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Social and environmental influences on pacing in a female Malayan sun bear (*Helarctos malayanus*)

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Abstract

Pacing behaviour is complex and identifying the motivational basis for pacing and designing an effective remedial strategy can be challenging. Details of the behaviour may provide insight into the motivational basis of behaviour and should be carefully examined. A long-term observational study of pacing by a female Malayan sun bear (*Helarctos malayanus*) was conducted to gather detailed information on the pacing behaviour and guide husbandry changes. Full-day behaviour observations were conducted (n=60; mean duration=5.9 hrs/observation). Pacing data were recorded using continuous sampling methodology with all-occurrences recording of events before and after pacing bouts. Solitary behaviour and social interaction between the focal female and a male and female exhibit partner were recorded using instantaneous sampling and all-occurrences methodologies, respectively. All pacing bouts occurred between tunnels to off-exhibit indoor holding areas, bouts were short in duration and variable, and pacing often began after the male bear entered a shift tunnel. Social interactions between the two females were frequently agonistic. Based on these findings, the non-focal female bear was removed from the group and the focal female and male were given access to indoor holding areas on most days. The focal female only paced once when provided access to indoor holding. When the bears did not have off-exhibit access, pacing characteristics appeared similar to bouts before modifications but pacing no longer appear to be influenced by the male's behaviour. Our detailed analysis of pacing by the female sun bear provided insight regarding motivation, the need for husbandry changes, and evaluation of those changes.

Background

Carnivores have long been among the zoo animals most likely to exhibit stereotypic behaviours (Boorer 1972; Mason and Latham 2004). Bear species appear to be particularly susceptible to these behaviours, specifically pacing (Shepherdson et al. 2004; Vickery and Mason 2004, 2005). Traditionally, stereotypic behaviours have been defined based on their characteristics: repetitive, invariant and having no obvious function (Mason 1991). Mason (2006) put forward a new definition: "repetitive behaviour induced by frustration, repeated attempts to cope and/or central nervous system dysfunction," thus defining stereotypies in terms of their motivational basis, or why they occur, as opposed to how they appear. Understanding the motivational basis of the behaviour is especially important for zoo managers as truly stereotypic behaviours may indicate poor welfare (Broom 1991; Carlstead 1996). Greater knowledge of why stereotypic behaviour occurs can also serve as an important tool for public education as such behaviours are often perceived as negative by zoo visitors (Boorer 1972; Robinson 1998; Miller 2012).

Environmental enrichment has been a useful husbandry tool in reducing pacing in zoo-housed bears by addressing exhibit design, feeding practices and exhibit enhancements (Keulen-Kromhout 1978; Forthman et al. 1992; Carlstead et al. 1991; Fischbacher and Schmid 1999). Most often, enhancements are directed toward what is known about the species' natural behaviour and have had varying degrees of success (Boorer 1972; Clubb and Vickery 2006). Enrichment is most likely to reduce stereotypic behaviour when environmental changes are made that correspond to the motivational background of the stereotypies (Kolter and Zander 1995). Therefore, it is important to understand the factors that underlie the behaviour in order to develop proper remedial strategies (Mason and Latham 2004). To guide research toward this goal, efforts must focus on gathering details of the actual pacing event. Vickery and Mason (2004) have suggested that properties of the behaviour such as the location of the pacing bout, timing and invariance (meaning movement is predictable and without variation) offer insight to the motivation and level of establishment. In addition to these properties, circumstances surrounding the behavioural event are also considered relevant in determining motivation.

A long-term observational study was conducted at Cleveland Metroparks Zoo to identify the motivational basis of pacing by a female Malayan sun bear (*Helarctos malayanus*). This female had engaged in persistent pacing behaviour since her arrival at the zoo. The goals of the study were to: 1) provide a detailed description of the pacing behaviour's characteristics, 2) identify motivational influences through analysis of social and environmental factors, and 3) assess the impact of guided husbandry modifications.

Action

The subject of this study was a female Malayan sun bear (*Helarctos malayanus*) housed at Cleveland Metroparks Zoo with a male (12 years old) and female (23 years old) conspecific. All three bears were wild born but confiscated by Malaysian wildlife officials from the illegal pet trade.

The sun bear exhibit was an open, moat design of concrete construction measuring 265 m^2. The space featured a waterfall and pool, natural soil throughout portions of the exhibit, live plants, numerous logs, and a dead tree for climbing (see Fig. 1A). Each bear had a separate off-exhibit overnight area indoors and would enter and leave the exhibit ("shift") through two tunnels located on the right and left sides of the rear of the exhibit. Before the bears entered the exhibit, enrichment in the form of various food items was occasionally hidden to encourage foraging behaviour. The main meal consisted of dry biscuits and fresh fruit and was fed indoors at the end of the day when the bears were taken off exhibit.

Data were collected before husbandry changes from June through November of 2005 (224 hrs; 39 days). Husbandry changes were made in 2006 that included the removal of the second female from the group and access to indoor off-exhibit holding areas was provided during most days. Data were recorded during April, June and August of 2006 (123 hrs; 21 days) to evaluate the husbandry changes. Observations on the focal female typically began as the bears entered the exhibit in the morning and ended as they left it at the end of the day. The duration of observations varied by day due to inclement weather and sampling difficulties, with a mean daily observation duration of 5.9 hrs (SD = 1.5 hrs; range = 1.8–7).

Activity budget data were recorded using focal instantaneous sampling at 10 min intervals (Table 1; Martin and Bateson 1993). Pacing duration was recorded by continuous observation with additional data recorded for stimuli occurring immediately before and after pacing bouts on an all-occurrence basis. Onset stimuli included whether the male entered a shift tunnel and a qualitative assessment of noise levels (quiet, moderate, or loud). After pacing bouts, it was recorded whether the focal female approached or followed the male, moved to the pool location, investigated the environment, or performed another behaviour. Social interactions were recorded on an all-occurrence basis beginning in July 2005, as bouts were occurring more frequently and in shorter duration than expected. Additional environmental factors were assessed and included daily zoo attendance and hourly recordings of ambient temperature from a mercury thermometer. All data were collected by JR.

Specific pacing bout characteristics (e.g. bout onset stimuli, subsequent behaviour, and number of pacing patterns) were evaluated for each bout, whereas analyses of daily variables, such as time of day, zoo attendance, temperature, and comparisons between housing conditions, were summarised in conjunction with daily mean bout duration (min) and daily mean bout rate (bouts/hr).

As data differed from a normal distribution (Shapiro-Wilk), non-parametric statistics were employed using Spearman rank correlation and Kruskal-Wallis and Mann-Whitney tests comparing mean ranks. Effect size of Mann-Whitney comparisons were calculated as $r=Z/\sqrt{N}$ with effect sizes of 0.1, 0.3 and 0.5 signifying a small, medium and large effect respectively (Cohen 1988; Clark-

Table 1. Ethogram of behaviours.

Behaviour	Description
Locomote	Locomotion other than stereotypic pacing; moving from one location another. Includes walking, running, changing positions e.g. from sit to stand, stand to sit, moving in or out of the pool. Does not include climbing.
Climb	Vertical locomotion up or down the tree or up and over logs.
Forage/Investigate	Ingesting food or water, licking logs or walls, sniffing any substrate, clawing or moving logs, digging in soil, sniffing air while moving, sitting or standing still. Manipulating objects.
Social–Agonistic	Non-playful interactions, includes stalking (watching or following one another with tense body posture), vocalizations such as growls, charging (swift and firm movement directly at another bear), swats and supplanting (one bears presence causing another to move away from a space it was occupying).
Social–Non-agonistic	Playful behaviour including sniffing, pawing, wrestling, gentle/playful biting, chase (running after one another), trailing (following at a slower pace), jawing (mouth to mouth in a playful context), mating behaviour.
Pace	Pacing movement along a definite path that is repeated 3 times in succession.
Inactive	Bear is sitting, standing, or recumbent without motion.
Other Maintenance	Self-grooming, scratching, biting at paws, rubbing against substrate, and urinating or defecating.
Not Visible	Bear is out of view. The location (exhibit or off-exhibit) was also recorded.

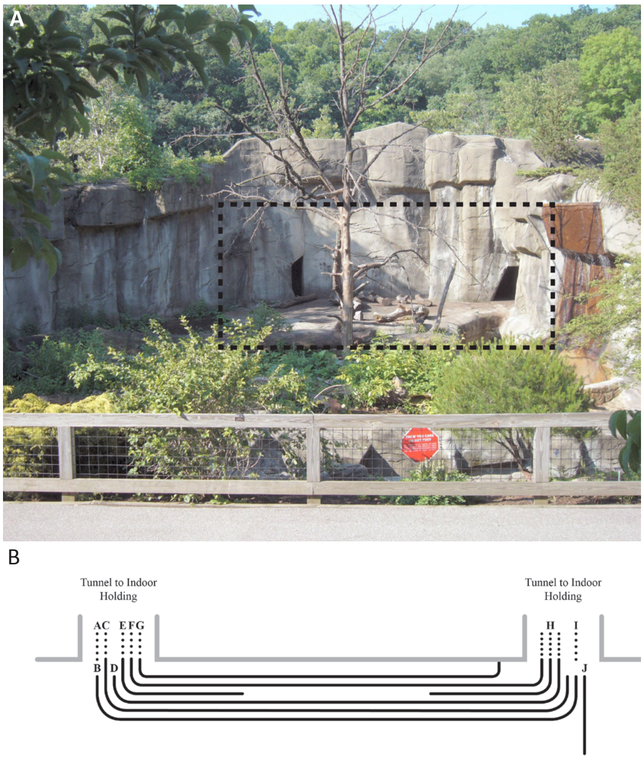

Figure 1. (A; above) photograph of the exhibit highlighting the area in which pacing occurred (above). (B; below) Diagram of the focal female's pacing patterns. All patterns (A–J) that took place in the exhibit (solid lines) or extended into the shift tunnels (dotted lines) occurred along the same path and are separated in the diagram for illustrative purposes.

Carter 2010). All tests were conducted using SPSS v12.0 with an alpha criterion of 0.05 for significance. As these data were from a single individual, these statistical comparisons were only meant to identify meaningful changes within this animal and we urge caution in generaliing these findings to other sun bears.

Pacing bouts that were artificially terminated by the animals being shifted off-exhibit (n=9) or by the end of an observation (n=4) were rare and are included in the analysis. One day (25 June 2005) was excluded from analysis because the female was kept off exhibit for the majority of the day.

In 2006 when the bears had access to the off-exhibit area, there were two occasions when pacing was observed immediately after the focal female entered the exhibit and before being given access to the off-exhibit area. This no-access period was brief (<10 min) and these bouts were relatively short (3 min), so these bouts were excluded from analysis. Also, the potential relationship between pacing onset and the male entering a shift tunnel was not recognised and systematically recorded until 28 June 2005, thus pacing onset data from the first three days of the study were not included in this analysis.

Consequences

Before husbandry modifications, a total of 642 pacing bouts were observed. All pacing bouts by the focal female occurred at the back of the exhibit in the area between the two shift tunnels (Fig. 1A). Pacing near shift doors has been observed by other researchers and suggested to be associated with proximity to food-related areas, as the bears were fed their daily meal in the holding area at the end of the day (Vickery and Mason 2004; Montaudouin and Le Pape 2004, 2005). Alternatively, agitated behaviour near shift doors has been described in giant pandas and it has been argued that it represents behavioural distress and an escape response (Owen et al. 2004, 2005; Powell et al. 2006). Although the pacing location was consistent, the focal female did display variability in the pacing path, with ten unique pacing patterns identified (Fig. 1b). The focal female would often switch between different pacing patterns within a bout (58% of bouts) and this appeared to depend on the duration of the pacing bout, with longer pacing bouts consisting of more patterns ($r_{s(640)}$=0.61, p<0.001; Fig. 2). Qualitatively, the focal female appeared to be attentive while pacing, often pausing to scan the environment or sniff the substrate, and varied the speed at which she paced. This variability and attentiveness to surroundings suggested that the focal female's pacing behaviour was not deeply ingrained and could be addressed through remedial treatment strategies.

Pacing rate differed throughout the day ($\chi^2_{(3)}$=14.96, p=0.002), with post-hoc pair-wise comparisons revealing increased pacing in the early afternoon compared to morning time periods (Fig. 3; 0900–1100 vs 1300–1500: $U^{(70)}$=385.0, Z=-2.96, p=0.003, r=0.35; 1100–1300 vs 1300–1500: $U_{(70)}$=343.0, Z=-3.45, p=0.001, r=0.41). Pacing bout duration did not differ significantly across time periods (p=0.11). As we did not observe increased pacing during the late afternoon prior to feeding, it did not appear that pacing was an anticipatory precursor to feeding as observed by other authors (Vickery and Mason 2004; Montaudouin and Le Pape 2004, 2005).

The most frequent behaviours after a pacing bout ended were to follow or move to the male (52.2%), investigate (19.0%) or perform other behaviours (21.0%). The focal female would occasionally move to a pool feature in the exhibit after a pacing bout (5.8%), and these pacing bouts were often longer in duration (median=9 min) than bouts that ended in other behaviours (Fig. 4; Follow/Approach Male, median=4 min, $U_{(370)}$=3708.5, Z=-4.03, p<0.001, r=0.21; Investigate, median=4 min, $U_{(157)}$=1301.5, Z=-3.91, p<0.001, r=0.31; Other Behaviour, median=4 min, $U_{(170)}$=1614.0, Z=-3.30, p=0.002, r=0.25).

Daily mean bout duration appeared to decrease on high attendance days but this effect was not significant ($r_{s(37)}$=-0.28, p=0.083). Daily attendance did not influence the rate of pacing bouts (p=0.69). Anecdotally, sounds did appear to stimulate the male, although no effect of loud noises were observed on the focal female's pacing bout duration (p=0.90). As the daily mean air temperature increased, the daily mean bout duration was shorter ($r_{s(37)}$=-0.40, p=0.011) but temperature did not appear to influence

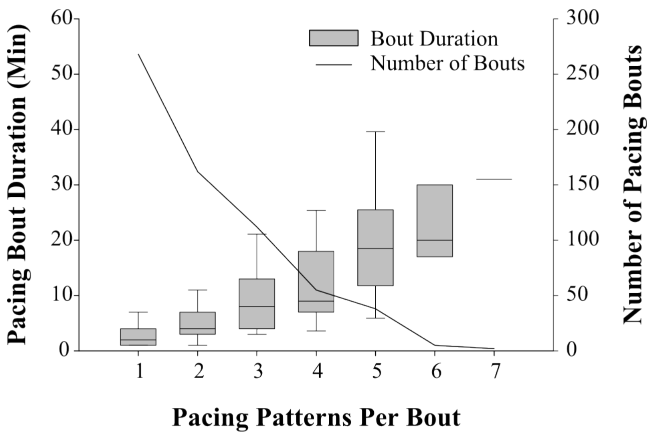

Figure 2. The duration and total number of pacing bouts observed in 2005 prior to husbandry changes that featured a given number of pacing patterns (see Fig. 1B for an illustration of the different pacing patterns). Box plots display the 10th, 25th, 50th, 75th, and 90th percentiles.

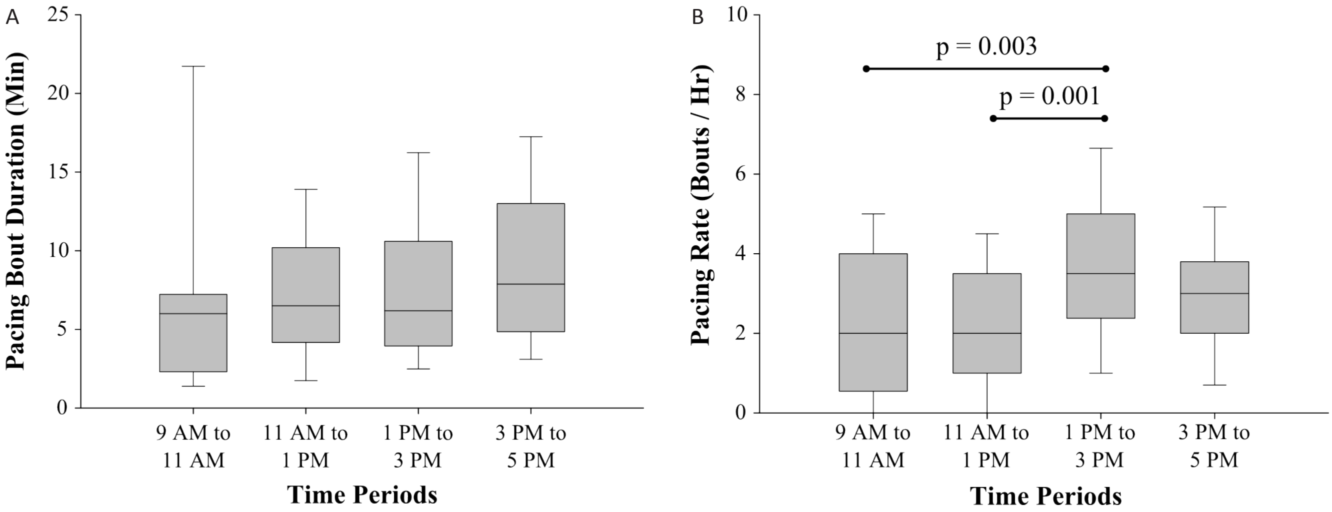

Figure 3. The (A) duration and (B) rate of pacing bouts by the focal female in 2005 before husbandry changes across two-hour time periods. Box plots display the 10th, 25th, 50th, 75th, and 90th percentiles. Pair-wise comparisons were performed using Mann-Whitney tests.

the daily rate of pacing bouts (*p*=0.34). It is possible that pacing, like any high activity behaviour, may have been constrained during the summer months as a result of thermoregulatory costs. The observation that this bear frequently ended long pacing bouts in the pool also supports a thermoregulatory cost to pacing. Alternatively, longer pacing bouts recorded during the autumn months may have been influenced by hormonal cycling, as the focal female was previously observed to enter oestrus in the autumn (Frederick et al. 2012). Owen et al. (2005), for example, described an increase in pacing in a female panda during oestrus. Additional research is needed to separate the respective influences of temperature and hormonal changes on pacing behaviour.

The majority of social interactions were between one of the females and the male (*n*=713, 88.7%), and these interactions were primarily non-agonistic (82%). However, when the females (*n*=74) or all three bears (*n*=17) did interact, these events were typically agonistic (81% and 82%, respectively). Play bouts were only ever observed to occur between the focal female and the male. A multi-zoo study of sun bear reproduction, which included these sun bears, cited similar findings regarding the social behaviour among these bears and concluded that housing one male and two female bears together is not a suitable grouping (Frederick et al. 2013). In a multi-zoo study of brown bears, Montaudouin and Le Pape (2005) found agonistic behaviour to be greater in exhibits housing more than two bears and pacing the predominate stereotypy in bears housed with unrelated bears. Bears are solitary by nature (Stirling 1993), and females may be particularly unwilling to share space with an unrelated female (Kilham and Gray 2002). This aspect of a female bear's nature may help explain the higher level of agonistic interactions we observed between the two females, and the focal female's pacing may in part have been a means to cope with this aversive situation (Lindburg and Fitch-Snyder 1994; Wechsler 1995).

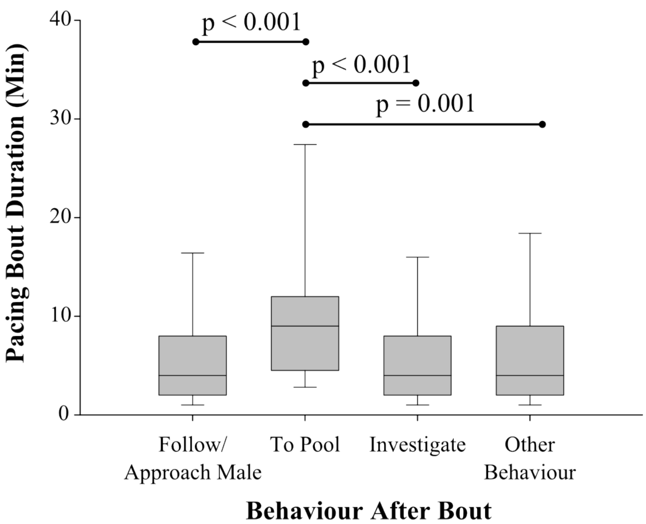

Figure 4. The duration of pacing bouts (min) by the focal female in 2005 before husbandry changes in relation to the subsequent behaviour performed after the pacing bout ended. Box plots display the 10th, 25th, 50th, 75th, and 90th percentiles. Pair-wise comparisons were performed using Mann-Whitney tests.

Based on these findings, the additional female bear was removed and access to off-exhibit areas was provided on most days. When the bears had access to indoor holding, the focal female was only observed pacing once and this bout lasted one minute (Fig. 5). Previous studies have reported benefits of providing free access to holding areas, including reduced pacing in polar bears (Ross 2006) and lower cortisol and decreased agitation-related behaviour in giant pandas (Owen et al. 2005). As Mason (2006) stated, stereotypic behaviour that is the result of coping or frustration responses and not due to underlying abnormalities is "maladaptive not malfunctional" and should respond to a husbandry change that addresses the "deficit". Providing access to indoor holding may have offered a retreat space not possible in the outdoor exhibit. When the bears did not have off-exhibit access, the rate (*p*=0.11) and duration (*p*=0.28) of pacing bouts were similar to bouts in the previous year before the additional female was removed.

Before husbandry changes, the location of the male did appear to influence the frequency of pacing, with 88% of pacing bouts occurring after the male entered the shift tunnel. However, after removal of the additional female, only 51% of pacing bouts occurred after this event (Fig. 6). Reduced response to the male's behaviour may have been due to the absence of the additional female after husbandry changes.

In addition to the decreased pacing when the bears were provided access to holding ($U_{(52)}$=0.5, Z=-5.69, p<0.001, r=0.77),

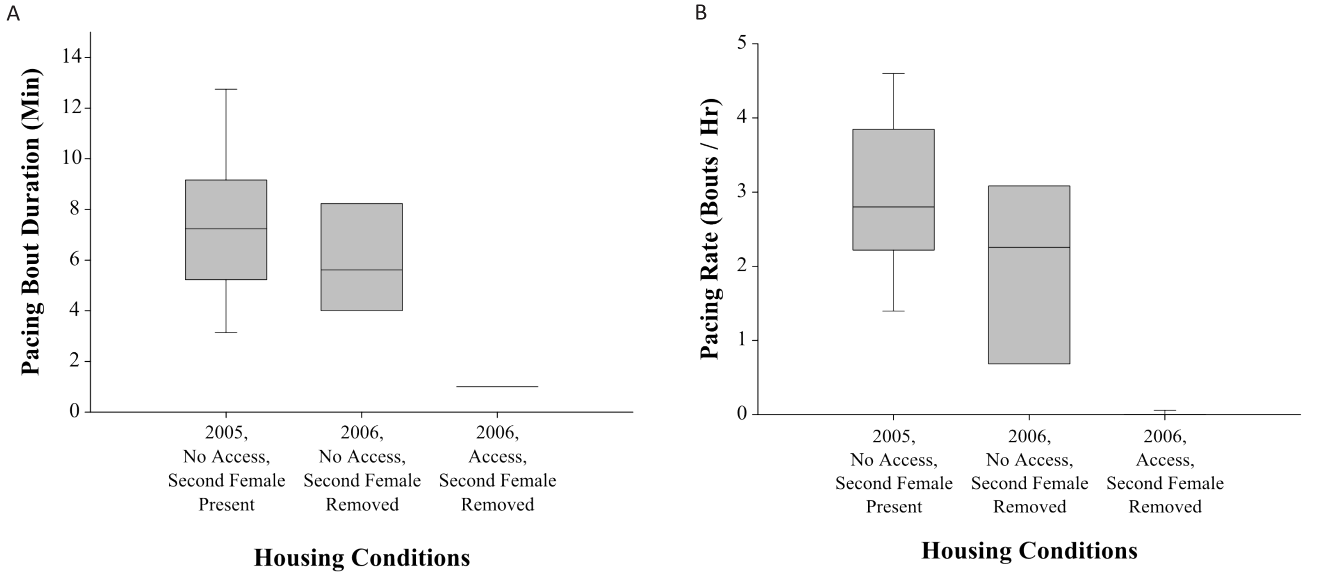

Figure 5. The (A) duration (min) and (B) rate (bouts/hr) of pacing bouts by the focal female across housing conditions before (2005) and after (2006) husbandry changes. In 2006, an additional female bear was removed from the group and the focal female and male exhibit partner were provided with access to off-exhibit holding areas on select days. Box plots display the 10th, 25th, 50th, 75th, and 90th percentiles.

other notable changes in the activity budget were observed after guided husbandry modifications (Fig. 7). After removal of the additional female, the focal female spent less time locomoting (No Access: $U_{(43)}$=45.5, *Z*=-2.39, *p*=0.014, *r*=0.36; Access: $U_{(52)}$=71.0, *Z*=-4.28, *p*<0.001, *r*=0.58) and more time inactive (No Access: $U_{(43)}$=42.0, *Z*=-2.51, *p*=0.010, *r*=0.37; Access: $U_{(52)}$=193.0, *Z*=-1.93, *p*=0.054, *r*=0.26). Also, differences were observed between days with and without access to holding after the additional female was removed. When access to holding was provided, the focal female spent more time foraging ($U_{(19)}$=0, *Z*=-3.51, *p*<0.001, *r*=0.76), less time pacing ($U_{(19)}$=8.0, *Z*=-3.61, *p*=0.002, *r*=0.79), less time engaged in other maintenance behaviours ($U_{(19)}$=19.0, *Z*=-2.32, *p*=0.045, *r*=0.51), and less time visible overall ($U_{(19)}$=14.0, *Z*=-2.42, *p*=0.014, *r*=0.53). Increased foraging and decreased pacing were desirable behavioural changes and supported the guided husbandry modifications.

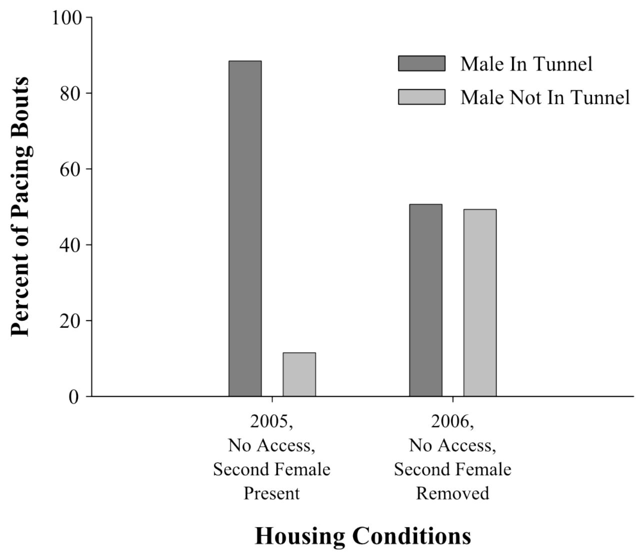

Figure 6. The annual percentage of pacing bouts by the focal female that occurred after a male exhibit partner entered the shift tunnel in 2005 before husbandry changes and in 2006 after the removal of an additional female from the group.

The origin and motivation of pacing behaviour is complex and may vary between individuals. Through a detailed analysis of pacing in a female sun bear, we were able to identify potential motivations and guide husbandry changes that successfully eliminated this behaviour. Although this study focused on a single bear and results are not directly applicable to other bears, the methodology of this study provides a model for animal care managers seeking to reduce pacing. Future research analysing the detailed characteristics of pacing may aid our ability to effectively and efficiently address pacing behaviour in bears by increasing our understanding of individual differences in this behaviour and the potential influence of motivational factors on pacing properties.

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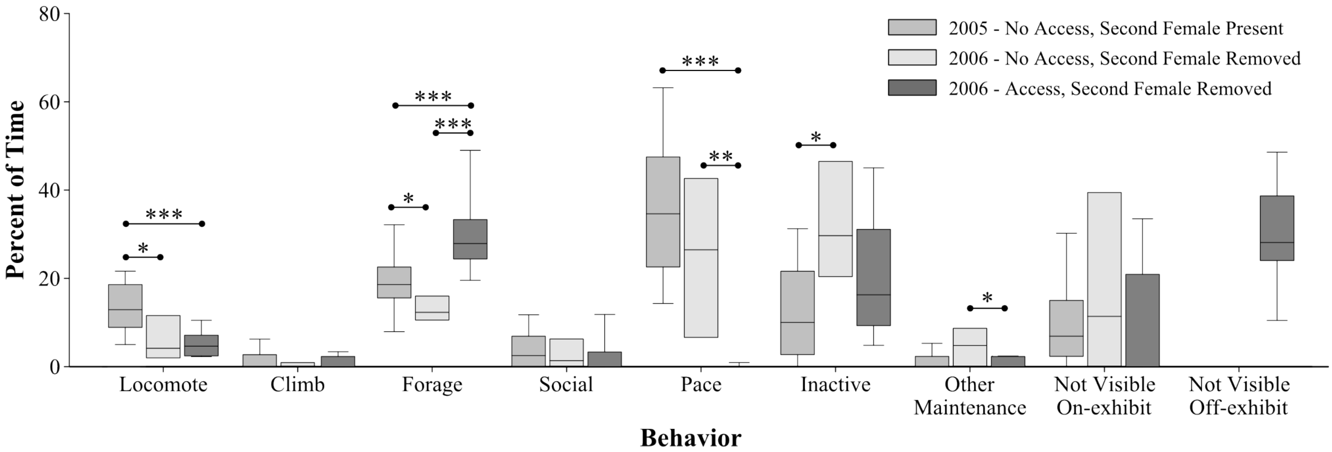

Figure 7. The activity budget of the focal female sun bear in 2005 before husbandry changes and in 2006 after changes. Box plots display the 10th, 25th, 50th, 75th, and 90th percentiles. Pair-wise comparisons were performed using Mann-Whitney tests (*=0.05>p>0.01; **=0.01>p>0.001; ***=p<0.001).

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