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Influence of Social Rank on Defecating Behaviors in Feral Cats

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Abstract – Feral cats, *Felis catus*, showed 2 different defecating behaviors: they buried feces or left then exposed on the ground. We studied the relationship between the spatial distribution of buried/exposed feces and body weight of the producers, using the bait-marking method. Disproportionally small numbers of feces were found in the core areas of home ranges. The proportion of exposed feces in the core area was not different from that outside the core area, either and was not correlated with body weight in either sex. Heavier male cats buried feces at higher frequencies at sites closer to the centers. Such relationships were not found for females. These results suggest that social rank influences defecating behaviors in male feral cats.

Introduction

In feral cats, some feces are buried while others are left exposed on the ground (L.K. Corbett, 1979; Liberg, 1980; Panaman, 1981), and the spatial distribution of buried and exposed feces is not random (L.K. Corbett, 1979; Liberg, 1980; Macdonald et al., 1987; Feldman, 1994). Cats may bury their feces in the main living area for hygienic reasons (Bateson & Turner, 1988), or they may leave feces exposed as a scent marking around the border of the home range to defend territory (Feldman, 1994). Some studies show that defecation patterns depend on the social rank of cats. L.C. Corbett (cited in Macdonald, 1980) observed that buried feces were often found near lairs of subordinate males, and speculated that whether or not cats bury their feces depends on their social rank if feces exposure is a marking function (L.K. Corbett, 1979).

This study tests the previous hypotheses by using quantitative data and proposes further possible explanations.

Material & Methods

Population

This study was conducted on Ainoshima Island (125 ha), which is located about 7 km off-shore from Shingu, Fukuoka Prefecture, Japan. About 90% of the island are covered with secondary forests mixed with evergreen and deciduous trees (for the description of the study area, see Yamane et al., 1994, 1996). Observations were made on 53 days between early June and late December, 1995. This period did not include the main breeding season.

Cats were identified either by their coat color patterns, or by the collars that we attached. We have been able to identify all cats in the study area since 1989. Of 70 cats in the study area, 47 were males and 23 were females. All the producers of investigated feces (28 males and 16 females) were sexually matured. Cats were trapped and weighed to the nearest 0.01 kg in January, 1996.

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Fig. 1. The census route. The route followed the sequence of ascending numbers.

Home range

A fixed route (about 1.7 km, Fig. 1) was surveyed several times a day between 6:00 and 22:00 in order to check the location and behavior of identified cats. Locations of cats were plotted on a map (1:1250; maximum error from true location about 50 cm). Home ranges of all individuals were plotted with the minimum convex polygon method and WILDTRAK software (Todd, 1993).

Feces

The producer of feces was identified by the bait-marking method (Ikeda et al., 1979). Cats were fed a piece of sausage (about 2.5 cm^3 in volume) made from processed fish containing 6 "tips", small disks (5 mm diam.) of colored plastic tape. On the surface of tips, one of 77 different letters was embossed. The combination of letters and colors allowed us to recognize 385 patterns of tips.

During a route census (see above), we fed cats with bait and searched for feces. When feces were found, tips were collected from them and their locations were plotted on the map. These feces were categorized as either "buried" or "exposed". Exposed feces with indications of burial attempts were regarded as buried.

Distance Score

We used a "distance score" as the standardized location of feces in a home fange to measure the spatial location of feces relative to the center of home range. Each home range was divided into 6 zones by superimposing contours of 5 polygons that cover 50%, 60%, 70%, 80%, 90% and 100% of the activities (peeled polygon method: Todd 1993). The central zone was defined as the area encompassed by the 50% polygon contour, hereafter the "core area." The second central zone was the ring-shaped area between the 50% and 60% polygon contours, hereafter "50−60%". The other 4 zones, "60−70%", "70−80%", "80−90%", and "90−100%" were defined in the same manner. Some feces were found outside the minimum convex polygon (i.e., estimated home range), so another zone, "over 100%", was defined. Each piece of feces in each zone was assigned a score as follows: 25 for core area, 55 for "50−60%", 65 for "60−70%", 75 for "70−80%", 85 for "80−90%", 95 for "90−100%" and 100 for "over 100%". Scores for each cat were averaged, and the average called the "distance score".

Results

1. Home range and body weight of cats

Mean home range size for males and females were 0.77±0.14 ha (mean±SE, n=28) and 0.37±0.07 ha (n=16, Fig. 2(a), (b)), respectively. Home ranges of cats were stable during the observation period, which did not include the main breeding season.

Thirty-two sexually mature cats of 44 producers of the examined feces were captured and weighed in January, 1996. The mean body weight of males and females was 4.21±0.12 kg (mean±SE, n=20) and 3.05±0.10 kg (n=12), respectively.

2. The number of feces found

Total number of collected feces containing tips was 402, deposited by 61 cats. Out of them, 70 feces from 17 cats which deposited all buried or all exposed feces were omitted from the analysis to avoid sampling error. Of 332 feces

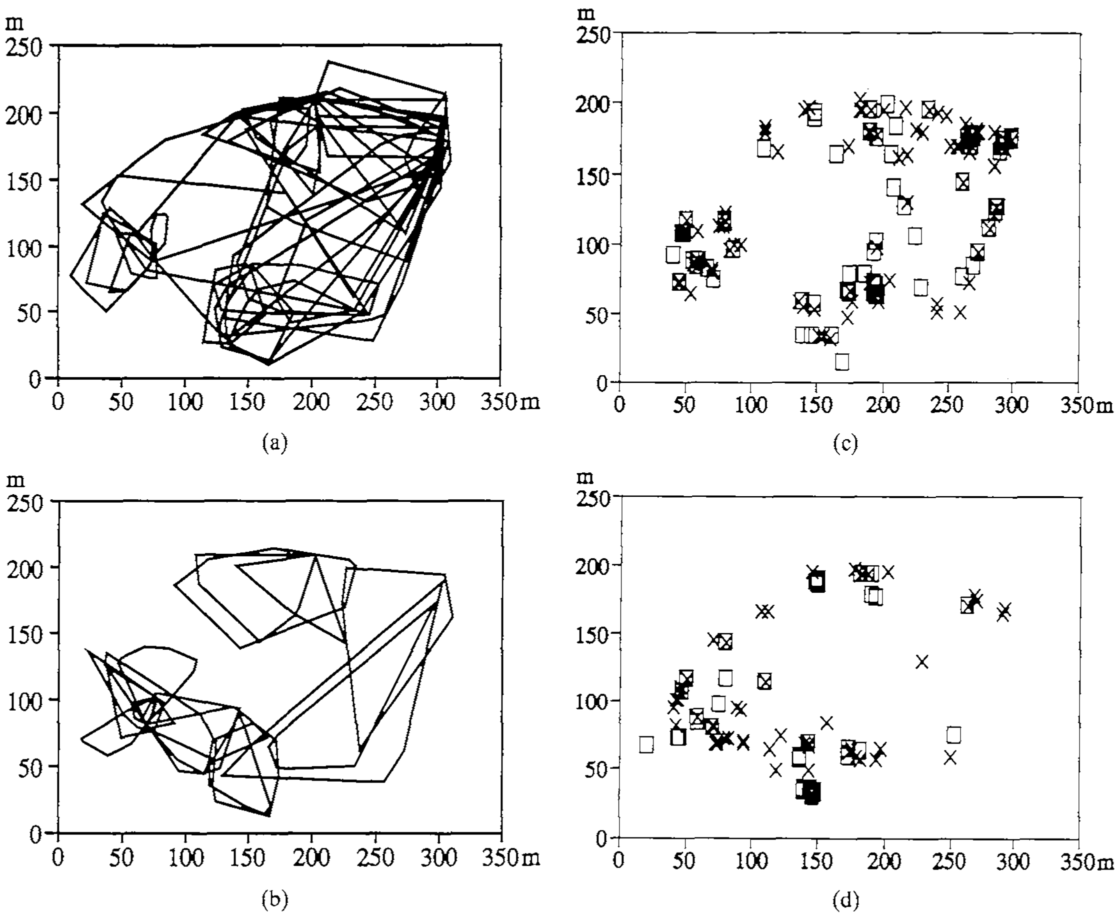

Fig. 2. (a) Home ranges of 28 males. The lines indicate ranges illustrated with the minimum convex polygon method. (b) Home ranges of 16 males. (c) The distribution of male feces. Cross: exposed feces, square: buried feces. (d) The distribution of female feces. Cross: exposed feces, square: buried feces.

by 44 cats (28 males and 16 females), 208 were exposed and 124 were buried (Fig. 2(c), (d)). The mean number of total feces collected for a cat was 7.55±0.6 (mean±SE). Numbers for exposed and buried ones were 4.73±0.6 and 2.82±0.3, respectively.

3. Exposed feces and buried feces

The mean proportions of exposed feces to all feces for males and females were 58.7±4.1% and 60.6±4.9%, respectively, and the difference between them was not significant (Mann-Whitney U-test, U=213.5, n=28 in males, n=16 in females, P=0.79).

Fifty six of 208 exposed feces and 28 of 124 buried feces were located in the core area (Table 1). Cats may have been exposing feces at different proportions in the core and outside areas. We examined this by 2 kinds of comparisons. As the number of feces deposited varied among cats, we made comparisons of the proportion of the number of exposed feces (or that of feces in the core area) for individual cats. First, we compared the proportion of the number of feces in the core area to the number of feces in the core and outside areas between exposed and buried feces. The proportion of feces in the core area was not significantly different between exposed and buried feces (Wilcoxon's signed rank test, total; z= −0.44, P=0.66, male; z= −0.78, P=0.44, female; z= −0.27, P=0.79). We then compared the proportion of the number of exposed feces to the number of exposed and buried feces between the core and outside areas. The proportion of exposed feces was not significantly different between the 2 areas (Wilcoxon's signed rank test, total; z= −1.04, n=21, P=0.92, male; z=−0.63, n=15, P=0.53, female; z=−0.63, n=6, P=0.53).

Table 2. Distance score of exposed and buried feces (mean ± S.E.).

	n[a]	Exposed	Buried
Males	28	73.5 ± 4.3	68.1 ± 4.9
Females	16	76.7 ± 6.0	72.2 ± 6.3
Total	44	74.7 ± 3.3	69.6 ± 3.8

[a] Number of individuals examined.

4. Spatial distribution of feces

Distance score of exposed feces was not significantly different from that of buried feces for all the cats (Wilcoxon's signed rank test, total; z=1.14, P=0.25, Table 2). The difference between the distance score of exposed feces and that of buried feces was not significant in either sex (Wilcoxon's signed rank test, male; z= −0.85, P=0.40, female; z= −0.88, P=0.38, Table 2). The distance scores for males and females were not different for exposed (Mann-Whitney U-test, U=213.0, P=0.36) or buried feces (Mann-Whitney U-test, U=236.5, P=0.98).

5. Distance score and body weight

There was no significant correlation between distance score of exposed feces and body weight in either sex (Kendall's rank correlation coefficient, males: τ=0.05, n=20, P=0.77; females: τ=0.41, n=12, P=0.06; Fig. 3). A significant negative correlation between distance score of buried feces and body weight was observed in males but not in females (Kendall's rank correlation coefficient, τ= −0.42, n=20, P=0.01; females: τ=0.19, n=12, P=0.40; Fig. 3). There

Table 1. Numbers of exposed and buried feces collected in the study site (mean ± S.E.).

	n[a]	Exposed		Buried		Total	
		core[b]	others[c]	core[b]	others[c]	core[b]	others[c]
Males	28	1.46 ± 0.46	3.43 ± 0.73	0.79 ± 0.29	2.07 ± 0.58	2.25 ± 0.58	5.50 ± 0.82
Females	16	0.94 ± 0.39	3.50 ± 0.61	0.38 ± 0.22	2.38 ± 0.46	1.31 ± 0.48	5.88 ± 0.87
Total	44	1.27 ± 0.33	3.45 ± 0.51	0.04 ± 0.20	2.18 ± 0.26	1.91 ± 0.41	5.64 ± 0.60

[a] Number of individuals examined.
[b] Feces collected in the core area.
[c] Feces collected outside the core area.

was no significant correlation between mean distance scores of all feces and body weights (Kendall's rank correlation coefficient, males: $\tau = -0.24$, $n = 20$, $P = 0.14$; females: $\tau = 0.26$, $n = 12$, $P = 0.24$).

When distance scores of a single female with a body weight of 3.88 kg are omitted from analyses, correlation between exposed feces and body weight is significantly positive (Kendall's rank correlation coefficient, exposed feces: $\tau = 0.62$, $n = 11$, $P < 0.01$; buried feces: $\tau = 0.38$, $n = 11$, $P = 0.10$). The age of this female was 1 year. She had already experienced breeding.

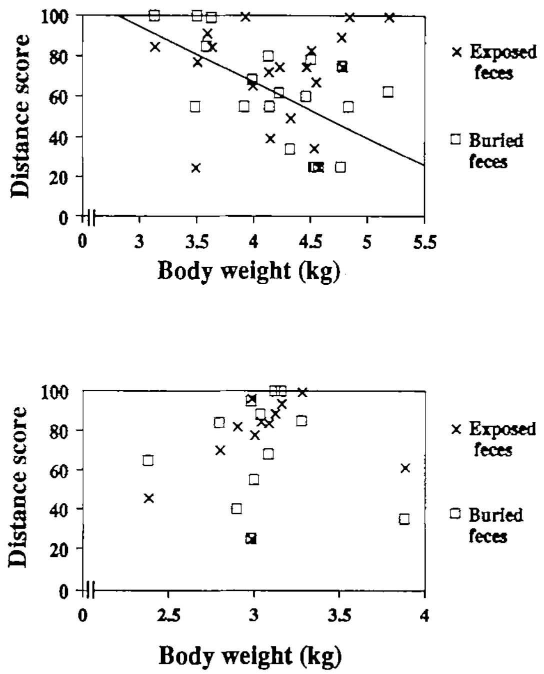

Fig. 3. Relationship between distance score and body weight. (a) Male, (b) female. Cross: exposed feces, square: buried feces.

Discussion

Previous studies suggest the importance of 2 factors, that is hygiene and scent marking, in determining spatial distribution of feces in feral cats. In all the previous studies, producers of feces were judged by their locations or by direct observations of defecating behaviors. Identification of feces producers is less reliable in the former, and it is difficult to obtain a large sample in the latter. In our study area, cats lived in high density with a large overlap of home ranges (Izawa et al., 1982; Yamane et al., 1994). When home ranges overlap, locations of feces do not provide information on the source, but the bait-marking method (Ikeda et al., 1979) used in this study allowed us to identify the producers of feces and collect an abundance of data. We used the distance score as the standardized location of feces to quantify the spatial position of feces from the center of the home range. Feldman (1994) reported that cats had tended to urinate and defecate at places more than 10 m away from the feeding area and suggested that it minimized contamination of food. In our study, 23.5±4.5% of total feces were deposited in the core area that was usually consistent with the feeding area. However, feces were not buried more frequently in the core area than outside of it.

Exposed feces have been thought to have a function of scent marking and territory defense. Panaman (1981) and Macdonald et al. (1987) claimed that more feces are left exposed outside the core area by females. In our study, no significant difference was observed between the proportions of exposed and buried feces in the core area. Exposed feces were not observed in concentrations along the perimeters of the home ranges. Furthermore, the spatial distributions of exposed and buried feces were not different.

L.C. Corbett (cited in Macdonald, 1980) noted that dominants in a group of feral cats leave feces at conspicuous sites, whereas subordinate cats bury their feces. Body weight of male feral cats is one of the important factors that influences fighting ability, rank during courtship and mating success (Yamane et al., 1996). In females, heavier cats have priority in feeding order (Yamane et al., 1997). In this study, heavier cats did not expose their feces more frequently than lighter cats in either sex. If the body weight of cats is regarded as an index of social rank, our results do not support the claim of L.C. Corbett.

We obtained an important finding that was not reported in previous studies. The distance score of buried feces correlated negatively with body weight in males. Heavier male cats tended to bury their feces at sites closer to the core area. This suggests that dominance rank is related to scent marking behaviors in males if exposed feces have such a function. On the other hand, there were no correlations between body weight and distance scores for both types of feces in females. This difference between sexes seems to correspond to the findings obtained from studies on urine spraying, that have reported that males react to urine spraying more than females (Natoli, 1985) and marked 4 times as frequently (Liberg, 1980).

Correlation between exposed feces and body weight was significantly positive when excluding the female with a exceptionally heavy body weight. As described in the results, we did not find any exceptional feature in this female. Further observations are needed to conclude the relationships between distance scores and body weight for females.

In this study, we showed that several hypotheses on the spatial distribution of feces suggested by previous studies were not empirically supported. However, this study does not disprove that cats burial of feces may depend on a balance of 2 factors, marking and hygiene, or prove why body weight affects defecating behaviors in males. To understand the function of spatial patterns of buried and exposed feces, the behavioral response to feces and the hygienic effect of exposed feces should be examined in future studies.

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References

Bateson, P. & D.C. Turner 1988 Questions about cats. In: D.C. Turner & P. Bateson (eds.), *The domestic cat: the biology of its behaviour*. pp. 193-201. Cambridge Univ. Press, Cambridge.

Corbett, L.K. 1979 Feeding ecology and social organization of wildcats (*Felis silvestris*) and domestic cats (*Felis catus*) in Scotland. Ph. D. thesis, University of Aberdeen, Scotland. pp. 231.

Feldman, H, N. 1994 Methods of scent marking in the domestic cat. *Can. J. Zool. 72*: 1093-1099.

Ikeda, H., K. Eguchi & Y. Ono 1979 Home range utilization of a raccoon dog, *Nyctereutes procyonoides viverrinus*, Temminck, in a small islet in western Kyushu. *Jpn. J. Ecol. 29*: 35-48.

Izawa, M., T. Doi & Y. Ono 1982 Grouping patterns of feral cats (*Felis catus* Linn.) living on a small island in Japan. *Jpn. J. Ecol. 32*: 373-382.

Liberg, O. 1980 Spacing patterns in a population of rural free roaming domestic cats. *Oikos 35*: 336-349.

Macdonald, D.W. 1980 Patterns of scent marking with urine and feaces amongst carnivore communities. *Symp. Zool. Soc. Lond. 45*: 107-139.

Macdonald, D.W., P.J. Apps, G.M. Carr & G. Kerby 1987 Social dynamics, nursing coalitions and infanticide among farm cats, *Felis catus*. *Adv. Ethol. 28*: 1-66.

Natoli, E. 1985 Behavioural responses of urban feral cats to different types of urine marks. *Behaviour 94*: 234-243.

Panaman, R. 1981 Behaviour and ecology of free-ranging female farm cats (*Felis catus* L.). *Z. Tierpsychol. 56*: 59-73.

Todd, I. 1993 *WILDTRACK*. ISIS Innovation Ltd., Oxford.

Yamane, A., Y. Ono & T. Doi 1994 Home range size and spacing pattern of a feral cat population on a small island. *J. Mamm. Soc. Jpn. 9(1)*: 9-20.

Yamane, A., T. Doi & Y. Ono 1996 Mating behaviors, courtship rank and mating success of male feral cat (*Felis catus*). *J. Ethol. 14*:

35-44.
Yamane, A., J. Emoto & N. Ota 1997 Factors affecting feeding order and social tolerance to kittens in the group-living feral cat (*Felis catus*). *Appl. Anim. Behav. Sci.* *52* : 119-127.

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