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Habitat selection of genet *Genetta genetta* in the mountains of central Spain

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Genet *Genetta genetta* Linnaeus, 1758 habitat selection was studied through midden locations in a mountain area of central Spain both at macrohabitat (habitat types, land use, roughness, distance to villages, etc) and microhabitat scale (tree, scrub, rock and pasture covers). Among the available habitats, genet preferred dehesas, due to their good trophic resources and shelter availability. Genet was scarce over 1200 metres, probably because of thermic restrictions. The most important microhabitat variables selected as faecal sites were rock-cover (refuges) and shrub--cover (feeding places and refuges). Other parameters of functional significance related to midden location were social communication and territoriality. There was no selection both sites with a high degree of tree cover (microhabitat) and for sites near to watercourses.

Key words: *Genetta genetta*, habitat selection, midden location, thermic restriction, Spain

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Introduction

Although the genet *Genetta genetta* Linnaeus, 1758 is relatively abundant in most of its distribution area (Livet and Roeder 1987) the biology and ecology of this species is still largely unknown. Most of the studies published focus on the diet of this species (eg Calviño *et al.* 1984, Hamdine *et al.* 1993, Palomares and Delibes 1991, Virgós *et al.* 1996) although other works focused on different ecological aspects (Delibes 1974, Cugnasse and Riols 1984, Livet and Roeder 1987). Microhabitat selection of faecal sites and the spatio-temporal ecology of this species has recently been studied in Doñana, SW Spain (Palomares 1993, Palomares and Delibes 1994).

Habitat selection is considered to be a key aspect of animal activity, affecting subsequent behavioral decisions and, ultimately, fitness (Orians and Wittenberger 1991). However, it is necessary to know the basic aspects of habitat choice before testing their effects on population dynamics, breeding success and interspecific interactions (Pulliam and Danielson 1991). In this context, habitat selection has been viewed as a hierarchical process from the small spatial scale of feeding patches to regional scales dealing with macroecological factors (Johnson 1980, Morris 1987). Mediterranean mountains are highly suitable for these kinds of studies due to their high environmental heterogeneity and the steep gradient of habitats they present (Rivas-Martínez *et al.* 1987). Heterogeneous conditions and environmental diversity in these areas offer an interesting opportunity to study the different responses of individuals and populations to different but nearby environments. On the other hand, it is necessary to attain baseline data in order to be able to design scientific management programs for areas inhabited by genets.

This work describes the habitat selection patterns of genets at microhabitat (faecal sites) and macrohabitat spatial scales from the Mediterranean mountains of central Spain.

Material and methods

Study area

The study area was located in the Alto Manzanares Regional Park (41°40'N, 4°10'E) and its surroundings, on the southern slope of the Guadarrama mountains (central Spain). The total area studied covers 65,000 ha. All vegetation stages of the central Spain mountains were represented in the study area. The lower level ranges between 600–1000 m a.s.l. and is covered by a mesomediterranean holm oak *Quercus ilex* forest and dehesas, a typycal habitat where the human-use (cattle) creates a mosaic of woods and pastures. In holm oak forests the most important land-use is game. The next stage (1000–1700 m a.s.l.) was originally occupied by a Pyrenean oak *Quercus pyrenaica* forest which has now been replaced by a mixture of different pine species. The level from 1700–2000 m a.s.l. is covered by an oromediterranean Scot's pine *Pinus sylvestris* forest and a scrubland dominated by *Cytisus oromediterraneus*. The two princpals land-uses were forestry and recreative activities. Finally, the upper stage (2000–2200 m a.s.l.) is a crioromediterranean pasture, rarely used by genet and, therefore, not studied. Further information about climatic and vegetation types in the study area can be consulted in Rivas-Martínez *et al.* (1987) and Font (1983).

Survey procedures

Field work was carried out between 1989 and 1991, from October to April. The survey consisted of an exhaustive search of the middens (scats amounts) located in predictable places in the field (Roeder 1978, 1980). Livet and Roeder (1987) use a similar procedure to study genet habitat requirements in France and this procedure is also recommended for carnivore-habitat studies by other authors (Kendall *et al.* 1992, Clevenger 1993).

Field work was carried out by four people with experience in midden location. The whole study area was divided into 5 × 5 km cells (n = 29), each classified following habitat stratification criteria (see Table 1 for habitat type). In order to minimize the error due to pseudoreplication, only the middens located sufficiently far from each other (about 1000 m) were considered. In order to avoid biases associated with scat data (Andelt and Andelt 1984, Kruuk *et al.* 1986, Clevenger 1993), selection patterns were studied with presence/absence data, although the marking behaviour of this species (Roeder 1980) permits more accurate estimations.

Variables 1–7 (see Table 1) were quantified on maps and could be considered as descriptors of macrohabitat environment: altitude (ALTIT), an index of roughness (ROUG), distance to near watercourse (WATER), distance to near village (VILL), distance to near road (ROAD), habitat-type

Table 1. Description of the macrohabitat (1–7) and microhabitat variables (8–11) used in this study.

Variable	Measure
1. ALTIT	Height above sea level in each point
2. ROUG	Number of level curves intercepted in 500 m radius around each point
3. WATER	Minimun distance (in m) from each point to the nearest watercourse
4. VILL	Minimun distance (in m) from each point to the nearest village
5. ROAD	Minimun distance (in m) from each point to the nearest road
6. HABITAT	Habitat type: holm oak forest, dehesa – a typical landscape with woods and pastures, and pine forest in each point
7. LAND USE	Type of land use: cattle, forestry, recreative, and game in each point
8. TREE	Tree canopy cover in 25 m radius around each point
9. SHRUB	Shrub cover in 25 m radius around each point
10. ROCK	Rock cover in 25 m radius around each point
11. HERB	Herb cover in 25 m radius around each point

(HABITAT), and land-use (LAND USE). The remaining variables were measured in the field and concerned microhabitat features associated with defecation sites: tree cover (TREE), shrub cover (SHRUB), rock cover (ROCK), and herb cover (HERB) (Table 1). Slicing of microhabitat and macrohabitat variables has been considered as a useful tool to describe density-dependent habitat selection patterns (Morris 1987). Variables belonging to the first set (macrohabitat) were measured by mapping the midden locations on a 1:50,000 topographical map. The second group of variables (microhabitat) were measured in the field by visual estimation within circular-plots of 25 m radius around the middens. Availability of the first set of variables was quantified using 100 random points scattered homogeneously over the topographical maps following a stratified sampling procedure. The second group (microhabitat) was quantified by carrying out 546 transects 500 m long following a stratified protocol too. The stratification procedure was made according to habitat availability in the study area (60% holm-oak forest, 20% pine forests, 10% dehesas). In these transects, values of variables were visually estimated within circular-plots of 25 m radius spaced at 125 m intervals.

Data analyses

The existence of selection in each variable was tested using a chi-square goodness of fit test (Sokal and Rohlf 1981). Expected values were calculated from the availability data.

However, the multidimensional characteristic of a species' environmental requirements requires a multivariate statistical approach, in order to avoid the problem of non-independence of variables. Among all the new and old methods to analyze multivariate data, principal component analysis (PCA) can be used to study the distribution of genet into an environmental gradient generate previously by availability data (James and McCullogh 1990). This procedure creates independent factors (orthogonals) which are composed by a linear combination of the original variables. Thus, this approach allows us to deal with correlated variables.

We performed two separate analyses, the first with topographical and habitat-land use variables (macrohabitat variables) and, the second with microhabitat features associated with faecal sites (microhabitat variables). This procedure was chosen for our study because of the different ecological significance and scale-measure of both variable types.

Prior to these analyses, variables were transformed as decimal logarithmic (altitude and distances), square root (roughness) and arcsine (covers) following Zar (1984).

Results

Univariate chi-square analysis

ALTIT, HABITAT and LAND USE were the only significant macrohabitat variables. Genets prefers the 1000–1200 m a.s.l. interval. The dehesas was the

Table 2. Chi-square values for each variable, number of genet middens (n) and expected values (after its environmental availability) in each category.

Variable	n	Expected	Variable	n	Expected
ALTIT			LAND USE		
600–800	1	5.2	Cattle	10	4.16
800–1000	12	7.8	Forestry	0	2.6
1000–1200	9	4.9	Recreative	5	6.93
> 1200	4	8.06	Game	11	11.7
$\chi^2_3 = 10.4, p < 0.05$			$\chi^2_3 = 8.93, p < 0.001$		
ROUG			TREE		
1–2	10	10.1	0–25	14	15.91
3–4	5	5.46	25–50	7	6.22
5–6	7	3.12	> 50	5	3.86
> 7	4	7.54	$\chi^2_2 = 0.64$, ns		
$\chi^2_3 = 6.61$, ns					
WATER			SHRUB		
0–200	10	10.66	0–25	3	13.6
200–400	8	7.28	25–50	8	4.91
> 400	8	8.32	> 50	15	7.47
$\chi^2_2 = 0.25$, ns			$\chi^2_2 = 17.79, p < 0.001$		
VILL			ROCK		
0–1000	4	6.24	0–25	2	18.47
1000–2000	5	6.5	25–75	15	5.82
2000–3000	8	6.5	> 75	9	1.71
> 3000	9	7.02	$\chi^2_2 = 60.22, p < 0.001$		
$\chi^2_3 = 2.05$, ns					
ROAD			HERB		
0–600	2	4.68	0–25	23	19.27
600–1200	10	5.46	> 25	3	6.73
1200–2400	4	5.91	$\chi^2_1 = 2.78$, ns		
> 2400	10	9.88			
$\chi^2_3 = 6.17$, ns					
HABITAT					
Holm-oak forest	13	15.86			
Dehesa	10	2.34			
Pine forest	3	4.68			
$\chi^2_2 = 22.77, p < 0.001$					

preferred HABITAT category and the cattle-use was the only significant LAND USE one.

Among the microhabitat variables, we found significant selection for SHRUB and ROCK ones. Genets preferred intermediate-high covers of both variables (see Table 2 for details and statistics).

PCA from macrohabitat descriptors

Three factors were obtained, which explains 76.77% of the total variance (Table 3). These factors were VARIMAX rotated to improve the biological interpretation of the originals one. The first factor generates a gradient from elevated and roughly regions of the study area (positive scores) to low-lying areas (negative scores). The second, describes the distance to villages (VILL), with the distant points associated to positive scores. Finally, the last factor creates a gradient from points near to watercourses (WATER) (negative scores) to more distant points (positive scores).

Table 3. Results of PCA analyses (VARIMAX rotation) from macrohabitat (A) and microhabitat variables (B) used in this study. EIGENV – Eigenvalues obtained from each PCA factor.

A

	PCA factor		
	1	2	3
ALTIT	0.925516	0.190967	0.062309
ROUG	0.919506	0.070343	–0.006491
WATER	0.035157	–0.045158	0.995316
VILL	0.161579	0.915981	–0.050463
ROAD	0.203975	0.420326	–0.106774
EIGENV	1.771020	1.059151	1.008527
% Total	35.4204	21.1830	20.1705

B

	PCA factor		
	1	2	3
TREE	0.046714	–0.974066	0.036040
SHRUB	–0.901127	0.207285	0.054157
ROCK	–0.063484	0.045036	–0.973175
HERB	0.746603	0.271697	0.396818
EIGENV	1.375659	1.067619	1.108766
%Total	34.3915	26.6905	27.7191

Genets were associated with negative scores of the first factor (low-lying areas) and thrid factor (WATER). When the second (proximity to villages) and third factor were plotted, is possible observe an assocation of genet middens with areas near to villages. However, this relationship dissapears when it is compared to first factor and, therefore, it is not plotted (Fig. 1).

PCA from microhabitat descriptors of faecal sites

We also obtained three VARIMAX rotated factors, which accounts 88.8% of total variance (Table 3). The first factor describes a gradient from the pasture and

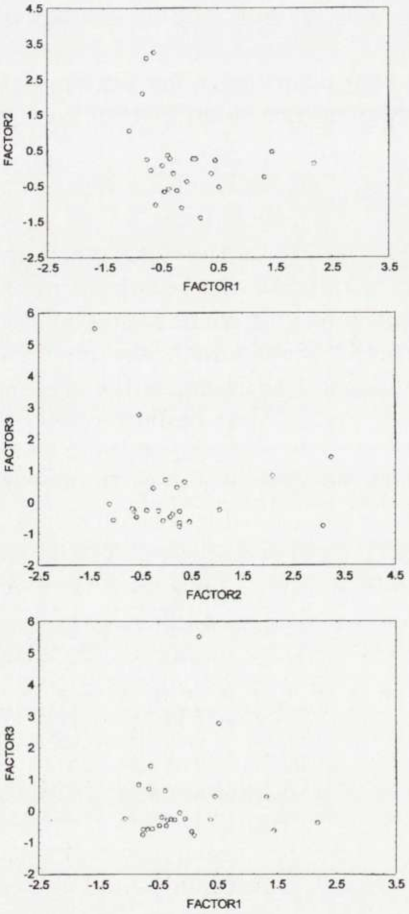

Fig 1. Midden distribution on the environmental gradient generates from the PCA analysis of macrohabitat variables. Points mean individual genets.

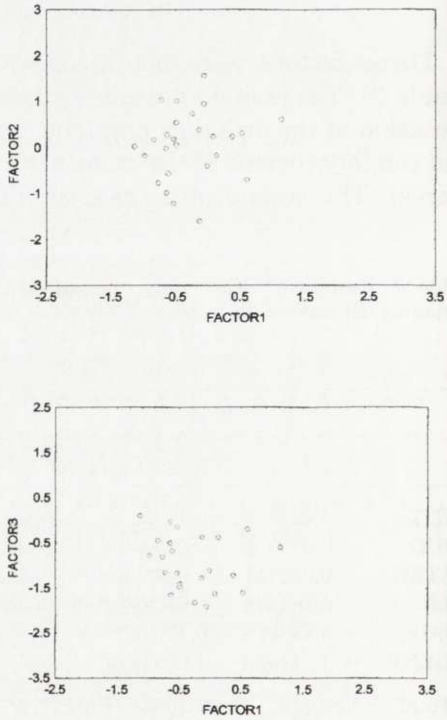

Fig. 2. Midden distribution on the environmental gradient generates by PCA analysis from microhabitat variables.

open areas (positive scores) to shrub and closed ones (negative scores). The second factor is related to a gradient of tree cover (with high covers associated to positive scores). The last factor describes areas with different rock covers (high covers associated to positive scores).

Genets were homogeneously distributed on the second factor (tree cover gradient). Furthermore, the middens were concentrated on the negative scores of the first factor (high shrub covers) and the positive scores of the third one (high rock covers) (Fig 2).

Discussion

The first studies on the general biology of the genet (Delibes 1974, Cugnasse and Riols 1984) revealed the flexibility of this species. In our study area, genets also seem to follow this pattern, both with respect to diet (Virgós *et al.* 1996) and the basic aspects of its habitat selection (this study). For all the variables studied we found that the genet has a strong preference to living in basal habitats and rarely above 1200 m a.s.l., in accordance with previous studies (Cugnasse and Riols 1984, Livet and Roeder 1987, Ruiz-Olmo 1990). Most middens in these low-lying areas were in dehesas (associated to cattle-use), whereas a few were found in holm-oak forest. The dehesas are optimal habitats with abundance in trophic resources supply (especially small mammals and birds, but also dung beetles, E. Virgós and J. G. Casanovas, unpubl.) and shelter (hollow trees and rocky places). Also, this choice reveals the affinity of this species for thermic places as pointed out in earlier studies (Schauenberg 1966, Delibes 1974, Ruiz-Olmo 1990, but see Desmet and Hamdine 1988). Despite the climatic wildness and richness in trophic resources and shelter (rocky places) of areas between 600–800 m (holm-oak forests), these were not selected. This fact may be caused by carnivore control techniques, and this is supported by the low richness and density of other carnivore species (Casanovas and Virgós 1993). On the other hand, the genet preferred higher areas than in France (Livet and Roeder 1987), where it lived in altitudes between 0–600 m a.s.l. and was rarely found above 800 m. A possible explanation is the climatic differences between both areas, although, due to the absence of availability resource information in the French data, we do not know the selection criteria.

The PCA analysis reveals a tendency of genets to inhabit areas near to villages (when we compare the second and thid factor in macrohabitat analysis), however, this fact is explained by the association of this species to low-lying areas (due to above suggestions), which were more man-populated (see the plot between the first and second factor). Livet and Roeder (1987), pointed out a tendency to live in areas with low human presence, although Delibes (1974) and Ruiz-Olmo (1990) suggestions were in accordance with our data. On the other hand, the significance of distance to watercourses is controversial. Chi-square approach reveals a lack of selection for this variable. However, the PCA shows an association of middens to areas near to watercouses. This factor were considered very important for some researches (Cugnasse and Riols 1984, Livet and Roeder 1987), but this association is not found elsewhere (Delibes 1974). Selection of areas near to watercourses may enhance the availability and diversity of trophic resources (Livet and Roeder 1987).

The not selection of places with dense tree cover is remarkable, but has also been recorded elsewhere (see Ruiz-Olmo 1990, Palomares and Delibes 1994). One possible explanation is that the potential shelter role previously fulfilled by trees is realized in the study area by rocks, which are very abundant both in the dehesa and holm-oak forest. Rocks were a perfect shelter for genets in providing a warmth (see Waechter 1975 for the stone marten) and undisturbed place. Moreover, the genet usually selects rocky places well protected by shrubs, which have not only a protective function but are also the habitat for some outstanding prey such as wood mice *Apodemus sylvaticus* (Alcántara 1992, Virgós *et al.* 1996). On the other hand, microhabitat features associated with middens could have a different functional significance. Likely, middens have a social and territorial function (Roeder 1978, 1980 for genets, Macdonald 1980 for a review from carnivore communities) and, therefore, their location could be aimed at maximizing detection by conspecifics. The high preference for tall structures which are available both here and elsewhere (trees, high rocks, etc) is due to the same reason. On the other hand, the two alternatives may be not exclusives and, therefore, a two-significance role (social communication-shelter) is possible to be associated to midden places. This subject requires future behavioral research.

In summary, genets selected areas lower than average probably due to thermic restrictions, although the holm-oak forests could be not selected due to human persecution. Among the microhabitat variables, places with high rock and scrub covers were selected.

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