABITAT VARIABLES | AVERAGE | SE | MIN-MAX |
|---|---|---|---|
| 1. Conifer forest | 2.6 | 0.86 | 0.0 - 67.0 |
| 2. Thermophylus conifer forest | 2.7 | 0.91 | 0.0 - 65.5 |
| 3. Thin conifer forest | 0.9 | 0.45 | 0.0 - 39.0 |
| 4. *Castanea sativa* forest | 26.3 | 2.48 | 0.0 - 96.0 |
| 5. *Fagus sylvatica* forest | 11.4 | 2.19 | 0.0 - 95.0 |
| 6. *Ostrya carpinifolia* forest | 5.7 | 0.80 | 0.0 - 40.1 |
| 7. *Quercus* sp. forest | 7.4 | 1.12 | 0.0 - 66.0 |
| 8. Thin deciduous forest | 1.8 | 0.39 | 0.0 - 29.5 |
| 9. Mcditcrranean macchia | 0.6 | 0.51 | 0.0 - 60.0 |
| 10. Mediterranean shrubs | 0.4 | 0.29 | 0.0 - 28.8 |
| 11. Shrubs | 2.5 | 0.34 | 0.0-21.1 |
| 12. Streams | 0.1 | 0.10 | 0.0 - 13.5 |
| 13. Rocky vegetation | 0.5 | 0.15 | 0.0 - 12.1 |
| 14. Pasture | 27.0 | 2.34 | 0.0 - 98.8 |
| 15. Crops | 9.6 | 1.60 | 0.0 - 77.0 |
| 16. Landscape diversity (a) | 1.1 | 0.03 | 0.0 - 1.9 |
| 17. Ecotone index (b) | 8.2 | 0.33 | 0.0 - 19.0 |
| 18. Ruggedness index (c) | 2.1 | 0.06 | 0.0 - 4.0 |
| 21. Density of abandoned houses | 7.9 | 1.23 | 0.0 - 105.0 |
| 22. Road length | i 247.4 | 1135.30 | 0.0 - 6000.0 |
| 23. Mean altitude | 657.2 | 26.91 | 153.0 - 1514.0 |
| 24. Altitude min. | 480.0 | 26.95 | 0.0 - 1408.0 |
| 25. Altitude max. | 834.3 | 27.54 | 306.0 - 1636.0 |

Four habitat variable indices were calculated: a) Landscape diversity, using the Sahnnon index (Odum, 1971); b) Ecotone index, calculated a the number of boundaries crossed by diagonals drawn across each square; c) Raggedness index, the ratio between the average length of all the contour lines in a square and the length of a square side; ci) Wood fragmentation index, the number of woods.

Finally habitat selection was analyzed by a goodness of fit chi-square test (Siegel, 1980) on differences between the observed and expected frequencies of observation For the different habitat types, testing the hypothesis that habitat types were used in proportion to their availability. When the chi-square test gave significant values ($P<0.05$) Bonferroni simultaneous confidence intervals for observed usage proportions were computed to evaluate which was the habitat for which selection occurred (Manly et al., 1993).

## RESULTS

Stone marten signs were recorded in **38** of the 102 sample squares (37.2 %). The function derived from DFA significantly discriminated the squares with stone marten signs from those without signs. The density of isolated houses, the wood fragmentation index, the percentage of Mediterranean shrubs and that of conifer forests were the habitat variables that mainly contributed to the discrimination (Tab. 2). DFA correctly classified 71.5 % of grouped cases: 82.8 % of squares without signs and 60.5 % of those with signs of stone martens. Four habitat variables showed significant differences between occupied and unoccupied squares (Tab. *3*). In particular Mediterranean shrubs and crops were larger in squares with signs of stone martens, wood fragmentation and isolated house density were higher in occupied squares (Tab. *3*).

The abundance index averaged 0.8 signs per Km (SE = 0.15; min-max = 0-11); the index was positively correlated to the density of isolated houses (r = 0.392; P = 0.0) and to the percentage of cultivated areas (r = 0.221; P = 0.025); while a negative correlation was found with altitude (r = - 0.221; P = 0.025).

Stone martens avoided deciduous forests and pastures and selected shrubs; coniferous forest and crops were used according to availability (Tab. 4).

Tab. **2** - Discriminant Function Analysis between squares with (A n=38) and without (B n=64) stone marten signs. * Variables with significant differences between the two types of squares (one-way ANOVA).

| Habitat variables | Standardized discriminant function coefficient |
|---|---|
| Deciduous forests | - 0.271 |
| Conifer forest | - 0.413 |
| Thin conifer forest | - 0.304 |
| Mediterranean shrubs | - 0.525 * |
| Streams | 0.268 |
| Wood fragmentation index | - 0.591 * |
| Density of abandoned houses | 0.610 |

Eigenvalue = 0.33; Canonical Correlation = 0.499; $\chi^2$ = 27.74; d.f. = 7; P = 0.0002

Tab. **3** - Average values (± SE) of the habitat variables with significant differences between squares with (A) and without **(B)** stone marten signs.

| Habitat variables | Average in squares | | F | Significance level |
|---|---|---|---|---|
| | A(n=38) | B(n=64) | | |
| Mediterranean shrubs | 1.26(0.9) | 0.00(0.0) | 3.34 | P = 0.05 |
| Crops | 14.64(3.4) | 7.76(1.9) | 3.58 | P = 0.05 |
| Wood fragmentation index | 6.97(1.0) | 4.20(2.8) | 9.15 | P < 0.01 |
| Density of abandoned houses | 13.10(3.1) | 5.40(i.1) | 7.27 | P < 0.01 |

Tab. 4 - Results of Bonferroni confidence interval analysis on expected and observed habitat usage proportions for the stone marten (n=71). * Differences at the minimum significance level of P<0.01.

| HABITAT TYPES | EXPECTED PROPORTIONS OF USAGE | OBSERVED PROPORTIONS OF USAGE |
|---|---|---|
| Deciduous forest | 0.528 | 0.253 * |
| Conifer forest | 0.063 | 0.042 |
| Shrubs | 0.032 | 0.577 * |
| Pasture | 0.277 | 0.028 * |
| Crops | 0.100 | 0.084 |

$\chi^2 = 827.119$ d.f. = 4 Significance level = 0.00

## DISCUSSION

Heptner and Naumov (1974) stated that stone martens show different patterns of habitat use in the mountains and in the plains. In the mountains the species can be found in poorly wooded slopes, rocky cliffs, landslides covered by a xeric and bushy vegetation and rocky slopes with scattered small woods. In these habitats stone martens are not synanthropic, using more natural habitats and in general avoiding conifer forest. In the plains stone martens select small woods, hedgerows bordering cultivated fields and surrounding areas of villages (Broekhuizen, 1983; Skirnisson, 1986). This is consistent with our findings. Indeed we found a preference for bushy areas and avoidance of large forests and pastures; furthermore the stone marten in our study area was present at low altitudes, around abandoned and isolated houses and where the forests were highly fragmented. The preferred habitat seemed to be formerly cultivated areas, where there were isolated houses surrounded by shrubs and abandoned crops in contact with small woods. The abundance of the species was higher at low altitudes where habitat fragmentation was more marked. Libois (1991) reported the duration of snow cover to be a limiting factor for stone marten distribution, but also stated that the species can occur up to 2600 - 2700 m a.s.l. where snow cover is not persistent. In our study altitude was not a discriminant variable for presence-absence of the stone marten but did influence the abundance. This was because in our study area snow falls were usually low as a result of the proximity to the sea even of the mountain zones. Thus the negative correlation between abundance and altitude may be mainly due to the low anthropic influence on the areas of highest altitude. Following this view the avoidance of pastures may also be explained by the correlation between the percentage of this habitat type and altitude (r = 0.424; P = 0.0).

From our results it seems that in areas where the pine marten is not present, the stone marten requires a habitat structure that is highly modified by human activity even though these areas are now becoming wilder as a result of their abandonment. These habitat requirements are probably due to the fact that the species can easily find a good variety of food sources, and also safe sheltering and breeding sites in a patchy habitat.

## REFERENCES

BROEKHUIZEN, S. 1983. Habitat use of beech inarteii (*Martes foina*) in relation to landscape elements in a Duich agricultural arca. Proc. XVI Cong. Int. Union of Game Biologists, 614-624

DELIBES, M. 1978. Feeding habits of Stone marten, *Martes foina* (Erxleben 1777) in northern Burgos, Spain. Z. Saugertierk., 43: 282-288

DELIBES, M. 1983. Interspecific coinpetition and habitat of the Stone marten *Martes foina* (Erxleben 1777) in Europe. Acta Zool. Fennica, 174: 229-457

HEPTNER, V. G. & N.P. NAUMOV. 1974. Die Säugertiere der Sowjetunion. Band II. Fischer Verlag, Iena, 1066 pp.

LIBOIS, R. 1991. La Fouine (*Martes foina* Erxleben, 1777). Encyclopedic dcs carnivores de France, 10: 1-53

MANLY, B., MCDONALD, L. & D. THOMAS. 1993. Rcsourcc selection by animals. Chapman & Hall. London, 177 pp.

NOVIKOV, G.A. 1962. K ekologii kamcnnoi kunicy v lesostepnych dubravach. - Bjull. **Mock.** Obsc. Ispit. Prir., Otd. Biol. 47(6): 5-16

ODUM, E.P. 1971. Fundamentals of ecology. 3rd cd. W.B. Saunders Co. Philadelphia, 574 pp.

ROBERT, T.J. 1977. The manual of Pakistan. Erncst Benn Ltd. London

SIEGEL, S. 1980. Statistica non parametrica pcr lc scienze del comportamento. Organizzazioni Speciali. Firenze, 269 pp.

SKIRNISSON, K. 1986. Untersuchungen zum Rauin-Zeit-System freilebender Steininarder (*Martes foina* Erxleben, 1777). Beitr. Wildbiol. 6: 1-200

WAECHTER, **A.** 1975. Ecologie de la fouine en Alsace. Rev. Ecol. (Terre et Vie), 29: 399-457