The influence of olfactory enrichment on the behaviour of captive black-footed cats, *Felis nigripes*

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Abstract

The value of olfactory enrichment for captive-housed animals is now well recognised. Large cats have been shown to benefit from the introduction of odours to their captive environment, but to date the effect of odour introduction on the behaviour of small cats remains unknown. This study investigated the behaviour of six zoo-housed black-footed cats, *Felis nigripes*, in response to four odours (no odour [control], nutmeg, catnip and body odour of prey) introduced individually on cloths into the animals' pens over a period of 5 days. It was hypothesised that the cats' behaviour would differ significantly between the control and experimental odours and that interest in the experimental odours would wane over time. All of the experimental odours influenced the cats' behaviour, resulting in an increase in the amount of time that the animals spent in active behaviours, i.e. moving (average increase of 8.3%), grooming (average increase of 5.9%), exploring the cloth (average increase of 10.9%) and exploring the pen (average increase of 9.2%). The experimental odours also resulted in a decrease in the amount of time that the cats spent in sedentary behaviours, i.e. standing (average decrease of 2.8%), sitting (average decrease of 5.2%) and resting (average decrease of 25.9%). Nutmeg exerted less of an effect on the cats' behaviour than catnip or odour of prey. The cats' response to all of the experimental odours waned over the course of the 5-day observation period, suggesting that the animals habituated to the stimuli. The results highlight the potential for odour to be employed as a method of environmental enrichment for small captive-housed felids, if presented in an appropriate manner.
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1. Introduction

The effect of captivity on the behaviour and welfare of animals has received much attention since original studies by Hediger (1950, 1955). It is now realised that keeping animals in small, uninteresting environments can induce abnormal and aberrant behaviour (see Appleby and Hughes, 1997; Broom and Johnson, 1993 for reviews), and many attempts to improve well-being by enriching the environment through the provision of extra stimulation have been undertaken (e.g. Markowitz, 1982; Renner and Lussier, 2002; Wells and Hepper, 2000; Wells et al., 2002).

Traditional methods of environmental enhancement for captive-housed felids have focused on changing feeding regimes, introducing toys or implementing operant-conditioning devices that require animals to work for food (see Mellen et al., 1998 for review). More recently, some attention has been directed towards the value of odours as a form of environmental enrichment for large wild cats. Powell (1995), for example, discovered that the introduction of scents including musk cologne, allspice and extracts of peppermint and almond, increased the activity level of captive-housed African lions, *Panthera leo*. Similar findings were reported by Schuett and Frase (2001) in their study of zoo-housed lions exposed to zebra dung, cinnamon, chilli powder and ginger, and by Pearson (2002) in her study of captive Asiatic lions exposed to herbs (i.e. rosemary, chives, lemongrass and allspice), and essential oils (i.e. peppermint, ylang ylang and eucalyptus).

To date, the value of olfactory enrichment for small wild felids has been completely overlooked. The following study thus explored the effect of olfactory stimulation on the behaviour of one of the smallest zoo-housed wild felids, the black-footed cat, *Felis nigripes*. There are currently 45 black-footed cats residing in captivity world-wide. In its natural habitat (central and western parts of South Africa, Smithers, 1971; Skinner and Smithers, 1990), the black-footed cat, a highly solitary species weighing between 2 and 5 lbs (Molteno et al., 1998; Sliwa, 1994), spends much of its waking hours active, hunting for foods including rodents, birds and insects (Olbricht and Sliwa, 1997; Sliwa, 1993). In captivity, however, this particular species is largely inactive (Mellen, 1989; Mellen et al., 1998). Enriching the environment of captive black-footed cats so that it encourages greater activity and more species-typical behaviour would thus be of great value.

The following study investigated the behaviour of six zoo-housed black-footed cats in response to the introduction of four individual odours to their environment. The odours consisted of a control (i.e. no artificial odour) and three experimental scents, including the spice nutmeg, the herb catnip and the body odour of a prey animal (quail). All of the odours were chosen on the rationale that they typically have an effect on the behaviour of other wild and domestic felids and are considered to be suitable olfactory stimuli for presentation to captive-housed cats (Mellen, 1989; Pearson, 2002; Powell, 1995; Schuett and Frase, 2001). The influence of the length of time the cats were exposed to each odour on the animals' behaviour was also examined. It was hypothesised that the cats' behaviour would differ significantly between the control and experimental conditions. It was also predicted that the cats' interest in the experimental odours would wane over time.

2. Method

2.1. Subjects

Subjects included six captive-born black-footed cats (see Fig. 1) housed singly at the Belfast Zoological Gardens, Co. Antrim (see Table 1). The cats were housed side-by-side in indoor enclosures (2 m × 2 m × 3 m) with wire-meshed walls and a concrete floor scattered with sand. No other animals resided in the cats' exhibit. Each enclosure was fitted with a raised platform, branches and hides (e.g. pipes). The temperature was maintained at 30 °C, and the humidity level at 15%, throughout the study. Artificial lighting was provided with three 20 W fluorescent tubes. The cats' enclosures were cleaned once every morning and the animals subsequently scatter-fed. Typical foods provided to the cats included whole birds (i.e. pheasant and chicken), rodents (e.g. hamster, rat, mouse and gerbil) and beef heart. All foods were supplemented with a multi-vitamin carnivore powder.
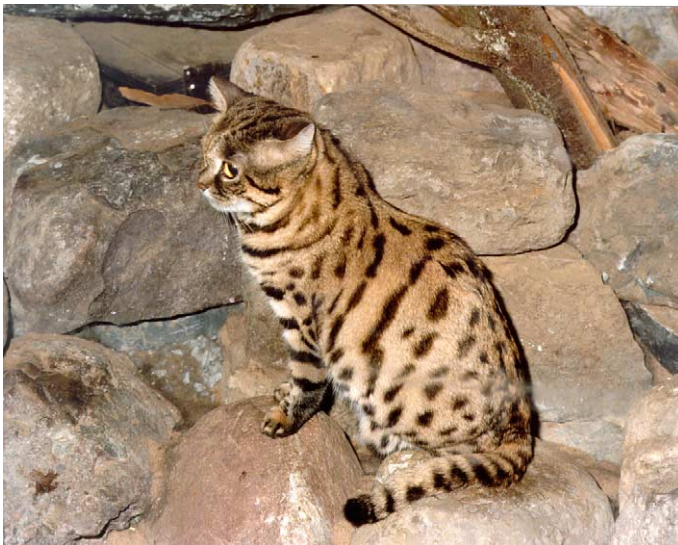

Fig. 1. A black-footed cat (photograph by John Fisher).

Table 1
Information on the sex, origins, age and length of time at the study site of the black-footed cats

Subject	Sex	Origins	Age (years)	Time at study site (years)
Korma	Male	Belfast Zoo	1.2	1.2
Quaver	Male	Belfast Zoo	2.0	2.0
Kruger[a]	Male	Frankfurt Zoo	4.2	2.8
Dee-dee[a]	Female	Frankfurt Zoo	4.2	2.8
Pepper	Female	Riverbanks Zoo	3.5	2.2
Salsa	Female	Belfast Zoo	1.2	1.2

[a] Indicates siblings.

2.2. Odours

The cats were exposed to three experimental odours. These included: (1) the spice nutmeg, *Myristica fragrans*. Three 5 ml teaspoons of the ground form of this spice were used; (2) the herb catnip, *Nepeta cataria*. Three 5 ml teaspoons of the dried form of this herb were used; (3) the body odour of a prey animal (quail, *Coturnix coturnix*). The quail were supplied frozen to Belfast Zoo by Honeybrook Farm, UK, stored in deep freezers and subsequently defrosted 24 h before the study. One quail, per cloth (see later) was used. All of the odours are considered to be appropriate novel scents for captive-housed felids (Mellen et al., 1998). All of the odours were completely novel to the cats born in Belfast Zoo; thus, prior to the experiment none of these cats had been exposed to any of the scents; whether the cats imported from other zoos had any previous experience with the odours was unknown due to limited background information.

The odours were introduced individually into the cats' environment on sterilised flannel cloths (1 m × 1 m). Each cloth was impregnated with one odour 30 min before its introduction into the animals' enclosures by rubbing a standard amount (i.e. 5 ml teaspoons of nutmeg and catnip and the entire body of one quail) of the appropriate stimulus (e.g. nutmeg) back and forwards over the flannel 50 times. Each cloth was then immediately placed into a plastic bag and sealed with a fastener to avoid contamination with external odours. Plastic gloves were worn by the experimenter throughout to avoid contaminating the cloths with human body odour. A fourth cloth (control), devoid of impregnated odour, was also employed. This cloth was handled in exactly the same way as the other flannels, minus the odour impregnation. Different source materials were employed for each cloth on all days of the study, rather than using the same odour sources multiple times.

2.3. Procedure

Each cat was observed in all four olfactory conditions (one control and three experimental). At the start of each study session one cloth was placed on the floor of each cat's enclosure. This cloth remained in the animal's enclosure for that particular study session (i.e. 24 h). The cloth was then removed and replaced with a new cloth with the *same*, but freshly impregnated, odour the next day. This procedure continued for 5 days. Following an intervening period of 2 days with no cloth, a new cloth with a *different* odour was introduced into the cat's enclosure; cloths with this particular odour again remained in the cat's environment for 5 continuous days (one cloth per day). This process continued for 4 weeks, until the cats had been exposed to all of the olfactory conditions. All six cats were exposed to the same odours in the same order since the wire mesh barrier between the animals' enclosures did not prevent scent transmission. The cats were presented with the control cloth first, followed by the nutmeg, catnip and then the body odour of the prey animal.

The behaviour of each cat was recorded by one experimenter (JME) on days 1, 3 and 5 during both the control condition (week 1) and each of the experimental conditions (weeks 2–4). The observer sat silently for 10 min outside the cats' enclosures prior to the start of each study session to ensure that the animals habituated to his presence prior to the data

Table 2
Ethogram of behavioural categories for the black-footed cats

Behaviour	Definition
Resting	Reclining in a ventral or lateral position
Standing	Supported upright with all four legs
Sitting	Supported by two extended front legs and two flexed back legs
Moving	Walking, running or pacing
Grooming	Licking own body
Exploring pen	Sniffing the ground or enclosure features within 5 cm
Exploring cloth	Sniffing the cloth within 5 cm

collection. No other humans, either zoo keepers or visitors, entered the cats' exhibit during any of the test sessions. Observations of the animals' behaviour commenced immediately following the introduction of the cloths into all of the cats' pens. The cats were studied using a scan-sampling technique (e.g. Martin and Bateson, 1986) every 5 min from 12:00 p.m. to 4:00 p.m., providing 48 observations of each cat's behaviour per day. At each sample point a behaviour from an ethogram adapted from one developed for African lions (Powell, 1995) was recorded (see Table 2).

Where a cat was observed performing two behaviours simultaneously (e.g. grooming and sitting or sniffing and standing), the more active of the two behaviours was always recorded (i.e. grooming and sniffing as opposed to sitting or standing). A cat was only recorded as exploring the cloth if its nose was directly over the top of the cloth at a distance of no more than 5 cm; if the animal was exploring the ground directly beside the cloth, the individual was recorded as exploring the pen. Whilst it would have been useful to have made a distinction between the behaviours walking, running and pacing, the latter two activities were seen so seldom (under 0.5% of the total observation time), that they were combined together with walking for the category of moving.

2.4. Data analysis

The total number of times each animal was observed performing each behaviour was summed for each condition, providing an overall frequency count per cat per behaviour on all days of the study. For each behaviour (e.g. resting, standing) a repeated measures design ANOVA (e.g. Howell, 1992) was conducted on this data, using SPSS 10 for Apple Macintosh, for the within subjects factors of odour condition (control:nutmeg:catnip:prey) and day of observation (day 1:day 3:day 5) to determine whether the cats' behaviour was influenced by the odours introduced into their environment and whether their behaviour was affected by the length of time the animals were exposed to the various scents. Results are expressed as the mean number of observations per behaviour out of a potential 48 sample points per day.

The assumptions underlying parametric analysis (e.g. Howell, 1992) were sufficiently met in terms of population normality, sample independence and homogeneity of variance (Mauchly Sphericity and Kolmogorov-Smirnov tests, n.s.).

3. Results

3.1. Resting

The cats' resting behaviour was significantly related to odour condition ($F[3, 15] = 91.95$, $P < 0.001$). The animals spent significantly ($P < 0.01$, Newman–Keuls test) more of their time resting during the control condition (mean number of observations = 25.89 ± 0.95), and less of their time resting during the catnip condition (mean number of observations = 7.50 ± 0.89), than the nutmeg (mean number of observations = 21.44 ± 0.61) or prey (mean number of observations = 11.39 ± 0.74), conditions.

The analysis also revealed a significant main effect of day of observation ($F[2, 10] = 83.72$, $P < 0.001$). A post hoc Newman–Keuls test indicated that the cats spent significantly ($P < 0.01$) less of their time resting on the first day of observation (mean number of observations = 12.50 ± 0.43), than on day 3 (mean number of observations = 17.54 ± 0.32) or day 5 (mean number of observations = 19.62 ± 0.45).

Importantly, there was a significant interaction between odour condition and day of observation ($F[6, 30] = 18.80$, $P < 0.001$). Tests for simple effects revealed that the cats spent significantly ($P < 0.001$, for all paired t-tests) less of their time resting on day 1 during all of the experimental conditions than the control condition. Resting remained at a significantly ($P < 0.001$, paired t-tests) lower frequency than the control on days 3 and 5 for both the catnip and prey conditions, but returned to a similar frequency as the control on these days during the nutmeg condition (see Fig. 2).

3.2. Moving

The ANOVA revealed a significant main effect of odour condition ($F[3, 15] = 52.26$, $P < 0.001$). Post hoc tests revealed that the cats spent significantly ($P < 0.01$, Newman–Keuls test) less of their time moving during the control condition (mean number of observations = 6.50 ± 0.41) than the nutmeg (mean number of observations = 8.17 ± 0.45), prey (mean number of observations = 11.06 ± 0.41) or catnip (mean number of observations = 12.22 ± 0.40) conditions. The cats also spent significantly ($P < 0.01$, Newman–Keuls test) less of their time moving during the nutmeg condition than the catnip or prey conditions.

Analysis revealed a significant main effect of day of observation ($F[2, 10] = 248.65$, $P < 0.001$). The cats spent significantly ($P < 0.01$, Newman–Keuls test) more of their time moving on the first day of observation (mean number of observations = 15.87 ± 0.59) than on day 3 (mean number of observations = 6.37 ± 0.23) or day 5 (mean number of observations = 6.21 ± 0.25).

There was a significant interaction between odour condition and day of observation ($F[6, 30] = 52.42$, $P < 0.001$). The cats spent significantly ($P < 0.001$, for all paired t-tests) more of their time moving on day 1 during the experimental conditions than the control condition. Both the catnip and prey conditions also encouraged significantly ($P < 0.001$, paired t-tests) more movement from the cats on day 1 than the nutmeg condition. Moving decreased to approximately control levels on days 3 and 5 for all experimental conditions (see Fig. 3).
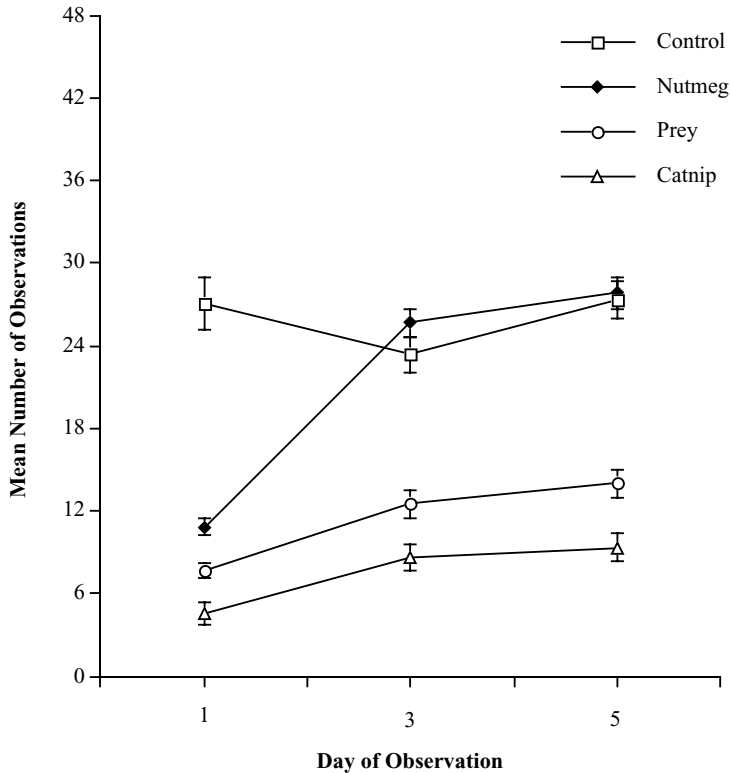
Fig. 2. The mean number of times (±S.E.) that the cats were observed resting during each olfactory condition on days 1, 3 and 5.

3.3. Standing

The cats' standing behaviour was significantly related to odour condition ($F[3, 15] = 10.00$, $P = 0.001$). Significantly ($P < 0.01$, Newman–Keuls test) more of the cats' time was spent standing during the control condition (mean number of observations = 1.33 ± 0.42) than any of the experimental conditions (mean number of observations for each condition = 0).

3.4. Sitting

The ANOVA revealed a significant effect of odour on the cats' sitting behaviour ($F[3, 15] = 10.00$, $P = 0.001$). The cats spent significantly ($P < 0.01$, Newman–Keuls test) more of their time sitting during the control condition (mean number of observations = 2.94 ± 0.73) than the catnip (mean number of observations = 1.00 ± 0.45), prey (mean number of observations = 0.67 ± 0.42) or nutmeg (mean number of observations = 0) conditions.
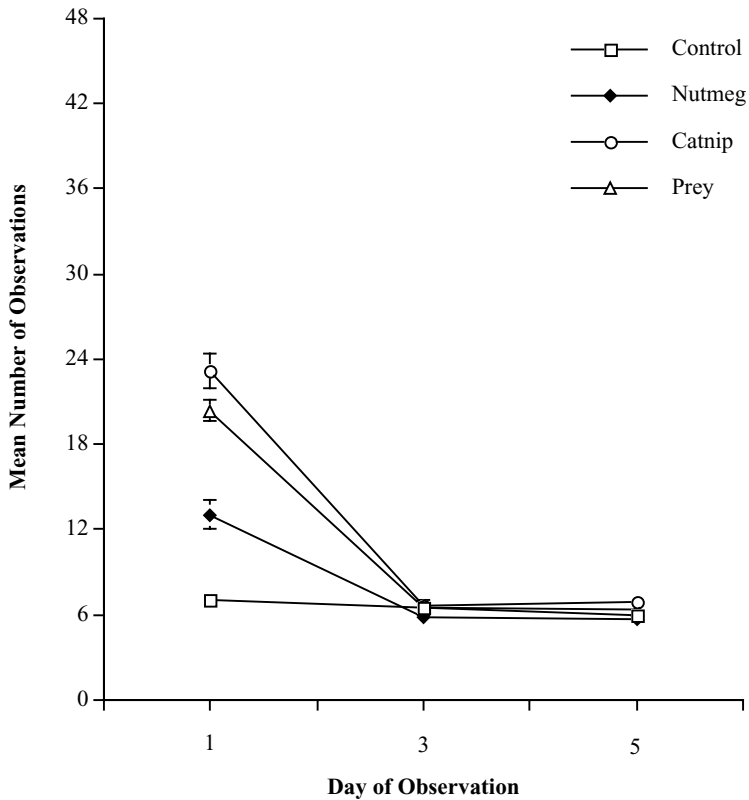
Fig. 3. The mean number of times (±S.E.) that the cats were observed moving during each olfactory condition on days 1, 3 and 5.

3.5. Grooming

The cats' grooming was significantly related to odour condition ($F[3, 15] = 10.84$, $P < 0.001$). Significantly ($P < 0.01$, Newman–Keuls test) less of the cats' time was spent grooming during the control condition (mean number of observations $= 2.11 \pm 0.41$) than the nutmeg (mean number of observations $= 4.33 \pm 0.21$), prey (mean number of observations $= 4.56 \pm 0.47$) or catnip (mean number of observations $= 6.00 \pm 0.73$) conditions.

3.6. Exploring pen

The ANOVA revealed a significant main effect of odour condition on the cats' exploration of their environment ($F[3, 15] = 13.48$, $P < 0.001$). The cats spent significantly ($P < 0.01$, Newman–Keuls test) less time exploring their pen during the control condition (mean number of observations $= 4.94 \pm 0.41$) than the prey (mean number of observations $= 9.78 \pm 1.23$) or catnip (mean number of observations $= 11.67 \pm 0.86$) conditions. The

cats also spent significantly ($P < 0.05$, Newman–Keuls test) less time exploring their environment during the nutmeg condition (mean number of observations $= 6.56 \pm 0.51$) than during the prey and catnip conditions.

There was also a significant main effect of day of observation ($F[2, 10] = 119.15$, $P < 0.001$). Post hoc Newman–Keuls tests showed that the cats spent significantly ($P < 0.01$) more time exploring their environment on the first day of observation (mean number of observations $= 14.67 \pm 0.93$) than on day 3 (mean number of observations $= 5.04 \pm 0.31$) or day 5 (mean number of observations $= 5.00 \pm 0.17$).

There was a significant two-way interaction between odour condition and day of observation ($F[6, 30] = 17.23$, $P < 0.001$). Tests for simple effects showed that the cats spent significantly ($P < 0.001$, for all paired t-tests) more of their time exploring their environment on day 1 during all of the experimental conditions than the control condition. Both the catnip and prey conditions also encouraged significantly ($P < 0.001$, paired t-tests) more exploration of the environment on day 1 than the nutmeg condition. The cats' exploration of their environment returned to approximately control levels on days 3 and 5 for all experimental conditions (see Fig. 4).
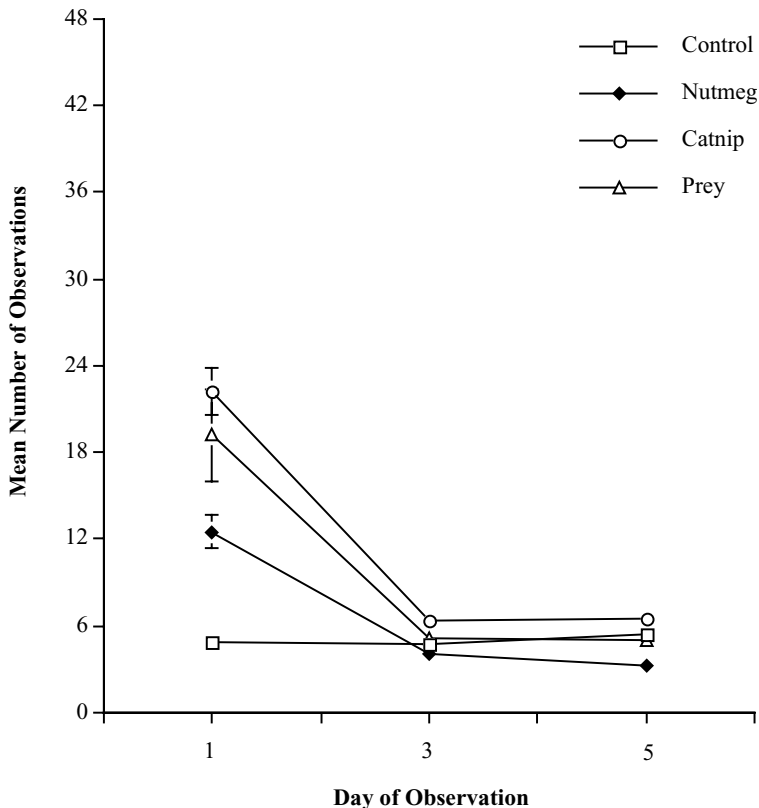

Fig. 4. The mean number of times ($\pm$S.E.) that the cats were observed exploring their environment during each olfactory condition on days 1, 3 and 5.

3.7. Exploring cloth

The cats' exploration of the cloth was significantly related to odour condition ($F[3, 15] = 41.56$, $P < 0.001$). Post hoc tests revealed that the cats spent significantly ($P < 0.01$, Newman–Keuls test) less of their time exploring the cloth during the control condition (mean number of observations = 4.00 ± 0.41) than the nutmeg (mean number of observations = $7.50 \pm 0.0.59$), catnip (mean number of observations = 9.61 ± 0.51) or prey (mean number of observations = 10.56 ± 0.42) conditions. The cats also spent significantly ($P < 0.01$, Newman–Keuls test) less of their time exploring the nutmeg impregnated cloth than cloths impregnated with catnip or prey.

The analysis also revealed a significant main effect of day of observation ($F[2, 10] = 1266.07$, $P < 0.001$). The cats spent significantly ($P < 0.01$, Newman–Keuls test) more of their time exploring the cloths on the first day of their introduction to the pen (mean number of observations = 16.33 ± 0.49) than on day 3 (mean number of observations = 3.96 ± 0.25) or day 5 (mean number of observations = 3.46 ± 0.19).

4. Discussion

The findings from the present study suggest that the behaviour of the black-footed cat, *F. nigripes*, is significantly influenced by olfactory stimulation, but that the effect of odours on the behaviour of this particular species wanes over time.

All of the odours employed in the present study exerted a significant effect on all aspects of the black-footed cats' behaviour. Compared to the control condition, the experimental odours encouraged the cats to spend less of their time in sedentary behaviours (i.e. resting, standing and sitting) and augmented the amount of time that the animals spent active (i.e. moving and exploring). This change in the animals' general activity could be considered a positive one. Many wild cats, including *F. nigripes*, spend much lengthier periods of time inactive in captivity than in their natural habitat (Powell, 1995; Mellen, 1989; Mellen et al., 1998). One of the goals of environmental enrichment is to encourage the expression of more species-typical behaviour, e.g. increase activity, decrease inactivity (see Broom and Johnson, 1993 for review). It appears from the present study that olfactory stimulation may, in part, fulfil this particular criteria of environmental enrichment. It must be pointed out, however, that an increment in activity may not necessarily be correlated with an increase in animal well-being. Just because an animal exhibits more species-typical behaviour, does not automatically imply greater welfare; it is possible that the higher level of activity observed in the wild animal, for instance, is a result of stressful stimulation, e.g. predation (see Appleby and Hughes, 1997 for review) and attempts to encourage greater levels of activity in the captive counterpart could be based on a misguided rationale.

It has been argued that attempts to increase activity levels in captive-housed cats may be both futile and unnatural (Hutchins et al., 1984). Rather, it has been suggested that enrichment studies focus on methods of changing *how* such animals partition their active time. Thus, Mellen et al. (1998), for instance, recommend forms of enrichment that encourage cats to spend less of their time pacing and more of their time investigating their environment. Olfactory stimulation may be one means of achieving such a goal. The odours

employed in the present study, for example, not only encouraged greater general activity in the black-footed cats, they also induced more exploration, both of the cloths impregnated with the scents, and their surrounding environment.

The experimental conditions also augmented frequencies of grooming. It is possible that the increment in this self-directed behaviour was an indirect consequence of the increased amount of time that the cats spent active during the experimental conditions. Alternatively, it may be the case that the olfactory stimuli introduced into the cats' environment directly encouraged oral grooming. One of the important functions of grooming is the removal of dirt (Eckstein and Hart, 2000). The experimental odours used in the present study, particularly catnip and nutmeg, were relatively powdery in nature. Exploration of the cloths may have resulted in some of the residue adhering itself to the cats' fur, thereby increasing levels of self-directed grooming. This does not, however, explain why grooming in the quail condition was intermediate to that observed in the nutmeg and catnip conditions. An alternative explanation is that the cats' increased grooming arose out of conflict. The animals may have been frustrated by the presence of the odours, giving rise to a self-directed displacement behaviour. The motivation behind the cats' increased grooming is worthy of further exploration so that an accurate assessment of the value of odours as enrichment stimuli can be established.

Whilst all of the experimental odours influenced the cats' behaviour, there were apparent between-odour differences. Of the scents employed, nutmeg exerted the least influence on the cats' behaviour, whilst the scent of prey, and in particular, catnip, elicited the strongest responses. The amount of time that the cats spent moving greatly increased immediately following the introduction of the catnip. This particular herb is widely believed to act as an 'aphrodisiac' for domestic cats, sending them into states of friskiness and euphoria. Interestingly, some wild felids, including tigers and bobcats, do not respond to the odour of catnip (Bradshaw, 1992). The findings from both the present study and previous work on lions (Powell, 1995), however, suggest that catnip, and related scents (e.g. peppermint extract), have a euphoria-inducing effect in other species of wild cat.

The cats' response to the experimental odours waned considerably over the course of the 5-day observation period, suggesting that the animals habituated to the stimuli. Altering the order of scent introduction (i.e. presenting catnip on 1 day followed by nutmeg the next, etc.) or only using odours on an occasional basis so that they serve as intermittent stimulants, may be two possible means of renewing cats' interest in such stimuli. It is of some interest that the cats habituated to the catnip. If this herb does indeed have a euphoria-inducing effect (implying a direct, neurophysiological action), one might have expected the cats to have elicited a similar response to this odour with repeated exposure. The fact that the subjects showed a reduced reaction to this herb over time might indicate that black-footed cats are not affected by catnip in the same way as other felids, as suggested earlier in this paper.

Overall, the introduction of odours into the environment of captive black-footed cats could be considered largely successful. All of the experimental odours increased the cats' activity, reduced sedentary behaviours and encouraged exploration, changes that could be considered advantageous to the animals' welfare. Such changes may also improve zoo visitors' perceptions of what are generally considered to be poor exhibit animals (Shepherdson et al., 1993). It must be borne in mind that, as with most zoo research, only a small number of animals were available for testing, hence generalisations should be avoided. One must also

consider the possibility that the method of odour impregnation employed in this study may not be the most practical. The process adopted was relatively time-consuming and may not be logistically possible for keepers with time constraints. Adding liquefied odours (e.g. essential oils) onto cloths, or perhaps directly onto cage fixtures, may be a more practical approach to odour presentation. Given that cats seem to habituate very quickly to the same odour, the type of scent employed is probably less important than the regular rotation of different odours. Whilst it is not believed that olfactory stimulation should be employed at the expense of other types of enrichment practice (e.g. toys and operant-conditioning devices), the results from the study highlight the potential for odour to be employed as an additional method of environmental enrichment for captive-housed felids.

Acknowledgements

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