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The influence of enclosure design on diurnal activity and stereotypic behaviour in captive Malayan Sun bears (*Helarctos malayanus*)

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ABSTRACT

The effect of enclosure design on diurnal activity and stereotypic behaviour was assessed in 17 adult Malayan Sun bears (*Helarctos malayanus*), kept either in barren indoor enclosures or relatively enriched outdoor enclosures. Locomotion was the most frequent activity observed in the indoor bears, followed by resting. In contrast, conspecifics housed outdoors spent most of the time resting. Eleven forms of stereotypic behaviours were recorded in the bears, with pacing being the most common. The frequency and repertoire of stereotypies were significantly higher in the indoor bears irrespective of enclosure size. Novel forms of locomotor (forward-reverse pacing) and oral (allo-sucking) stereotypies were recorded. Oral stereotypies were predominant in the bears housed indoors, while patrolling was confined to the outdoor bears. Enclosure complexity significantly influences activity budget and occurrence of stereotypic behaviours, highlighting the importance of appropriate enclosure design and enrichment for the welfare of captive bears.

1. Introduction

Captive animals are subjected to an environment that differs greatly from their natural habitat, often restricting them from performing natural behaviours. Conditions of the captive environment have been shown to limit the repertoire and also the amount of time spent engaging in innate activities (Stolba et al., 1983; Shepherdson et al., 1993; Veasey et al., 1996; Swaisgood et al., 2001; Young, 2003; van Tuly, 2008). In addition, these artificial environments often do not promote interaction with the surroundings, which is important for the development of sensory and cognitive abilities, and the expression of species-specific behaviours (Morgan and Tromborg, 2007). The restrictions in the expression of normal behaviour in captive animals often lead to stress and frustration, which are detrimental to their welfare (Friend, 1989). Chronic stress invariably leads to the development of abnormal behaviours (Schouten and Wiegant, 1997; Carlstead and Brown, 2005), which are of concern to zoo managers because of their association with sub-optimal captive conditions and poor animal welfare (Mason, 1991a). In addition, chronic stress due to unsuitable captive environments increases activities such as behavioural inhibition (Carlstead et al., 1993a; Vyas and Chattaji, 2004; Carlstead and Brown, 2005), vigilant behaviour (Carlstead et al., 1993a), and compromises the reproductive potential (Shepherdson, 1994; Chrousos, 1997), immune response (Barnett et al., 1992; Ferrante et al., 1998) and overall health (Broom and Johnson, 1993; Sapolsky, 1996) of captive animals. It is well established that while certain zoological species thrive in captivity, others are often difficult to maintain without behavioural problems and breeding difficulties (Clubb and Mason, 2003).

Cage stereotypies, defined as behavioural patterns that are repetitive, invariant and apparently functionless (Odberg, 1978; Mason, 1991b) are a commonplace in captive zoo animals, and are of growing concern due to their negative implications. While the exact underlying mechanism is yet to be elucidated, this anomaly has been associated with perseveration, as the captive environment is hypothesised to alter behavioural organization by affecting the functionality of the striatum that is involved in the selection and ordering of behavioural patterns (Garner, 1999; Garner and Mason, 2002). In order to reduce the occurrence of stereotypic behaviour and improve the welfare of captive zoological animals, zoo communities have initiated enrichment strategies to enhance captive environment (Young, 2003; Swaisgood and Shepherdson, 2005). Experimental enrichment programs often involve the improvement of the physical characteristics of enclosures, incorporating structural changes to increase the complexity of the environment and to promote interactive and exploratory behaviour (Mason et al., 2007). It has been shown that improving the captive environment alleviates the occurrence and frequency of behavioural anomalies and stereotypies (Carlstead et al., 1991; Grindrod

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and Cleaver, 2001; Swaisgood and Shepherdson, 2005), reduces fearfulness (Reed et al., 1993) and also allows the animal to better manage confinement-related stress (Carlstead et al., 1993b).

Throughout the world, bears are commonly housed in zoological parks for public viewing, captive breeding, conservation and education purposes. In contrast to their natural habitat, captive bears are generally confined in small and barren enclosures with a fixed routine. In such monotonous and non-stimulating environments, bears tend to perform stereotypies (Carlstead et al., 1991; Wechsler, 1991; Forthman and Bakeman, 1992). Since the first report of an unusual behaviour of hind-foot sucking in captive Malayan Sun bears (*Helarctos malayanus*) by Dathe (1975), a wide repertoire of stereotypic behaviours has been documented in captive ursids including locomotor, deprivative, and oral repetitive behaviours (Vickery and Mason, 2004).

The Malayan Sun bear (*H. malayanus*) is the smallest of the extant bear species and inhabits the equatorial lowland rainforest of parts of mainland Asia and its adjacent islands (Servheen, 1999). Its natural habitat is predominantly the dense lowland dipterocarp forests, but they may also be found in lower montane, swamps, mixed secondary forests and plantations (Lekagul and McNeely, 1977; Medway, 1983; Francis, 2008). Currently listed as "Vulnerable" in the IUCN Red List of Threatened Species 2011 (Fredriksson et al., 2008), this bear species remains the least researched member of the Ursid family (Pereira et al., 2002; Servheen, 1999). The lack of biological information on *H. malayanus* has been recognized as a serious limitation to conservation efforts, and it has been advocated that research on this species should be of the highest priority for any bear species worldwide (Servheen, 1999). A number of studies have documented the captive behaviour of *H. malayanus* (Hewish and Zainal-Zahari, 1995; Vickery and Mason, 2004, 2005), however, there remains a paucity of published information on the effect of enclosure design on the behaviour patterns and manifestation of stereotypies in this species. In this paper, we present comparative data on the diurnal activity budget and stereotypic behaviour of captive *H. malayanus* housed in barren indoor and enriched outdoor enclosures, in order to elucidate the effect of enclosure design on the behaviour of these bears in captivity. We also constructed an ethogram of normal and stereotypic behaviour of *H. malayanus* in captivity.

2. Materials and methods

2.1. Animals and housing

Seventeen adult *H. malayanus* (5 males and 12 females) housed in two separate zoos (Zoo-A and Zoo-B) were observed in this study. Based on the zoo records, the age of the bears ranged from 3 to 23 years at the beginning of the observation. All the bears were acquired from the wild and donated to the zoos, except for a female that was born at Zoo-A in 1998. All bears were reared in captivity for a minimum period of one year prior to the commencement of the study.

In Zoo-A, four bears were released into an outdoor enclosure (109.3 m^2) between 0930 and 1630 h for public viewing and were coaxed back to the night stalls with food in the evening. The enclosure was enriched with a pond (8.1 m^2) and an artificial tree (2.5 m diameter $\times$ 5 m height), which allowed the bears to climb and rest (Fig. 1a). Another four bears were kept as pairs in two separate indoor enclosures (9.6 m^2) with a concrete floor and walls made of metal bars and concrete throughout the observation period. Apart from a sleeping platform erected approximately 1 m above the floor and a water trough, the indoor enclosures were barren. These indoor enclosures were not open for public viewing. Five bears in Zoo-B were released into an outdoor enclosure (380 m^2) between 0930 and 1730 h for public viewing. The enclosure included a perimeter dry moat, enabling the bears to climb down and move freely within it, an L-shaped pond (37.5 m^2), and several vertically and horizontally placed tree logs (Fig. 1b). Four other bears were kept as pairs in two separate concrete floor indoor enclosures (3.75 m^2) with walls made of concrete and metal bars. There was no furniture in the indoor enclosures except for a cement water trough on the floor. Detailed description of the enclosures and animals are presented in Table 1. Bears in both zoos were fed once daily with bread, milk and assorted tropical fruits. All animals were fed after the observation ended in the evening.

2.2. Data collection

Three to four weeks prior to the start of the experiment, all the bears were sedated with Tilatemin/Zolazepam (Zoletil 100, Virbac, 5 mg/kg), in order to conduct a health screen, which involved a general physical examination, a visual screen for ectoparasites, coprological evaluation for endoparasites, and haematologic and serum biochemical analyses. Blood was drawn from the medial saphenous vein of the anaesthetized animals using 18 gauge needles and placed into ethylenediaminetetraacetic acid (EDTA) coated blood collection tubes (BD Vacutainer®). Blood samples were transported on ice to the laboratory for further processing. Serum biochemistry values were determined using an automated biochemistry analyser (Roche Hitachi 902, Roche Diagnostics, Germany) with standard commercial kits (Roche Diagnostics, Germany). Total cell counts were done using an automated haematology counter (ABC Vet, Horibar-ABX, France). Differential white blood cell counts were determined by microscopy examination of blood smears stained with Wright Stain. Packed cell volume was obtained by the micro-haematocrit technique using a micro-haematocrit reader (Hawsley Micro-Haematocrit Reader, England). Plasma protein concentration was measured with a refractometer (Atago T2-NE, Atago Co. Ltd., Japan).

Behavioural observations were done using a scan sampling method for 14 consecutive days in each zoo. The animals and observers were conditioned to the behavioural observation protocol for seven days prior to actual data collection. Data were recorded by instantaneous sampling at 10 min intervals (Martin and Bateson, 2007). Daily observations started between 0910 and 0950 h after the bears were released into their enclosures and ended approximately 30 min before the bears returned into their night stalls (1520 h in Zoo-A and 1630 h in Zoo-B). A minimum of 35 scans was done each day for each individual. The ethogram and parameters recorded during the observation (Table 2) include original descriptions from observations in this study and adaptations from other sources (Hewish and Zainal-Zahari, 1995; Liu et al., 2003; Montaudouin and Le Pape, 2004; Vickery and Mason, 2004).

2.3. Data analysis

All data were analysed using IBM SPSS Statistics 20 for Windows. The frequency of each activity was the relative percentage score of the total amount of activities. Data from animals kept under similar conditions (indoor or outdoor) in the same zoo were pooled. When computing activity budgets, locomotory stereotypy was grouped under "Locomotion" while other forms of stereotypic behaviours were classified as "Other stereotypies". Non-parametric Mann–Whitney U-test was performed to detect differences in activity budget and stereotypic behaviour between