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Faecal marking behaviour of Iberian wolf in different zones of their territory

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A b s t r a c t. In northwestern Spain, the spatial distribution of Iberian wolf scats left during the reproductive period in the den area and other zones of the territory was analysed. In the den area, a large number of scats were left on inconspicuous substrates and at ground level, whereas scats were left mainly on conspicuous substrates and above-ground level in the rest of the territory. In the den area the number of scats detected in the centre, tire, and lateral sections of the roads was identical. In the rest of the territory, scats were left in the lateral section of the roads. The distribution of the scats on the access trail to the den area site showed characteristics that were intermediate between the other two areas. The results of site analysis suggest that the scats left in the den surroundings and areas removed from the den area have a function in the wolf's scent-marking and visual signalling. They are not left at random, but at points and on substrates that enhance their effectiveness as olfactory and visual marks. The abundance of scats left in the den area were only a consequence of continuous passage through the area.

Key words: den area, scent marking, signalling, wolves

Introduction

Scent marking in canids using urine, secretions and faeces has been well-documented (K l e i m a n 1966, F o x & C o h e n 1978, G o r m a n & T r o w b r i d g e 1989, A l b e r t s 1992, B a r j a et al. 2001, B a r j a 2003, B a r j a & M i g u e l 2003, B a r j a & M i g u e l 2004) and is considered a mechanism for territory defence in many carnivores (see B r i s c o e 2002, Z u b et al. 2003 for wolves in Poland). Wolves (*Canis lupus*) mark their territory with visual (scratching and faeces) and olfactory marks (urine, faeces and secretions from the anal sacs and interdigital glands) (P e t e r s & M e c h 1975, R o t h m a n & M e c h 1979, A s a et al. 1985b, A s a & M e c h 1995, M e c h & B o i t a n i 2003, B a r j a et al. 2004) and although the majority of studies of marking behaviour in wolves has been carried out on urine marking (mainly in the U.S.A.), many authors have suggested that faeces are an important scent and visual signalling method for wolves (P e t e r s & M e c h 1975, A s a et al. 1985b, V i l à et al. 1994, B a r j a 2003, B a r j a et al. 2004).

The role of faeces in marking can be inferred when certain conditions that clearly indicate their function in scent and visual communication are met. One of the most common patterns observed in carnivores is the deposition of faeces on conspicuous landmarks or on above-ground substrates (M a c d o n a l d 1985), this is believed to enhance the visual impact of the faeces, e.g. make them more noticeable to other individuals. Some studies

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have indicated that wolves will preferentially leave scats at crossroads (V i l à et al. 1994, B a r j a et al. 2004), probably to maximise their detection by other individuals. This method of defecating in prominent sites has also been observed in other carnivores such as the Iberian lynx *(Lynx pardinus*) (R o b i n s o n & D e l i b e s 1988) and the red fox (*Vulpes vulpes*) (M a c d o n a l d 1980, B a r j a et al. 2001). The scent function of faeces can be further enhanced when a wolf leaves secretions from anal sacs on top of the faeces (A s a et al. 1985a) or when the wolf scratches the ground with its hind legs near the faeces, infusing the ground with secretions from the interdigital glands (P e t e r s & M e c h 1975).

The objective of this study was to examine the faecal marking behaviour of wolf in three zones of their territory (den area, access trail to the den area, the rest of the territory), analysing the spatial characteristics of faeces in each one. If faeces are used as scent marks, these should be deposited in substrates and zones that enhance its permanence as well as its detection by other congeners.

Study Area

The study site was a 9,000 ha area of Montes do Invernadeiro, a series of mountain ranges located to the south of the Macizo Central Ourensano, Montes do Invernadeiro Natural Park in the NW Iberian Peninsula (Fig. 1). The topography of the area is mountainous, with altitudes ranging from 880 m, the high-water level of the Das Portas reservoir, to 1,707 m at the summit of Monte Seixo. The flora and fauna are diverse, occupying a transitional zone between the Mediterranean and EuroSiberian regions (C a s t r o v i e j o 1977). This is manifested by the alternation between Mediterranean plant communities and Atlantic relict forests (C a s t r o v i e j o 1977). Scrubland predominates the plant community, mainly heather (*Erica australis*), prickled broom (*Pterospartum tridentatum*) and sandling (*Halimium lasianthum*). Large extensions are occupied by repopulated forests of Scot pine (*Pinus sylvestris*), whereas the original forest subsists in valleys and water courses and is formed principally by associations of oak (*Quercus robur*), birch (*Betula celtiberica*), and holly (*Ilex aquifolium*). The area has a high density of wild ungulates, including roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*). While the field work was being carried out, the main prey of the wolves was roe deer, being found in 62.8 % of the faeces analysed (B a r j a & B á r c e n a , unpublished).

The den area was located at an altitude of 980 m with a SSE orientation. The wolves established themselves in an area of well-developed, mixed forest of oak, birch and Scot pine, as well as brush of Spanish white broom (*Cytisus multiflorus*) that reaches a height of 5 m. The underbrush was dominated by grasses. The den area was located in a secluded place on a sunny slope near a small river. It had three exit ways: one by the mountain crest located to the north, another to the east, and one to the Southeast. Numerous wolf trails dissected the vegetation.

Materials and Methods

In March 1999, a pair of wolves established themselves in the study area. The present study was carried out from March to July 1999. Data were obtained by establishing transects along roads and firebreaks crossing the study area because the use of roads in wolves and other carnivores has been reported (D i c k m a n & D o n c a s t e r 1984, R o b i n s o n &

Delibes 1988, Vilà et al. 1994). A total of three samplings were made over a mean distance of 61.9 km and lasting three days each. To avoid bias, all transects were conducted by the two same persons. Maps with 1 km² cells (UTM) were used to record faeces position and to avoid pseudoreplication.

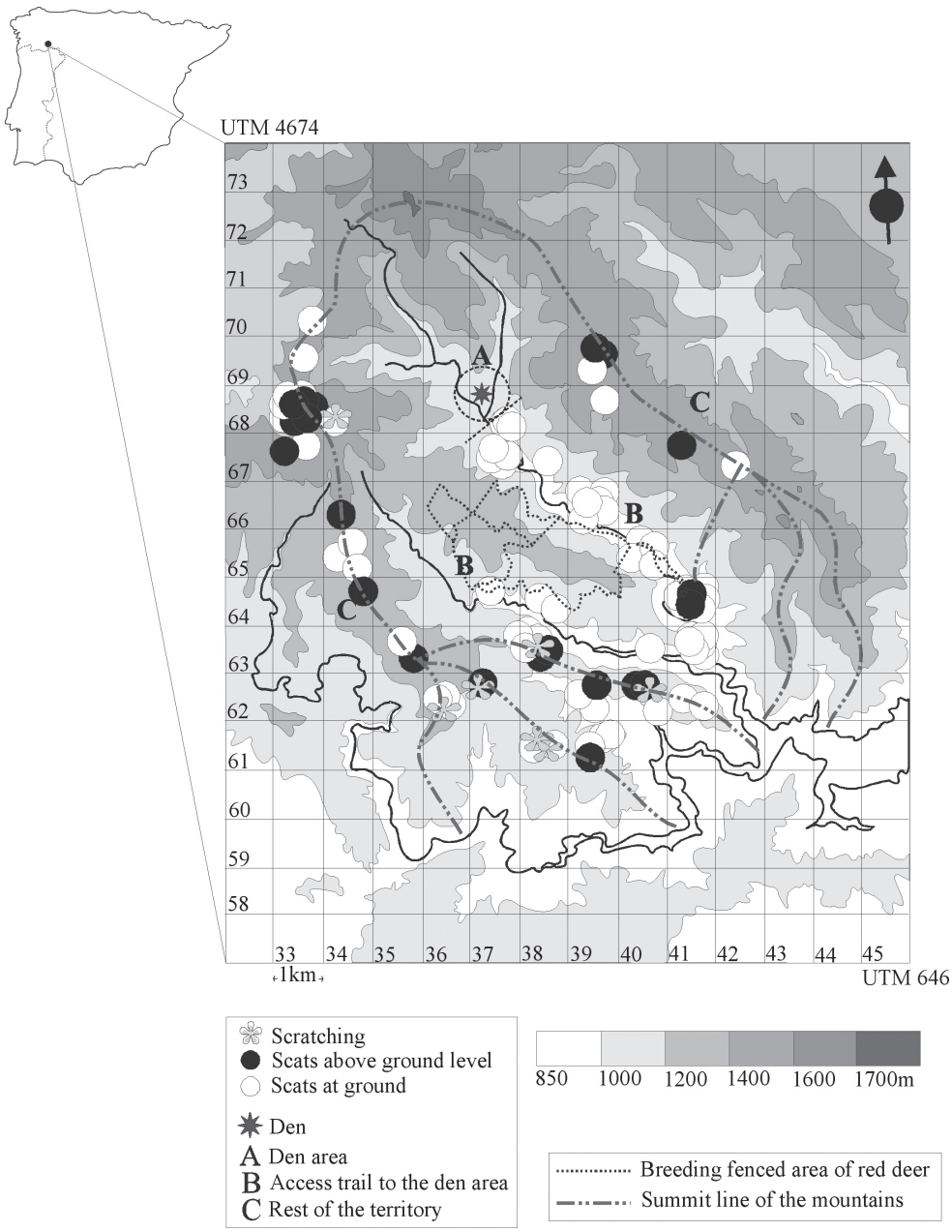

Fig. 1. Location of scats left by wolves between March and July 1999.

To determine if there are any differences in faecal marking behaviour, the area was divided into three zones by location: den area, access trail to the den area, the rest of the territory (Fig. 1). The distance from the first crossroads to the den area was 0.8 km. This radius around the den site was regarded as the den area, including the next roads and crossroads (length of the transects 2 km). The roads that went by the valleys and gave access to the den area were considered as access trail to the den area (length of the transects 24.1 km). The rest of roads that went by the summit areas and are far from den area were considered as rest of the territory (length of the transects 36.5 km).

In order to assess the possible function of scats as scent marks, the following variables were considered in relation to their location: height above ground level, type of substrate, and frequency of use of the different road sections.

In relation to the variable height above ground level, the only consideration was whether the scat was left at ground level or perched above ground level. All the scats deposited above ground level were considered elevated.

Two categories were established to analyse the type of substrate where scats were deposited:

– Conspicuous substrates, which stood out from the surroundings, such as mound, plants, stones. We considered that a scat was on a conspicuous substrate when the substrate was the most notorious to the observer within a circle with 2 m radius, with the scat at the centre.

– Inconspicuous substrates were all others.

The habitat features were similar in the three zones of the territory. In all roads of the study area there was a high number of conspicuous substrates where the wolves could deposit their faeces, such as different woody species, herbaceous, dry trunks, stones and mound. The availability of conspicuous substrates in the roads was also similar between zones.

For the variable road sections in relation to scat location, the following sections were considered:

– Centre, or middle of the road for vehicles, which occupies 14.3% of the road width.

– Tire, which occupy 14.3% on each side of the centre, or 28.6% of the road surface.

– Lateral, 10.5% outside each tread, a total of 21% of the surface.

– Marginal, 18% on each side of the road, just outside the road itself, a total of 36%.

The mean width of the roads in the study area was 7 m.

Since the number of kilometres surveyed was not the same in the three zones of the territory, the abundance kilometric index (number of detected scats per surveyed kilometre) for each zone was calculated from the total number of detected scats divided by the number of kilometres surveyed. We found the variables not normally distributed so we used non-parametric statistics. To test for differences between the categories of each variable we conducted a χ^2 test. For the variable of road sections, we estimated the expected frequency of the sections considering the area of each within the road. Results of all statistical tests were considered significant at $\alpha < 0.05$.

Results

During the study, a total of 111 scats were found. 59.4% of the scats were found on the roads in valleys and 40.6% in the roads along the mountaintops.

The Abundance Kilometric Indices (number of scats per surveyed kilometre) for each area were: 16 scats/km in the den area, 4 scats/km in the access trail to the den area, and only 0.01 scats/km for the itineraries in other territorial areas.

With respect to the height where scats were left, the percentage of scats left above ground level in different areas of the study zone was: den area 0%, access trail to den area 6.2%, and rest of the territory 34.5% (Fig. 2). The use of above ground level substrates differed significantly between the three zones ($c^2 = 17.7$, df = 2, $p < 0.001$). The mean height at which scats were left was 14.2 cm above ground. All scats left above ground level were left at crossroads. In addition, scats were distributed along the ridges surrounding the den area. In contrast, the scats left at ground level were distributed randomly throughout the study area (Fig. 1). The shortest distance in a straight line from the den area to a scat left above ground level was 2.7 km, with a difference in altitude of 555m. The mean distance in a straight line from the scats left above ground level to the den area was 4.6 km ± 1.7 SD and the mean altitude was 1300 ± 225.9 m SD (Fig. 1).

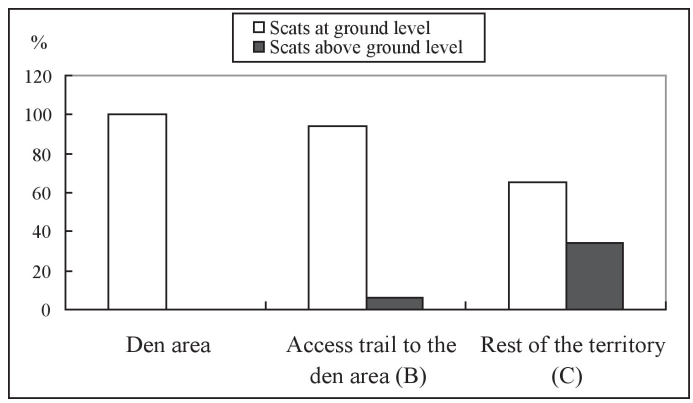

Fig. 2. Percentage of scats left on high substrates and at ground level in the different zones of the wolf territory.

During the period between March and May, ground scratching was observed. All the scratching was seen at crossroads in the heights of the mountain ranges surrounding the den area. Their distribution was similar to that of the scats deposited on elevated substrates (Fig. 1).

The percentage of scats left on conspicuous substrates in the different zones was: den area 8.3%, access trail to den area 50%, and rest of the territory 67.3% (Fig. 3). There were

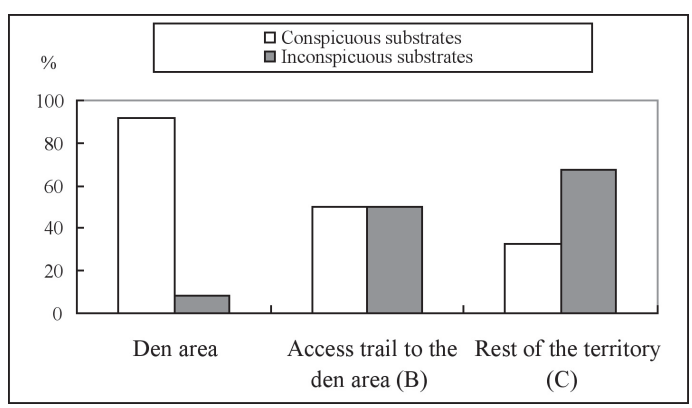

Fig. 3. Percentage of scats left on conspicuous and inconspicuous substrates in the different zones of the wolf territory.

significant differences in the use of conspicuous versus inconspicuous substrates in the three zones ($c^2 = 23.2$, df = 2, $p < 0.001$). On the heights of the mountain ranges, the percentage of scats left on conspicuous substrates (65.9%) was greater than the percentage left on inconspicuous substrates. Nevertheless, in the routes through the valleys the proportion of scats left on conspicuous substrates (35%) was smaller than the percentage of scats left on inconspicuous substrates. These differences were statistically significant ($c^2 = 8.1$, df = 1, $p < 0.01$).

With respect to variations in the use of different sections of the road, in the den area the wolves left similar numbers of scats in the centre, tires, and lateral areas. In the other two zones (access trail to den area and rest of the territory), they mainly selected the lateral areas (Fig. 4). The differences in the disposition of scats in the different sections of road in the three territorial zones were significant ($c^2 = 18.6$, df = 6, $p < 0.01$). In zones farther away from the den area, the wolves preferred the centre of the road instead of the tires, although the tires occupied a larger surface area ($c^2 = 10.5$, df = 1, $p < 0.01$). In contrast, in the den area ($c^2 = 2.1$, df = 1, $p > 0.05$ NS) and access trail to the den area ($c^2 = 0.000$, df = 1, $p > 0.05$ NS), the wolves left scats in the centre and tires similarly.

Comparison of the use of each section of road in the three territorial areas showed that the proportion of scats in tires was greater in the den area than in the access trail to den area and the rest of the territory. In the rest of the territory, scats were infrequently left in tires. These differences between the three zones were statistically significant ($c^2 = 14.7$, df = 2, $p < 0.01$). Nevertheless, the centre of the road was used with a significantly greater frequency in the rest of the territory than in the other two zones ($c^2 = 13.3$, df = 2, $p < 0.01$). The wolves did not leave scats along the margins of the road in the den area, but the use of margins increased in the access trail to den area and, especially, in the rest of the territory ($c^2 = 19.8$, df = 2, $p < 0.01$) (Fig. 4).

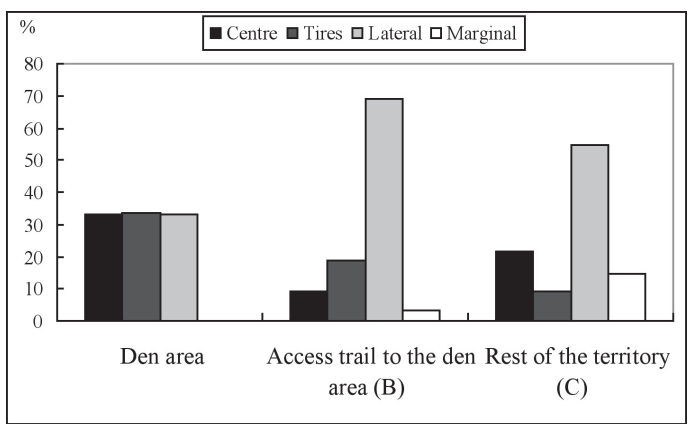

Fig. 4. Percentage of scats left in the different sections of the road in the zones of the wolf territory.

Considering only the scats left in the den area and access trail to the den area, there were no significant differences in the variable "height above ground level" ($c^2 = 1.6$, df = 1, $p > 0.05$ NS); scats were left mainly on the ground. Nevertheless, there were significant differences between the two zones for the variable "substrate" ($c^2 = 9.1$, df = 1, $p < 0.01$). The variable road section also differed significantly between the two zones ($c^2 = 9.1$, df = 3, $p < 0.05$).

Comparison of the distribution of scats between the den area and the rest of the territory revealed significant differences for the three variables considered: height above ground level ($c^2 = 9.1$, df = 1, $p < 0.01$), substrate ($c^2 = 20.9$, df = 1, $p < 0.001$) and road section ($c^2 = 11.9$, df = 3, $p < 0.01$).

When considering the scats left on the access trail to the den area and the rest of the territory, the distribution of scats was similar between both zones. The frequency with which scats were left on high substrates was significantly greater in the rest of the territory than in the access trail to the den area ($c^2 = 7.4$, df = 1, $p < 0.01$). Nevertheless, there were no significant differences for the variables type of substrate ($c^2 = 1.9$, df = 1, $p > 0.05$ NS) and road section ($c^2 = 6.5$, df = 3, $p > 0.05$ NS). In July 1999, the den area, which was still occupied, was located in the northern part of the region. In that period evident differences were detected in the faecal marking behaviour in areas close to and distant from the den area.

Discussion

The results of our study show that there are differences in the distribution of scats left by wolves in the different zones of their territory. In the den area, the scats were left at random, with no selection of substrates that would enhance their effectiveness as visual and scent marks. The large number of scats detected in the den area is probably due to continuous use. As Peters & Mech (1975) have suggested, the accumulation of scats left by the adults at certain points of the den area seems to be the consequence of repeated visits to the den area during the reproductive period. However, in zones farther from the den area, a large percentage of scats were left on elevated and conspicuous substrates located at crossroads. The placement of scats at strategically important points around the den area, especially at crossroads, has already been discussed by Peters & Mech (1975). The marking function of scats left at conspicuous or elevated substrates and at highly strategic points has been suggested by various authors (Kleiman 1966, Mech & Frezel 1971, Peters & Mech 1975, Macdonald 1980, 1985, Robinson & Delibes 1988, Vilà et al. 1994, Barja 2003, Barja et al. 2004). Nevertheless, until now there had been no study of the distribution of scats in different zones of a wolf territory during the reproductive period.

There is a certain gradient in the use of scats as marks, from the den area to peripheral zones of the territory, where scats are left preferentially on conspicuous substrates, at crossroads, and, in large measure, on high substrates.

During the reproductive period, a critical period in the social life of the pack, it is vitally important to define the territory well and defend the den area by leaving visual and scent marks in prominent places surrounding the den area. A similar strategy has been demonstrated in other carnivores, like the badger (*Meles meles*), which marks the environs of the den area with its anal glands (Kruuk et al. 1984). In earlier studies of urine signalling, it was shown that scent marks left in high places seem to have an important function in territorial marking, being left preferentially on the boundaries of the territory. The boundaries of wolf territories seem to be recognisable from the high frequency of scent marks (Peters & Mech 1975). The present study shows that scats left preferentially elevated above ground level in the zones surrounding the den area seems to confirm the territorial function of scats left on elevated substrates, as evidenced by wolves most frequently defecating at crossroads in high places. The crossroads, where the largest number of scats were left, were generally located in the highlands surrounding the den area, suggesting that crossroads

have an important function in the territorial marking of the wolf. Defecating at crossroads instead of along a single trail multiply the effectiveness of the territorial display. B o w e n & C o w a n (1980) noted, in relation to the scent marks left by coyotes (*Canis latrans*), that the scent of scats can be detected at a considerable distance, which is why the scent gradient can help wolves to locate the boundaries of the territory.

In the den area, the wolves left their scats at random on the trail, with no preference for one section or another. The wolves travel most frequently along the tires, where movement is easiest, so the probability of leaving scats on the sides and centre of the road is similar, given their proximity to the tires. In the den area, scats are left on both sides. In the rest of the territory, fewer scats are left in the tires than in the other three sections, and scats are most frequently left in the centre. The same occurred in the marginal section, where the proportion of scats increased in the access trail to the den area and particularly in the rest of the territory. This seems to be because the marginal section was where the highest substrates were, which potentiates the effectiveness of scats as marks. The same occurred in the centre, already a prominent zone, which is generally covered by conspicuous substrates where scats might be left.

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