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Husbandry of the Fennec fox *Fennecus zerda*: environmental conditions influencing stereotypic behaviour

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The Fennec fox *Fennecus zerda* is the smallest canid and inhabits the deserts of North Africa and the Arabian region. The species is reported to be nocturnal in the wild (Gauthier-Pilters, 1967); in zoos they are often housed in reversed-light/dark cycle exhibits. As is the case with many canid species, stereotypic behaviour is common in zoo-housed Fennec foxes. Such behaviour is indicative of poor or inappropriate welfare conditions (Broom, 1988) and may result from a deprivation in the present environment or from one experienced in the past. In order to rectify these inadequacies the cause of a stereotypy must first be determined for a given species. Odberg (unpubl.) observed that in Fennec foxes arousing stimuli, such as the public tapping on windows, keeper noises outside the enclosure and fighting, elicit stereotypic running back and forth or increase its rhythm. Adding a sandbox may initially reduce pacing and varying the population density modulate its frequency. Rensch (1950) reported regular rhythmic running at dusk in a ♂ which he kept at his home and Gauthier-Pilters (1962) similarly observed stereotypy by the ♂ at dusk along the boundary of a 3·7 × 4 m enclosure housing a pair. The situation suggested to both authors that stereotypic running is analogous to appetitive, food-acquisition behaviour in the wild. Stereotypy in Fennec foxes thus occurs under various external conditions that elicit behavioural arousal.

In two pairs of Fennec foxes kept in two adjacent exhibits in the Small Mammal House of the National Zoological Park, the predominant activity of both ♂♂ was running back and forth in an area ranging from 0·5–1 m along the glass at the front of the enclosure. The behaviour was termed stereotypic because it always occurred at the same spot, was performed repeatedly for extended periods, varied little in form and had no apparent function or goal. The purpose of this study was to determine the causes of the behaviour by examining its temporal variation in relation to environmental events. It was hypothesized that the quality of the cage environment could be improved sufficiently to reduce or eliminate stereotypy by addressing the causal factors. Experiments were carried out modifying substrate material, the method of feeding and disturbances associated with cleaning the exhibit. In addition, 31 zoos with Fennec foxes contributed information on exhibit space and husbandry procedures as well as the presence or absence of stereotypic behaviours.

ANIMALS AND HOUSING

At Washington's NZP two exhibits, measuring 2·4 × 1·8 × 2·4 m high, both housed 1.1 Fennec foxes. The walls of exhibit 1 were glass on two sides, while exhibit 2 had glass on one side only. Each contained artificial rock cliffs which the animals could not climb except for two ledges on which the ♂♂ usually slept. The substrate was a thin (< 1 cm) layer of sand. Access to a wiremesh holding cage, 1·2 × 1·2 × 1·2 m (exhibit 1) or 1·2 × 1·8 × 1·2 m high (exhibit 2), in the service area

behind the exhibit, was continually available. The cage contained straw or woodchip substrate and a wooden nestbox. The building was on a 12:12 light/dark cycle, although some natural light entered through windows and skylights. The ♀♀ were eight and nine years old, captive born and hand-reared; both ♂♂ were wild born, ♂1 was three years old and ♂2 ten years old.

The exhibits were cleaned each morning at *c.* 0930 hours, the keeper entering the cage with a vacuum cleaner hose and quickly removing debris from the cage floor without shifting the animals. At 1330 the animals were fed 60–80 g Nebraska brand feline diet, augmented on different days by a hard-boiled egg, a piece of banana, fish, bones or mealworms. Once a week they were given three adult mice each.

METHODS

Daily 24-hour video recordings were made of both exhibits for five, eight or ten-day periods from November 1986 to May 1987; for some experiments observers sat in front of the exhibits and scored behaviour. The time spent in the categories Pacing, Digging, Exploring, Burying Food, Resting/Sleeping, Off Exhibit or Eating was noted.

Behaviour in the exhibit area (but not the holding cage) was observed for five continuous days to establish the daily pacing pattern of each ♂. For experiment 1 an 8 cm layer of sand was added to the exhibits and the behaviour observed for five days. In experiment 2 live crickets were fed on four days and behaviour compared to four intermittent days on which they were not offered. Experiment 3 examined the effect on behaviour of feeding meat in one large piece compared with several small pieces by observing behaviour for two hours after feeding on four days of each method. In experiment 4 behaviour for eight consecutive days with no vacuum cleaner noise anywhere in the building was compared to that for ten days with the normal cleaning routine. Finally, the effect of the number of zoo visitors on behaviour was analysed *post hoc* by comparing behaviour on all weekdays to all weekends and by calculating Spearman rank correlations for visitor numbers with frequency of pacing. Differences in daily total durations of the behaviours scored under experimental and control conditions were tested using a non-parametric Mann-Whitney U test.

RESULTS AND DISCUSSION

Both ♀♀ spent the majority of their time in the holding areas out of view of the videocamera and neither was ever observed to pace in the exhibit area. Therefore, only the behaviour of the ♂♂ is reported on here. The daily ($n = 5$) pattern of stereotypic running is given for each ♂ in Fig. 1. Male 1 was nocturnally and diurnally active whereas ♂2 was active only during the day. In general, three eliciting situations for the behaviour could be discerned: exhibit cleaning around 0930 hours, after feeding at 1300 and after dusk. During the course of observations two other causes were incidentally identified: unexpected loud noises made in the keeper area or by machines in or outside the building, and large numbers of zoo visitors. The latter is corroborated by a positive correlation between the daily frequency of stereotypic running and estimated number of zoo visitors ($n = 14$ days, ♂1, $r_s = 0{\cdot}721$, $p < 0{\cdot}005$; ♂2, $r_s = 0{\cdot}699$, $p < 0{\cdot}01$). The two ♂♂ responded differentially to the eliciting situations, ♂2 being most sensitive to cleaning and ♂1 to evening hours and zoo visitors. In both ♂♂ stereotypy associated with cleaning was observed mainly after the keeper had been in the exhibit but it also occurred in response to vacuum cleaner noise prior to the event. In contrast, feeding-associated running was never observed in anticipation of the event and occurred exclusively after food had been placed in the exhibit. It is suggested that the latter is motivated by a desire to run away and eat or cache food as Fennec foxes do in the wild (Gauthier-Pilters, 1967), since the animals

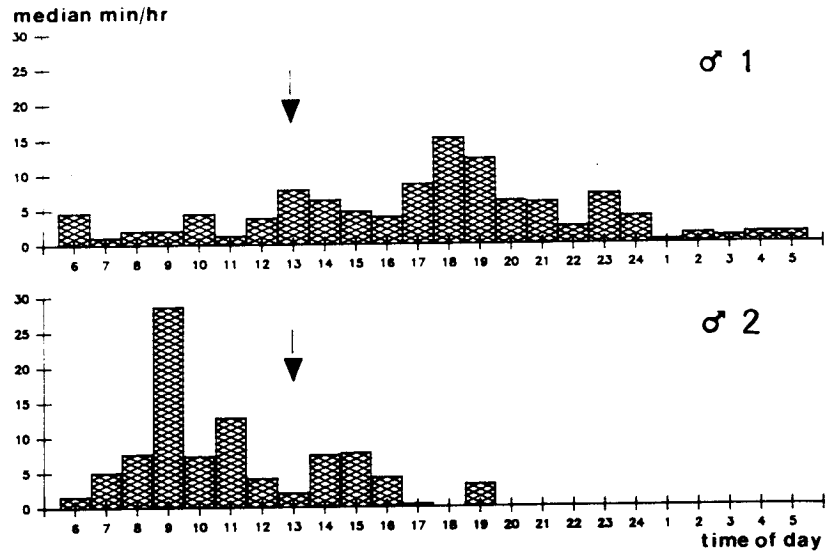

Fig. 1. Duration of stereotypic running behaviour of two Fennec foxes *Fennecus zerda* at Washington's NZP. The columns show the median number of minutes per hour spent pacing over five days. The arrow indicates feeding time.

were sometimes observed pacing after feeding with uneaten food or mice in their mouths.

Although husbandry procedures and large numbers of zoo visitors are sufficiently arousing to elicit stereotypy in both animals, other causes must be postulated for ♂1's evening running when keepers and visitors are not present. Further analysis of video tapes indicated that only the pair in exhibit 1 buried food after feed time and it was retrieved after dusk. The presence of the ♀ in the exhibit area retrieving food may have been an arousing situation that elicited stereotypy in the ♂; this is indicated by a positive correlation between the number of items buried by both animals and the amount of evening running by ♂1 (n = 14 days, r_s = 0·816, $p < 0·001$).

Experiments 1–3 attempted to modulate post-feeding and evening stereotypy.

Experiment 1 The addition of a thicker layer of sand, had no effect on the frequency of running in either ♂ (Table 1). Digging, however, did increase for all four animals.

Experiment 2 Feeding of live crickets also had no effect on running frequencies although both ♂♂ showed a significant increase in exploration from a median of *c.* 40 minutes/day to 80 minutes/day. D. Shepherdson (pers. comm.) found a cricket feeder had a similar effect on exploration in a pair of Fennec foxes at London Zoo, but it also reduced running in one animal. His feeder allowed for the slow, unexpected release of the crickets over the course of a day (Christie & Wheeler, 1990: 230), whereas at NZP they were all released loose into the exhibit at the same time.

Experiment 3 It was thought that by feeding meat in small pieces, the foxes would be more likely to eat it immediately and be less motivated to cache than when it was offered in one large piece. This did significantly reduce the amount of running in the hour after feeding in ♂1 but it had no effect on ♂2 (Table 1).

EXPERIMENT	DURATION OF BEHAVIOUR MEAN (RANGE) (mins/day[1])	
	♂1	♂2
1. Adding sand $n=$ 5 days		
control: no sand	81 (28–237)	69 (49–106)
with sand	86 (37–187)	98 (39–187)
2. Feeding live crickets $n=$ 4 days		
control: no crickets	153 (109–235)	146 (57–222)
with crickets	135 (117–140)	60 (45–330)
3. Size, number of meat $n=$ 4 hours		
control: 1 large piece	25 (8–38)	13 (4–24)
5 small pieces	6 (0–11)[2]	16 (0–44)
4. Cleaning method $n=$ 10 days		
control: vacuum cleaner in use	103 (4–174)	79 (45–275)
no vacuum cleaner in use	25 (0–172)[2]	26 (1–52)[2]
5. Number of visitors $n=$ 8 days		
control: weekdays	110 (23–219)	111 (55–330)
weekends	182 (33–235)[2]	102 (45–232)

[1]Read as mins/hour for experiment 3.
[2]$p<0{\cdot}05$.

Table 1. Changes in duration of stereotypic running behaviour of two Fennec foxes *Fennecus zerda* at Washington's NZP under 'control' and test conditions.

Experiment 4 Disturbance due to cleaning was minimized by sweeping the exhibits instead of vacuuming. This significantly reduced running in both ♂♂ (Table 1).

Large numbers of zoo visitors also appeared to elicit increased running in ♂1, as this behaviour was significantly more frequent on weekends, which were more crowded than weekdays.

Stereotypic running in these foxes therefore appears to have many different eliciting factors, all of which are arousing and stimulate an escape or flight response. This is readily apparent when the stimulation is from a vacuum cleaner or keeper noises but flight motivation may also cause stereotypy in social situations, such as when an animal wants to move away from its cagemates to cache or retrieve its food. Minimizing disturbances, feeding small food items and live prey and providing substrate for digging and caching can all contribute to the reduction of stereotypic behaviour either by removing the eliciting factors or by distracting the animal from them. Unfortunately, these measures still fail to provide the animal with what it needs to cope with the arousing stimulus; that is, flight distance and hiding places. Providing a large enough area for animals to avoid each other and a secure hiding place to which they may withdraw when disturbed may be the best means of eliminating stereotypy which is caused by high behavioural arousal. This is strongly suggested by an epilogue to these experiments and the survey of zoos.

After these experiments had been concluded the pair in exhibit 1 were moved to an outdoor cage for nine months. The enclosure provided 48 m^2 of space (compared with 4·3 m^2 in the indoor quarters), as well as a dark and isolated den. Although no data were collected systematically in this environment neither animal was ever observed to run back and

	NO. OF ZOOS REPORTING ANIMALS WITH		
	NO STEREOTYPY	STEREOTYPY	% WITH
♂♂ (no. of individuals)	16 (32)	14 (16)	46 (33)
♀♀ (no. of individuals)	23 (35)	8 (10)	26 (22)
Indoor exhibits (mean m^2)	7 (9·1 ± 3·1)	12 (8·7 ± 1·6)	63
Outdoor exhibits (mean m^2)	10 (20·3 ± 4·7)	2 (18·4 ± 1·2)	17
Exhibit 'mostly flat'	14	7	33
Exhibit 'mostly contoured'	2	8	80
Offered live prey	12	6	35

Table 2. Number of zoos reporting presence or lack of sterotypic behaviour in Fennec foxes under various circumstances (see text).

forth nor were there any tracks in the soil indicating repetitive movement. In the survey presented below several zoos also reported the elimination of stereotypy by moving their animals to larger enclosures.

SURVEY RESULTS

Questionnaires detailing exhibit spaces and husbandry procedures were sent to 62 zoos housing Fennec foxes. The 31 responding zoos were divided for analysis into those reporting stereotypy in some or all of their animals and those in which no stereotypic behaviour had been observed. It should be noted that, as far as is known, no systematic behavioural observations had been made at any of responding zoos and any reported stereotypic behaviour is thus most likely that occurring during the daytime when staff were present. The most relevant observations from this survey are summarized in Table 2. More zoos reported ♂♂ with stereotypy than ♀♀. More behavioural problems were reported in indoor than outdoor exhibits, although this observation is confounded by a difference in the mean size of the exhibits reported and a potential difference in activity cycles; outdoor exhibits tend to be larger and the animals in them may be more nocturnally active than those in indoor exhibits. Nevertheless, indoor-housed foxes may be over-sensitized to keeper noises and other disturbances due to generally lower incidental noise levels than outdoors. Interestingly, exhibits described as 'mostly contoured' were much more likely to contain stereotyping foxes than those described as 'mostly flat'. Thus, for this desert-dwelling animal, the shape of the available space may be a significant factor influencing behaviour. Feeding live prey also seems to correspond with fewer pacing problems. Not shown in Table 2 are husbandry factors that did not differ in the number of zoos with or without stereotyping animals: substrate type (all zoos reported housing their animals on some sort of loose substrate); animals wild or captive born in origin; reversed light/dark cycle; proximity of public; removal or otherwise of animals during cleaning; a direct view into the keeper area or otherwise.

In conclusion, stereotypic running in Fennec foxes is elicited by many different kinds of social and environmental stimulation that evoke a flight response. Individual differences in sensitivity to various kinds of stimulation are pronounced. All evidence taken together suggests that the most important environmental element for Fennec foxes, which enables them to cope with sensitivity to stimulation, is sufficient space to withdraw from what they perceive as threats. Large, flat, outdoor exhibits with secure hiding places would appear to be the most beneficial for captive Fennec fox husbandry.

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PRODUCT MENTIONED IN THE TEXT

Nebraska Brand feline diet: Central Nebraska Packing, Inc. PO Box 550, North Platte, NE 69103-0550, USA.

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Food dispensers as occupational therapy for the Walrus *Odobenus rosmarus divergens* at the Harderwijk Marine Mammal Park

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Most pinnipeds are opportunistic feeders and when they discover a school of fish, they usually eat to their full capacity. Walruses *Odobenus rosmarus* have a different feeding strategy. *Odobenus rosmarus* eat benthic organisms such as bivalve molluscs (Fay, 1982) and, because this prey is small in relation to the predator's body weight, a large proportion of time is spent feeding; this is similar to the technique used by grazing animals. Kastelein *et al.* (1989) calculated that in the wild a Walrus has to spend an approximate minimum of six hours per day feeding, based on the feeding rate from Oliver *et al.* (1983), and the food requirements from Nelson & Johnson (1987) and Dittrich (1987). In the wild, Walruses find mollusc beds and then dig furrows in the ocean floor (Nelson & Johnson, 1987). Using their sensitive mystacial vibrissae they locate and identify prey (Kastelein & van Gaalen, 1988; Kastelein *et al.*, 1990), excavate it and, in the case of bivalve molluscs, suck the contents from the shells (Oliver *et al.*, 1983, 1985; Kastelein & Mosterd, 1989).

In zoological parks, Walruses are usually fed on fish and only have to spend *c.* 15 minutes per day feeding (Coates, 1962; Hagenbeck, 1962; Ruempler, 1976; Dittrich, 1987). If this reduced opportunity for performing feeding behaviour is not compensated for by social interactions with conspecifics, members of other species or by interactions with humans, boredom may occur and stereotypic behaviour may develop (Kastelein & Wiep-