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Authors
Bauer, Erika
Babitz, Mindy
Boedeker, Nancy
et al.

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Approaches to Understanding and Managing Pacing in Sloth Bears in a Zoological Setting

Erika Bauer, Mindy Babitz, Nancy Boedeker, and Heidi Hellmuth
Smithsonian's National Zoological Park, U.S.A.

A significant challenge for animal care staff in zoos is the prevention or reduction of stereotypic behaviors in the animals they manage. Zoo professionals work to create opportunities for animals to demonstrate species-typical behaviors and to teach visitors about the natural behaviors of the animals on exhibit. Therefore the expression of stereotypic behavior presents a multi-disciplinary problem. Behavioral researchers have repeatedly examined stereotypic behavior in zoological settings to determine successful approaches to address this challenge. Three investigations of pacing in two adult male sloth bears (*Melursus ursinus*) at Smithsonian's National Zoological Park are presented here. In addition, a case report detailing observations of the rapid onset of an intense stereotypy in a young male sloth bear is included. The first study investigates the effects of five different enrichment strategies on pacing behavior in an adult male with a long history of pacing. The second is a two-year study examining seasonal changes and the effects of social companionship on pacing when the same adult male was housed with a breeding female, a non-breeding (contracepted) female, or a young male. In the third study, we present preliminary data on the effects of the selective serotonin re-uptake inhibitor, fluoxetine, as an adjunct pharmacological treatment for pacing. And finally, our case report details the development an intense stereotypy in a young male sloth bear just after he is weaned and separated from his mother. The findings reveal that the causes, degree, and effective management of even a single observed behavior such as pacing within even a single species can vary greatly by individual and circumstance, highlighting the need for individualized assessment and management plans.

A significant challenge for zoo animal care staff is the prevention or reduction of stereotypic behaviors in the animals they manage. Stereotypies have been defined as repetitive, invariant behavior patterns with no obvious goal or function (Mason, 1991). They are considered abnormal in that they are not part of the behavioral repertoire of healthy, free-living animals (Mason, 1991). Rather, they are typically observed in animals living in captivity or manifesting some underlying pathology (Vickery & Mason, 2005). Zoos strive to create environments and opportunities that allow animals to express species-typical behaviors and to teach visitors about their natural behaviors. The expression of stereotypic behavior presents a multi-factorial problem that can benefit from a multi-disciplinary management approach involving animal managers and keepers, veterinary staff, nutritionists, exhibit design staff, and behavioral researchers.

Carnivores, including bear species, seem to be particularly prone to stereotypic behaviors in zoos and such behaviors often account for a high proportion of their time budget (Clubb & Vickory, 2006). In a meta-analysis of the literature on stereotypies across species, Clubb and Mason (1999) determined that carnivores show a particular proclivity for locomotory stereotypies such as pacing (81% of 63 carnivore species). In addition, wild carnivore species which typically have large home ranges and high daily travel distances show higher frequencies of stereotypies than those with smaller ranges and lower daily travel distances (Clubb & Mason, 2003). An understanding of the natural history of carnivores can shed light on why these animals might favor locomotory forms of stereotypic behaviors. For instance, they could be driven by an

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underlying motivation to engage in natural behaviors that incorporate locomotion (e.g., foraging, hunting, searching for mates or other conspecifics, patrolling territories). Such behaviors are largely unrealized in captivity (Clubb & Vickery, 2006).

Captive bears seem particularly susceptible to developing stereotypic behaviors (Vickery & Mason, 2004; Carlstead, Seidensticker, & Baldwin, 1991). In a survey of 33 carnivore species in captivity, ursids displayed the highest frequency (proportion of observed time) and highest prevalence (percentage of individuals affected) of stereotypic behavior when compared to canids and felids (Clubb, 2001). The stereotypies most commonly exhibited by bears include pacing, weaving, head swaying, stereotypic swimming, and tongue-flicking (Ames, 1994; Fox, 1971; Hennessy, 1996; Kolter & Zander, 1995; Langenhorst, 1997; Meyer-Holzapfel, 1968; Wechsler, 1991), with locomotor stereotypies such as pacing predominating (Clubb & Mason, 2003).

Past research has influenced the development of higher standards of bear care and enclosure design. Results from a 1974 survey of 58 bear-holding zoos (Van Keulen-Kromhout, 1978) indicated that larger enclosures were linked with lower levels of stereotypic behavior. The addition of natural substrate areas to concrete/rock enclosures has also been shown to decrease stereotypies (Ames, 1999). Further evidence suggests that enrichment programs which incorporate creative feeding strategies (e.g., scatter feeding, food hiding, manipulatable feeder objects, automated food dispensers, etc.) result in decreased expression of stereotypies and more natural behaviors like foraging and exploration (Carlstead et al., 1991; Forthman et al., 1992). Enrichment is one of the most common methods utilized to address stereotypic behavior in animals (Mason, Clubb, Latham, & Vickery, 2007), and evidence clearly shows that enrichment strategies can help to reduce the frequency of these behaviors in mammals by a considerable degree (Shyne, 2006). In a meta-analysis of 41 studies, enrichment was shown to significantly reduce stereotypies in a wide variety of species (Swaisgood & Shepherdson, 2005). Enrichment is a useful tool to improve welfare by offering animals new behavioral opportunities (Mason et al., 2007) and it is most successful when it corresponds to the assumed motivational background (e.g., a need for cognitive stimulation, a drive to express a particular natural behavior, etc.) of the animal (Carlstead & Seidensticker, 1991; Kolter & Zander, 1995). However, even with this tool, finding the best approach to reduce a stereotypy can be a significant challenge for animal managers. Adding enrichment items rarely eliminates stereotypies entirely. Modern bear exhibits now provide more space and exhibit complexity. Management programs employ complex strategies involving not only enrichment objects, but also the introduction of new scents, new social opportunities, enhanced training programs, and more opportunities for choice and control, yet pacing is still a common problem in zoo bears.

Why do Bears Pace?

Many studies have attempted to reduce or eliminate stereotypic behavior in bears with varying degrees of success (Carlstead et al., 1991; Fischbacher & Schmid, 1999; Forthman et al., 1992; Swaisgood et al., 2001), but few have examined the motivations behind these behaviors (Carlstead, 1998; Vickery & Mason, 2003). Possible motivations that can contribute to the development of stereotypic behaviors can be linked to natural history, seasonality, acute external events, or even internal biological triggers. To add to the complexity, not only are different individuals likely to have different motivations to pace, but the same individual may have different motivations to pace at different times. In their study of American black bears (*Ursus americanus*), Carlstead and Seidensticker (1991) found that the provision of olfactory enrichment was more successful in the spring (when mate-seeking is a strong motivation) and food hiding enrichment more successful in the fall (when seasonal hyperphagy is a strong motivating force). Strategies to reduce or eliminate pacing are more successful when they appropriately address the motivations behind the behavior, but the motivations are not always clear. Stereotypies frequently become generalized to new contexts and may persist long after the original eliciting motivation has been addressed, which makes it even more challenging to identify the motivation.

Even modern zoo enclosures are far from replicating wild habitats. Reduced habitat size, survival challenge, and environmental complexity may create stress and frustration for the inhabitants, as they may be unable to perform some species-specific behaviors for which they are naturally motivated. In the wild, for example, bears spend considerable portions of their time foraging or hunting for food (Carlstead et al., 1991) using complex foraging patterns (such as digging, sucking, tearing, slapping, stabbing, climbing, or turning over objects). Food in zoos is typically abundant and readily available, which may cause frustrated appetitive behaviors for animals which are naturally motivated to search for food in the wild. Stereotypic pacing in this case may be a displacement activity or redirected behavior. Zoo enclosures may also lack other important stimuli found in the wild, such as scents from other animals, potential mates, opportunities to search and compete for mates, and the conditions and materials required for den digging or nest building. Opportunities for animals in zoo enclosures to make choices and exhibit some degree of control over the environment are also typically limited. Lack of stimulation, predictability, and control over the environment may all be causes of stereotypic behavior (Mason, 1991; Odberg, 1978).

Seasonal variation in stereotypic behavior has also been noted (Carlstead & Seidensticker, 1991; Fischbacher & Schmid, 1999; Kolter & Zander, 1995). Seasonal pacing appears to be motivated by changes in hormone levels or natural changes in food resources (Carlstead & Seidensticker, 1991). In zoos is not uncommon to see seasonal pacing in male bears during the breeding season (when wild bears would be spending increased time and energy searching for females), especially if they do not have access to a mate; both sexes may exhibit pacing during the season that local wild bears go through their period of hyperphagy, caused by an internal motivation to build up fat reserves prior to winter denning (Ames, 1993; Carlstead & Seidensticker, 1991; Fischbacher & Schmid, 1999; Kolter & Zander, 1995).

Acute external events, such as deprivation or unavoidable stress, may also cause stereotypic behavior. It has been suggested that stereotypic behaviors may develop as coping mechanisms and may actually relieve anxiety or reduce arousal, thus becoming self-reinforcing (Mason, 1991; Odberg, 1978). Stereotypic behaviors performed over a long period of time may become emancipated from their original causes; the result is that they then take place outside of the original eliciting context even in the absence of apparent stressors (Odberg, 1978; Kennes, Odberg, Bouquet, & de Rycke, 1988). Chronicity of stereotypic behaviors may alter the functioning of the striatum, which is comprised of brain structures that play an important role in the selection and ordering of behavioral patterns (Vickery & Mason, 2005). Involvement of the striatum is also seen in repetitive behaviors associated with human pathologies such as schizophrenia and autism (Ridley, 1994). Mental disorders such as obsessive-compulsive disorder (OCD) or addiction, and neurological disorders such as Tourette's syndrome, Parkinson's disease, and those associated with frontal lobe lesions may be considered as other clinical forms of stereotypy (Ridley, 1994). In some cases it may be difficult to distinguish whether a clinical condition is the cause of the stereotypy or whether continued stress or frustration may have had long-lasting, potentially irreversible effects on the central nervous system, causing stereotypies resembling clinical conditions (Mason, 1991). It is not uncommon for bears to continue pacing despite improvements in their environment, removal of original stressors, or provision of opportunities to express appetitive behaviors (Mason, 1991; Odberg, 1978; Vickery & Mason, 2004). It is therefore necessary to consider all motivations for stereotypic behavior when attempting to reduce or extinguish it.

Our Study Species: Sloth bears

Sloth bears (*Melursus ursinus*) are native to India, Sri Lanka, Nepal, Bhutan, and Bangladesh. Their home ranges are small compared to other bear species, ranging from 2.2-27.4 km^2 depending on location and season (Joshi, Garshelis, & Smith, 1995; Ratnayeke, van Manen, & Padmala, 2007). This smaller range size could be due to differences in feeding strategies and the distribution of food resources. Sloth bears are myrmecophagous, feeding primarily on colonizing insects like termites and ants, which are abundant in their habitat. They also consume fruits, which are often plentiful. Sloth bear life span in the wild is unknown but in captivity is typically 20-30 years. They are sexually mature around three years of age. Aside from females with cubs, these bears live generally solitary lives, but adults will congregate when food sources are abundant or during the breeding season when estrus females may be accompanied by several males at a time. In the wild, breeding season is April through June in India, and year-round in Sri Lanka. At the Smithsonian's National Zoological Park (NZP), in the climate of Washington, D. C. (where our studies were conducted), breeding season is typically May through August.

This paper presents three investigations of pacing in sloth bears at NZP. The first study investigates the effects of five different enrichment strategies on long-established pacing behavior in an adult male. The second is a two-year study examining seasonal changes in pacing behavior and the effects of social companionship on pacing when the same adult male was housed with a breeding female, a non-breeding (contracepted) female, or his young male offspring. In the third study we present preliminary data on the effects of the selective serotonin re-uptake inhibitor fluoxetine (SSRI) as an adjunct pharmacological treatment for pacing. In addition, we have included a case report detailing our observations of the rapid onset of an intense stereotypy in a young male sloth bear. The onset of such stereotypies are rarely documented or reported in the literature. Reported observations in all these studies were conducted during normal operating hours when animal care staff was present and actively engaged in management activities in the park.

STUDY 1 - Adult male sloth bear (Merlin) - Enrichment Study

Method

Subject

The subject of Study 1 was Merlin, an adult male sloth bear (25 yrs old). Merlin was born at NZP in 1981, and for his first 25 years was exhibited in older, grotto style enclosures. In late summer 2006, Merlin was moved within NZP to a newly constructed exhibit at Asia Trail comprised of two large, naturalistic outdoor habitats (measuring approximately 5,000 and 10,000 sq. ft.) containing natural substrate, shallow pools, waterfalls, rockwork, deadfall, and climbing trees. There was also a state of the art off-exhibit indoor holding area consisting of large adjoining enclosures (measuring 20’ x 20’8” x 10-12’ high), with natural climbing opportunities (secured log structures), platforms, hanging enrichment, and hay beds. Merlin shared the new exhibit and holding space with an adult female sloth bear and her cub (sired by Merlin) but they were housed as a separate social group; each group typically had access to one yard during the day and two adjoining enclosures overnight.

Merlin had a long history (18+ years) of stereotypic pacing in his former exhibit, and this behavior continued after his move into the larger and more complex habitats at Asia Trail. He developed a clear preference for pacing in specific locations along the exhibit rockwork in each yard. This pacing was typically exhibited as a leisurely pace, and Merlin could be distracted from his pacing activity with minimal effort (i.e., he would respond quickly to the calls of his keepers or other environmental stimuli), but he would often return to the same pacing location after such distractions.

Procedure

Volunteers were recruited to assist with data collection and trained to identify and record behaviors as defined by a detailed ethogram which included the following behaviors: Resting, Eating, Foraging, People Watching, Alert, Digging, Climbing, Exploring, Pacing, Playing (alone or with object), Other, and Not Visible. In this study, pacing was defined as "Repetitive movement back and forth along a set path." Each behavioral observation was accompanied by a notation to indicate whether Merlin was stationary or engaged in locomotion during the observation. Observations began approximately four months after Merlin's move to the Asia Trail exhibit. Merlin was observed in his outdoor exhibits seven days per week for six hours per day in two-hour shifts from 10:00 AM to 4:00 PM. Behavioral data were recorded every five minutes via instantaneous sampling (Altmann, 1974; Martin & Bateson, 1993). Three months of observation continued over six 2-week phases of study.

During the baseline phase, no changes were made to Merlin's normal management and husbandry routine. Merlin was offered two primary feedings a day (a morning feeding on exhibit and an evening feeding in holding). A basic level of enrichment was provided as follows: Infrequently offered food items were rotated into the diet, keepers placed scents and food items throughout the yard, some foods were hidden in commercial plastic feeder toys, boxes, bags, paper and/or cloth, while others such as mealworms, nuts, and raisins were scattered on the ground. Training sessions were also conducted at least once per day, and on most days public demonstrations took place in which Merlin either sucked mealworms out of artificial termite mounds in the yard, or fruit was tossed into the yard midday for Merlin to find.

Baseline data were collected for approximately two weeks. Next, novel or intensified enrichment strategies were implemented for approximately two weeks each. Strategies were selected based on what is known about the natural history of this species, what enrichment and training strategies have been implemented successfully with other bear species, and what was possible within the confines of the exhibit space and management routine. These strategies all provided novelty, in different forms. The enrichment conditions included: (1) increased amounts of food inserted into holes drilled in logs (to provide opportunities on exhibit for the natural suction feeding of sloth bears), (2) choice of which yard to go into each day (to offer Merlin more choice and control over his routine), (3) extra training sessions during exhibit hours (two extra sessions per day, in addition to the routine training sessions conducted daily in the holding area, to increase cognitive stimulation), (4) increased use of feeder devices such as heavy-duty plastic objects with holes (to elicit object manipulation, increase food processing time, and offer more cognitive stimulation), mealworm bags with treats (to provide opportunities for tearing), and food in ice blocks (to provide opportunities to claw at and break an item to get at food; all behaviors that sloth bears naturally exhibit in the wild as they tear open termite mounds, break open bee hives, and roll logs to gain access to the insects they eat), and (5) installation of deep mulch digging pits, provisioned daily with food items (to elicit natural digging behavior and foraging).

Results and Discussion

In total, over 500 hours of data were collected. Pacing accounted for the highest proportion of Merlin's activity budget in every condition. At baseline, Merlin paced in 45% of observations, and in the enrichment conditions he paced in 42-52% of observations. The proportion of time spent pacing was lower than baseline in enrichment condition 5 (dig pits) and higher than baseline in conditions 1-4, perhaps because activity level in general increased (i.e., he rested less in enrichment conditions 1-4 than in baseline). For data presentation, similar behaviors (alert & people watch, eat & forage, climb & explore) have been combined (Figure 1).

Although these strategies did not dramatically reduce Merlin's pacing behavior, they did provide cognitive stimulation as well as new opportunities for him to engage in natural, species-typical behaviors. Animal care staff continued utilizing these strategies post-study on a more variable schedule. To continue the effort to reduce Merlin's pacing, animal care staff targeted subsequent management strategies that were more closely linked to the apparent initial motivation of Merlin's pacing. Anecdotal reports in historic keeper records indicated that in his former exhibit, Merlin's pacing tended to increase when he was separated from a female or when housed with a female who didn't want to socialize with him. Study 2 was initiated to investigate the influence of social companionship on Merlin's pacing behavior. It was extended to two years to capture seasonal (breeding versus non-breeding) variation as well.

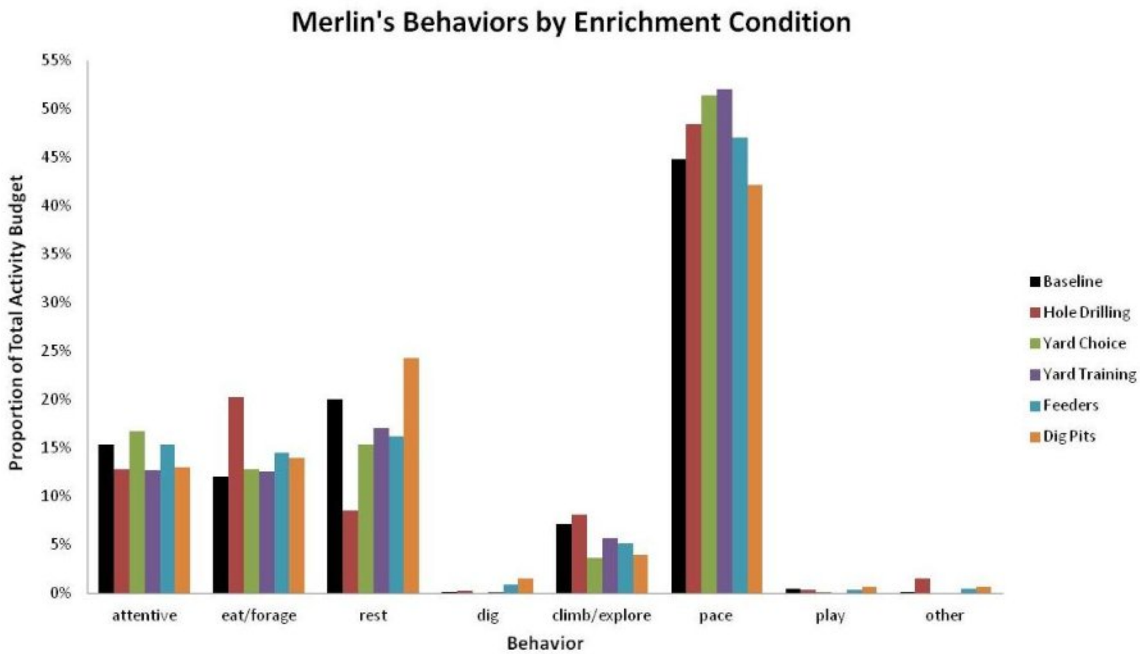

Figure 1. This chart indicates what proportion of Merlin's activity budget was spent performing each type of behavior in each enrichment condition. Only the condition with the digging pits resulted in less pacing than in the baseline condition.

STUDY 2 - Adult male sloth bear (Merlin) - Social Companionship & Seasonality

Method

Subjects

The adult male subject from Study 1, Merlin, was also the focal animal for Study 2. At the start of Study 2, Merlin was 26 years old and lived in the Asia Trail exhibit described in Study 1. At the time, the NZP collection presented a rare opportunity for studying the effects of social companionship because three separate conspecific social companions were available to Merlin: a breeding female (Hana, 14 yrs), a contracepted female (Khali, 10 yrs), and Merlin's young male offspring (Bala, 2 yrs). Though there were some externally imposed limitations as to when we could pair Merlin with each social companion, the ability to introduce Merlin independently to each of these three individuals allowed us to compare the unique effects of these different social situations on Merlin's pacing behavior. Merlin was also housed alone at various times over the course of the study.

Procedure

Again, trained volunteers collected data according to a detailed ethogram (Table 1) and each behavioral observation was accompanied by a notation to indicate whether Merlin was stationary or engaged in locomotion. Mean interobserver agreement was 97.67% using this ethogram. Focal animal observations were conducted three days per week, twice per day, over a period of two years. Observation sessions took place from 10:00 AM-12:00 PM and 1:00 PM–3:00 PM and data were recorded via instantaneous time sampling at five minute intervals. We collected 5,292 data points when Merlin was housed alone, 4,787 when he was housed with a social partner (2,282 with Hana, 1,526 with Khali, and 979 with Bala); 833 data points were collected when Merlin was housed alone during the breeding season, 4,459 when he was housed alone in the non-breeding season.

Due to management restrictions, it was not possible to house Merlin with all of the possible social partners in both the breeding and non-breeding seasons, so the effects of social companionship must be considered independent of seasonal effects.

Table 1

Behavioral ethogram for Merlin social companionship & seasonality study (Study 2)

Category	**Behavior**	**Definition**
Solitary Behaviors – none of these should be coded if subject is engaged in social interaction		
	Pacing	Repetitive locomotion back and forth along a set path; must observe *more than* two travel lengths along the same path before it can be coded as pacing rather than travel
	Resting	Appears to be sleeping by himself (no physical contact with partner); eyes are closed, exhibiting little or no movement of body
Attentive	Alert	Awake, eyes open, but not engaging in any of the behaviors on this ethogram; essentially awake but inactive; no physical contact with partner
	People Watch	Attention focused on keeper or visitor movements, sounds, or position
Locomotion	Travel	Traversing the enclosure, but not following or approaching partner
	Climb	Ascending or descending a fixed structure (such as a tree or a wall)
Exploration	Investigate/ Explore	Actively investigating the environment, i.e., sniffing/licking/touching some feature of the enclosure – not obviously associated with eat/forage
	Dig	Using claws to move substrate or shred logs – not obviously associated with eat/forage, trumps investigate/explore
Food-Related	Eat/Forage	Actively manipulating food in mouth or sniffing and/or digging interspersed with eating – trumps investigate/explore, no feeding device involved
	Feeding Device	Engaging with a feeding device
Solitary Play	Play Alone	Animated rolling, running, jumping, hanging/dangling, biting of own feet, or otherwise entertaining self (no object or partner involved)
	Object Play/ Manipulation	Engaged in play with any detached natural (stick, grass clump, etc.) or unnatural (box, ball, etc.) object
	Other	Any behavior that does not fit any of the definitions in this ethogram
	Not Visible	Subject is not visible to the observer; cannot confirm behavior

Table 1 (cont.)

Category	Behavior	Defininition
Social Behaviors – these supersede solitary behavior codes		
Affiliative Contact	Contact	Subject is in restful physical contact with partner, either sleeping or alert
	Grooming	Subject in physical contact with partner, grooming or actively touching
Social Initiation	Investigation	Subject is investigating partner through sniffing; no contact is made
	Follow	Subject is following or approaching partner at a walking pace, focused on partner and clearly not just traveling to an area near partner
	Running To	Subject is following/chasing or approaching partner at a running pace
Social Play	Contact Social Play	Subject is engaged in play that involves physical contact with partner
	Non-contact Social Play	Subject is engaged in play with partner, but is not in physical contact with partner
Conspecific Aggression	Contact Aggression	Subject is engaged in aggression with partner involving physical contact
	Non-contact Aggression	Subject is engaged in aggression with partner, but they are not in physical contact (could be open mouth threats, swipe *attempts*, etc.)
	Sexual	Subject is engaged in sexual behavior with partner

Note: In Study 2, observers coded Merlin's behaviors using this ethogram. In analysis, similar behaviors were combined into broader categories of behavior, as listed in the first column. In Study 1, observers used a simplified version of this ethogram, but the definitions closely followed the ones displayed here.

Results and Discussion

Breeding season had little effect on Merlin's pacing behavior when he was housed alone, suggesting that his pacing may not be the result of an underlying motivation to search for mates. For data presentation, we combined similar behaviors into broad categories of behavior (as listed in Table 1), and any category that occupied less than 1% of Merlin's activity budget was lumped with "other" behaviors. When housed alone, Merlin's time spent resting was lower in the breeding season, seemingly replaced by active species-typical behaviors such as investigate/explore or travel (see Figure 2). During the breeding season, his general movement around the exhibit increased, but pacing did not. In the non-breeding season, 48.25% of Merlin's observed time was spent in locomotion, 50.93% stationary; during the breeding season, 53.68% of his observed time was spent in locomotion, 45.44% stationary.

Independent of breeding season, Merlin paced less when he was housed with a social partner than when housed alone, regardless of which partner he was paired with (Figure 3). The proportion of his observed time spent pacing was lowest when he was housed with Khali, a non-breeding (contracepted) female companion (Hana 23.53%, Khali 11.80%, Bala 21.35%) (Figure 4). Merlin initiated closer proximity with and investigated his female partners more than Bala, but his social initiations were highest with Hana, the breeding female (Hana 9.33%, Khali 4.13%, Bala 0.92%). He also explored the exhibit most when housed with Hana (Hana 14.99%, Khali 13.50%, Bala 10.52%). Though they accounted for only a few observations, the only instances of socio-sexual behavior and masturbation (which was coded as "other") occurred when Merlin was with Hana. He played most with his offspring Bala (Hana 1.27%, Khali 0.92, Bala 9.09%). Although Hana was sometimes receptive to Merlin's social initiations, she responded by engaging in positive social interactions less often than Khali and Bala. Also, Hana did not initiate social interactions with Merlin as often as Bala and Khali did. It may be that his social partner's interest in actively engaging in social interaction made Merlin more comfortable, resulting in less pacing. It is also possible that he was most frustrated by Hana's disengagement because when housed with her, his motivation to engage in social interaction was driven by an interest in breeding as well as companionship. This study highlights the potential value of social companionship in zoos, even when partners are not intended for breeding, in species generally thought of as solitary like the sloth bear and other ursids.

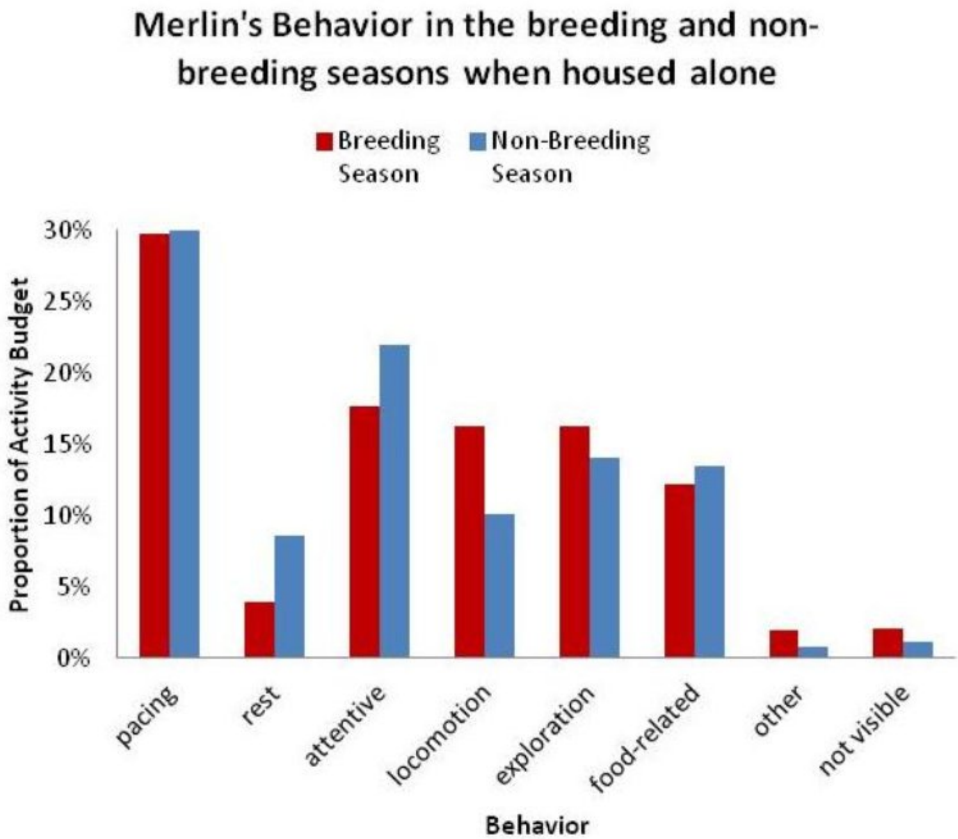

Figure 2. Behavior and season.

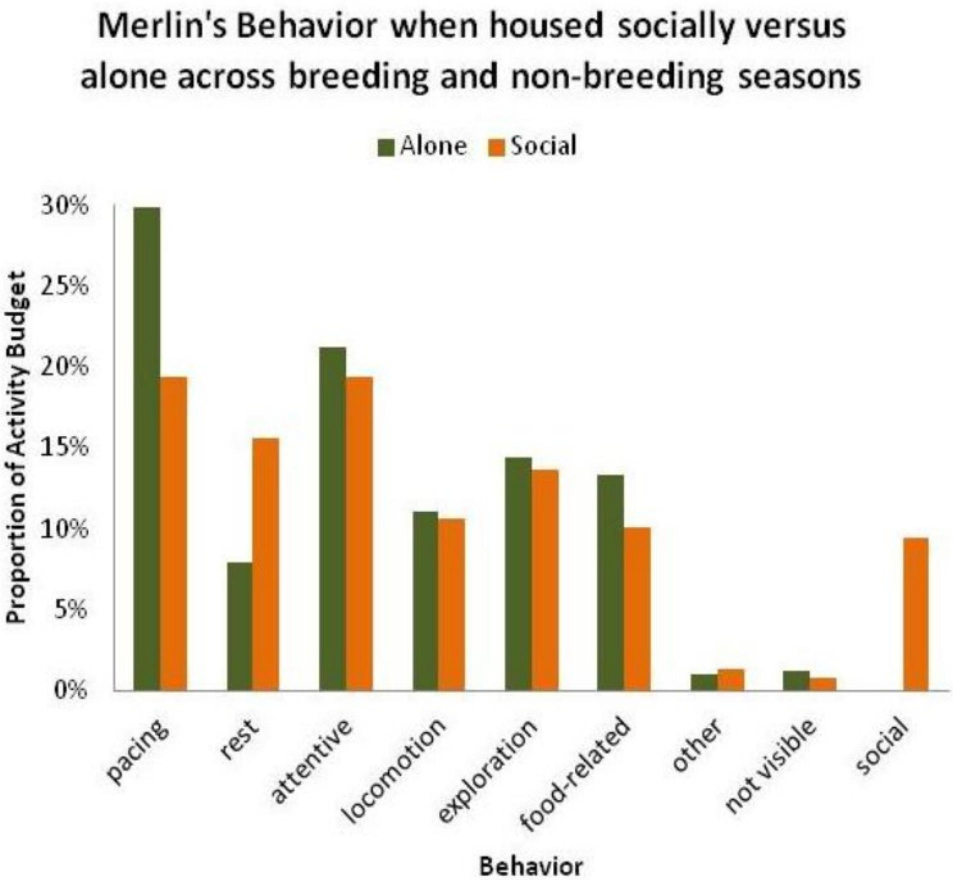

Figure 3. Behavior and social companionship.

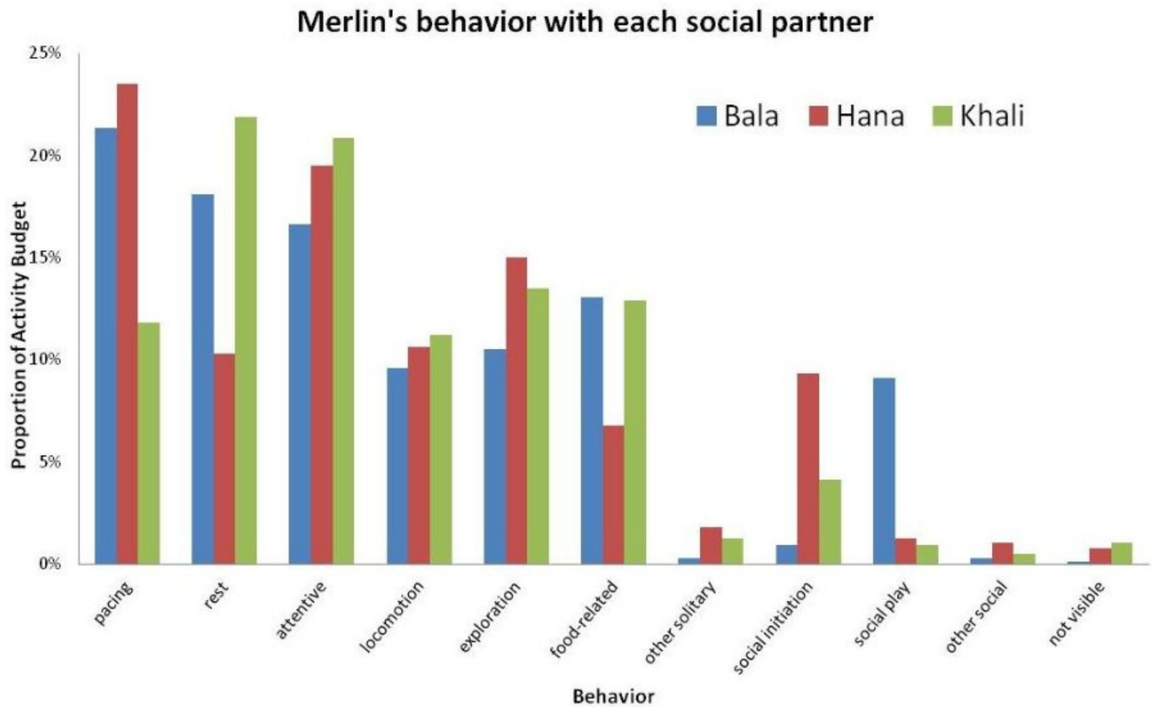

Figure 4. Broad categories of behavior are displayed in this chart, with behaviors combined as listed in the ethogram (Table 1). Any behavioral category that occupied less than 1% of Merlin's activity budget was combined into the "other" category: solitary play behaviors are included in "other solitary," and affiliative contact and conspecific aggression behaviors are included in "other social."

STUDY 3 - Adult male sloth bear (Francois) - Pharmacological Treatment
Introduction to Fluoxetine

Evidence suggests that some stereotypic behaviors observed in bears are similar to compulsive behaviors exhibited by humans with OCD, indicating involvement of the serotonergic system (Poulsen et al., 1995, 1996). SSRIs such as fluoxetine have been used successfully to treat disorders such as OCD in humans, separation anxiety, acral lick dermatitis and other OCDs in domestic animals (Dodman, Bronson, & Gliatto, 1993; Irimajiri et al., 2009; Rapoport, Ryland, & Kriete, 1992), and stereotypic pacing in polar bears (*Ursus maritimus*) (Poulsen et al., 1996) and brown bears (*Ursus arctos*) (Yalcin & Aytug, 2007). We found no previously published reports of the use of an SSRI in sloth bears.

Fluoxetine appears to function by selectively inhibiting neuronal reuptake of serotonin which ultimately leads to a down-regulation of the receptors. No pharmacokinetic assessment of fluoxetine in ursid species has been published. Its use in sloth bears is extra-label and doses and expected effects have been extrapolated from reports in other species (Irimajiri et al., 2009; Poulsen et al., 1996; Yalcin & Aytug, 2007). In humans it is known to have a delayed onset of full effect (weeks) and maximal behavioral modification is not immediate upon starting treatment with the drug (Nierenberg et al., 2000).

Method

Subject

In March 2010, a 19-year-old sloth bear, Francois, with a chronic history (first noted in 2002) of stereotypic pacing was transferred to the NZP's Asia Trail exhibit (described in Study 1) from another zoo. At the time of this study, Asia Trail also held two separately housed adult female sloth bears (Hana and Khali). Francois exhibited pacing of excessive duration and intensity within 12 hours of arrival, along with an extreme startle response to the movement of objects outside the enclosure. The behavior showed similarities to that described for a polar bear at the Calgary Zoo (Poulsen et al., 1996). His pacing included a motor tic (a huff at the end of each pacing cycle when changing direction), a glazed look in the eyes, an apparent inability to break from the behavior, and an apparent limit to the number of enrichment or training activities he would participate in before returning to the stereotypy.

An intense program of enrichment and training was implemented immediately and included desensitization to objects. However, no change in Francois' pacing behavior was observed. Therefore an adjunct pharmacological treatment strategy was employed to manage this behavior. Due to immediate concerns about the potential for detrimental health effects secondary to the intense pacing (e.g., foot pad wear, hyperthermia, anorexia), a short oral course of a benzodiazepine sedative, midazolam (Mfd. by Roxane Laboratories, Inc., Columbus, OH, 43216), was initially prescribed with good effect to act rapidly to decrease pacing. Due to the quality and presentation of such intense pacing behavior in this bear, we suspected that neuronal uptake of serotonin might be a causal factor, and expected an SSRI would have a positive effect on the behavior long term. While Francois was still on the short course of midazolam, a long term pharmacological treatment with fluoxetine (with an expected slower onset of action) was initiated. Since seasonal pacing may be influenced by testosterone levels (Kolter & Zander, 1995) and likely operates via a different internal mechanism in this species than that which we intended to influence using an SSRI, we did not expect that fluoxetine would eliminate pacing entirely, but did hope for a significant reduction.

Procedure

Francois was closely observed for more than a year as fluoxetine dosage was adjusted based on his clinical condition. Initial treatment with fluoxetine (Mfd. by Taylor's Pharmacy, Winter Park, FL, 32789) began with a dosage of 100mg SID (once daily) when his weight was 130kg. From the start of treatment, keepers maintained detailed management records and one month after treatment began, keepers started recording Francois' status (pacing vs. not pacing) via instantaneous sampling at 30 minute intervals for twelve hours per day (6:30 AM to 6:30 PM).

Data included in this analysis incorporate 6488 observations across 508 days (from April 2010 to September 2011, with a pause in data collection from late May to early July 2011). Changes in pacing while on varying doses of fluoxetine were analyzed across five different treatment phases: (1) 100 mg fluoxetine SID for 50 days (observations started one month after treatment with this dose began), (2) 120 mg fluoxetine SID for the next 231 days, (3) tapering off of fluoxetine (initiated to see if the positive changes noted in the quality and frequency of his pacing would be maintained off of the drug) by 20mg dosage reductions every 10 days over the course of 50 days, (4) no treatment with fluoxetine for 59 days, and (5) 120mg fluoxetine SID resumed for 143 days.

Results and Discussion

Treatment decisions were based on Francois' condition, therefore not all factors could be controlled and it is difficult to differentiate the effects of fluoxetine treatment and seasonal fluctuation on pacing. Results are presented in Figure 5. Approximately two months after starting fluoxetine treatment (~ days 25-40), keepers began noting qualitative changes in Francois' pacing and sensitivity, even though the amount of time he spent pacing remained high (40-80% of daily observations). Francois no longer had a glazed look in his eyes, he easily broke from pacing when presented with distractions, and he spent an increased amount of time engaging with enrichment and with keepers during training sessions. More species-typical behaviors, most notably resting or sleeping mid-day, were also more frequently observed. The extreme startle response to the movement of objects outside his enclosure was also greatly reduced during this phase. These qualitative improvements continued with treatment. However, a marked reduction in proportion of time spent pacing was not seen until about 150 days into the study (125 days after beginning treatment with 120 mg fluoxetine).

Despite treatment with 120 mg fluoxetine, an increase in pacing is noted around day 220 (December 1st, 2010). We believe this to be correlated with external factors. Washington, DC experienced an extreme cold spell during December 2010 that resulted in a need to keep the bears inside without access to outdoor yards for most of that month. Francois' increase in pacing at this time may have been related to this abrupt reduction in space and choice of location during the day. In January, despite the extremely low temperatures he was offered access to the outdoor mesh chute (approx. 121' long) that connected the holding area to the exhibit yards, and when conditions weren't hazardous (i.e., icy) he was also given access to the yards. This appeared to reduce his time spent pacing. To evaluate whether he could maintain an overall improved (lower) level of pacing without the fluoxetine, we began to taper him off the drug. The lowest levels of pacing observed during this study were seen during the tapering phase of treatment. This may reflect a combined influence of husbandry changes, seasonality, and/or the suspected prolonged elimination of fluoxetine as documented in other species. In humans, clearance of all metabolites of fluoxetine takes about four weeks from termination of treatment (Altamura, Moro, & Percudani, 1994).

By the end of the tapering phase (phase 3), an increase in pacing was observed. This timing also corresponds with the beginning of breeding season and may be confounded by an increase in testosterone-motivated pacing (as seen in other captive male bears during breeding season; Carlstead & Seidensticker, 1991; Kolter & Zander, 1995). While there may be more than one factor causing this increase in pacing (the cessation of pharmacological treatment and a rise in testosterone), qualitative notes provide insight into the possible beneficial effect of fluoxetine. Starting at the end of the taper and continuing through the no-treatment phase, keepers noted that the glazed look in Francois' eyes returned, it again became difficult to interrupt his pacing, and he became increasingly unable to engage in enrichment and training activities for more than brief periods of time. Keepers noted Francois' apparent desire to participate in training or engage with enrichment (he would approach and initiate interactions), but his need to pace seemed to override his desire to engage in other behaviors (he would end sessions early or break away from sessions intermittently to engage in pacing). Francois' extreme startle response to movement of objects outside the enclosure also returned. Due to these qualitative changes, treatment with 120 mg fluoxetine SID was resumed.

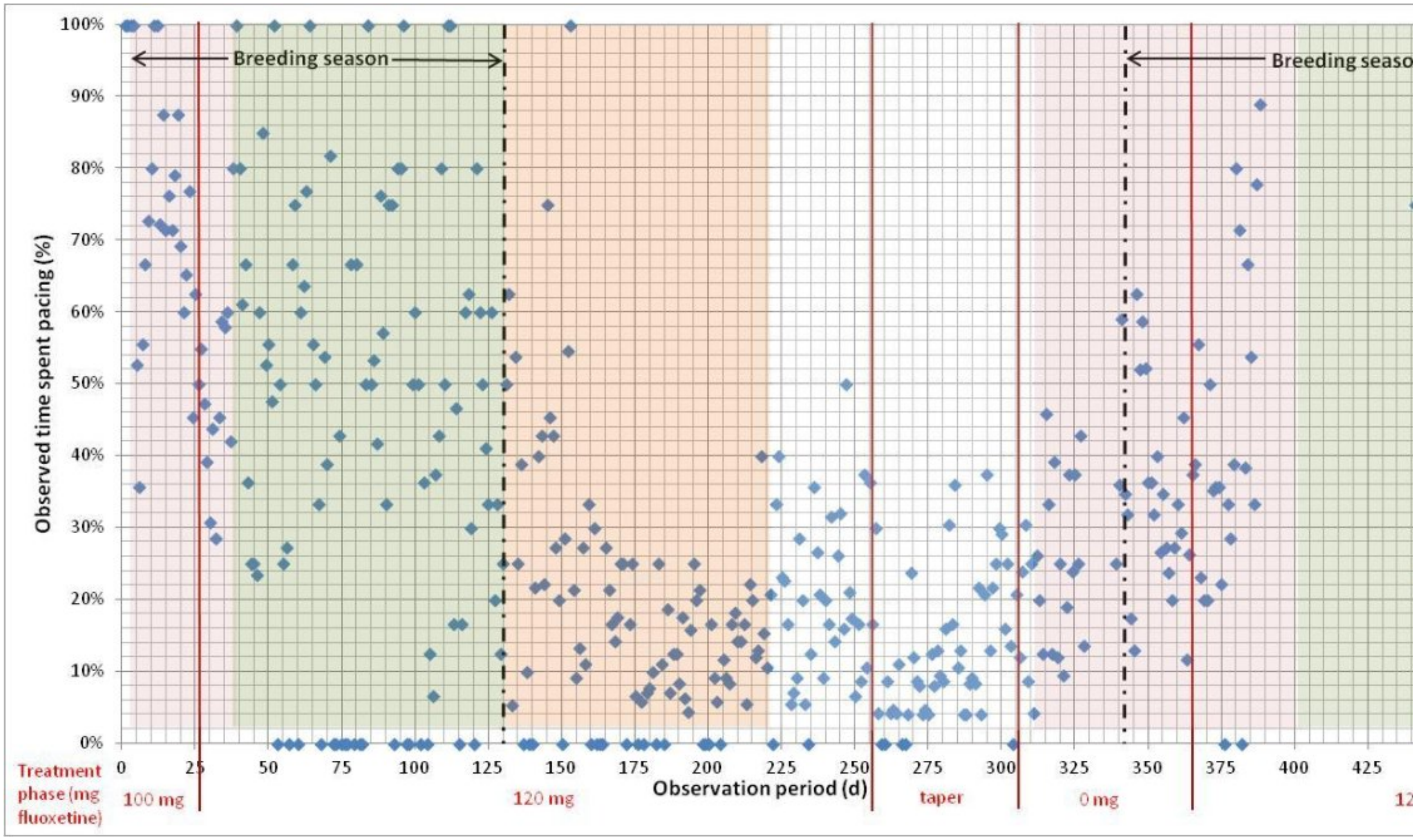

Figure 5. Changes in Francois' pacing behavior at varying fluoxetine doses (mg) and seasons are displayed. Points indicate the percentage of observ 6:30 PM that Francois was observed pacing each day over a 508 day period. Observations were not conducted from day 389-440. Treatment phases lines and breeding seasons are indicated by black vertical hashed lines. Time of year is color coded: spring = pink, summer = green, fall = orange, wir

CASE REPORT - Bala's Rapid Onset of Stereotypy, 2008

Bala, a male sloth bear cub, was housed for his first two years with his mother, Hana, in the highly enriched environment of the NZP's Asia Trail exhibit (described above). Two other sloth bears, an adult male (Merlin, his father) and adult female (Khali, unrelated), were also housed separately in this area. In addition to the complex design of the exhibits and enclosures, the enrichment program incorporated a variety of activities meant to stimulate natural behaviors such as digging, tearing, sucking, manipulating, climbing, and using problem-solving skills (for example, commercial plastic feeder toys containing kibble or produce, boxes, bags, paper and/or cloth with food wrapped up and hidden inside, scattered forage foods such as mealworms, nuts and raisins, enrichment placed up high in trees, and honey, jelly or peanut butter placed in log holes). Training sessions were conducted at least once per day, and on most days the bears were invited to participate in feeding or training demonstrations for the public.

During Bala's rearing he exhibited several dramatic episodes characterized by agitation, crying, anorexia, lethargy, reduced responsiveness to keeper staff, and heightened fear response. These episodes were most frequent between 1.5-2.25 years of age. In April 2008, when Bala was 2.25 yrs of age, he was abruptly weaned and rejected by Hana after she was implanted with a deslorelin contraceptive (2 x 9.4 mg implants; Mfd. by Virbac Animal Health, Fort Worth, TX, 76137) which was administered to prevent undesired breeding behavior between mother and son. Six days after implantation, Hana exhibited extreme aggression towards Bala, repeatedly attacking and biting him, and continuing to pursue him even when he tried to escape. A decision was made to separate them for the remainder of the day and overnight (with visual access) to prevent serious injury to the cub. Hana's sudden aggressive behavior was speculatively attributed to an earlier than normal ovulation stimulated by the contraceptive implant. Attempts were made to reunite Bala and Hana over the following weeks but proved unsuccessful; Hana continued exhibiting aggression towards Bala even when only given limited visual access through a mesh gate. Bala's enrichment and training program was intensified by adding multiple daily (a) training/keeper socialization sessions, (b) exhibit/enclosure re-enrichment, and (c) moves between different enclosures, to keep him mentally stimulated and to help him through this sudden transition.

Unlike the stereotypic pacing exhibited by the bears in the previous studies, Bala's stereotypy derived from a digging behavior. Table 2 shows the timeline of Bala's stereotypy development. The initial digging behavior began the day after he was separated from Hana (Day 2) and was focused at the door separating them. This behavior escalated and was combined with depression and anorexia. Bala was further separated from Hana in an effort to extinguish this behavior; first two mesh doors separated him from Hana, then visual access was removed, and finally they were moved to opposite ends of the building with two enclosures (containing other bears) between them. By Day 25 keepers noticed evidence that Bala had been digging at the door overnight. This may be the point at which his initial digging behavior started to become a stereotypy. On Day 27 keepers observed Bala not only digging at the door, but pushing his head and shoulder into the door and then scooting backwards across the floor afterwards. By Day 36 this behavior escalated to include a frantic run towards the door prior to the digging, and then a scoot backwards across the floor afterwards, leaving him mildly to moderately hyperpneic after repeatedly performing this behavior. By Day 41 keepers noticed that Bala was spending the majority of his day performing the stereotypy and was spending less time interacting with enrichment or keeper staff, even missing the public feeding demonstration some days (an activity in which he typically readily engaged). On Day 48, a modified version of the stereotypy began in which Bala would sway/step forward and back in front of the door with a circular head motion instead of running towards the door, digging and scooting back away from it. At this point Bala was introduced to an unrelated adult female (Khali) and his father (Merlin) with the hope that companionship might reduce his stereotypic behavior. Companionship with each of these bears correlated with a reduction but not complete resolution/extinction of Bala's stereotypic behavior. Bala continued to exhibit this behavior while housed with the other bears, and when he was separated from them for any reason the stereotypic behavior escalated and became more frantic. On Day 69, Bala was seen performing the stereotypy at a new location in front of the public viewing glass in the yard, instead of at a door. This may be the point at which the stereotypy became emancipated from the original motivation (Odberg, 1978).

Bala's stereotypic behavior continued despite all management efforts to stop its development and decrease its frequency. Over time, the stereotypic behavior eventually decreased, but when presented with any new stressor (e.g., separation from a companion or transfer to a new zoo), the stereotypy increased in frequency and become more frantic. Dramatic behavior (e.g., agitation, crying, anorexia, lethargy, etc.) also continued to be exhibited on occasions when play solicitations were rejected by his new companions. It was postulated that Bala's experiences might result in abnormal social development, or a permanent reduced ability to cope with social and environmental variation which could negatively impact his ability to contribute to a successful, sustainable captive population management program. In fact, Bala's transfer to a new zoo was reportedly more stressful for him than is typical for this species. But once settled he was successfully introduced to his new female companion and has exhibited appropriate breeding behaviors with her, though the stereotypy is still part of his behavioral repertoire at NZP in the new facility.

Summary and Concluding Discussion

The studies detailed above provide insight into individual variation in the motivation behind and the qualitative aspects of pacing and other stereotypic behaviors, even within the same species. The primary subjects of the three pacing studies exhibited very different pacing styles. Both Merlin and Francois had paced for many years, and a significant portion of their activity budget was devoted to pacing, but the quality of their pacing differed dramatically. Merlin exhibited a relaxed, almost leisurely, pacing style and could easily be distracted from the behavior, while Francois' pacing prior to fluoxetine treatment was far more intense and focused, and harder to interrupt. Additionally, Francois appeared unable to engage with increased amounts of enrichment (e.g., he did not interact with feeder toys long enough to remove the food contained within, he did not participate in training sessions or he disengaged from sessions before they were complete, etc.), while Merlin engaged fully with the enrichment provided even though his time spent pacing remained fairly consistent.

Table 2
Timeline of Bala's stereotypy development (Case Report)

Day	Behavioral & Physical Observations	Keeper Actions
Pre-maternal separation, Bala did not exhibit any signs of stereotypic behavior		
1		Separated from Hana for 1st time overnight but has visual access
2	Digging at door between him and Hana begins	
7	Door digging becomes frantic	
10	Depressed	
12		Separated from Hana by 2 doors but has visual access
15	Clawing and digging at door	Visual access to Hana taken away
16	Depressed, not eating, door digging	Bala was moved 3 dens away from Hana
22	Furiously door digging	
25	Staining floor from repeated door digging	
27	Door digging and pushing head/shoulder against door, then scooting backwards across the floor	
36	Frantic digging combined with a run towards the door and then a scooting backwards across the floor after digging; out of breath	
41	Door digging most of the day; did not participate in feeding demo, interact with enrichment, or interact with keepers	
48	Swaying/stepping forward and back in front of door (shortened version of run, dig, scoot behavior)	Begin visual introductions to unrelated adult female (Khali)
69	Begins performing stereotypy at viewing glass in yard	

Note. These notations were taken from daily keeper reports, and reveal the progression of Bala's stereotypic behavior after separation from his mother, Hana.

Enrichment and training strategies employed to reduce Francois' pacing had minimal positive effect, and the quality and intensity of Francois' pacing led animal care staff to think there was a different or additional internal motivation behind this behavior. In his case pharmacological treatment with fluoxetine correlated with a reduction of pacing and presumptively improved psychological welfare (as indicated by his increase in species-typical behaviors, increased engagement with enrichment and training activities, and a decrease in his startle response), suggesting that the serotonergic system was involved in his motivation to pace. We found only two other published cases describing the use of this drug to effectively help reduce pacing in bears - one in a polar bear (Poulsen et al., 1995, 1996), and one in a brown bear (Yalcin & Aytug, 2007). Although these studies suggest that this drug may contribute to producing the desired effect (reduced pacing), it should be noted that one of the possible side effects associated with fluoxetine treatment in humans is sexual dysfunction, including delayed ejaculation and decreased libido (Csoka, Bahrick, & Mehtonen, 2008; Rosen, Lane, & Menza, 1999). Francois, a proven breeder prior to his fluoxetine treatment, did not successfully breed while on fluoxetine despite access to, interest in, and several attempts to breed a cycling female during the breeding season. During breeding introductions and observed bouts of masturbation he appeared to have difficulty attaining an erection. A causal relationship between fluoxetine use and sexual dysfunction has not been established in bears, but the potential for fluoxetine to affect sexual function in bears warrants further investigation and should be considered, particularly if treating genetically valuable individuals that are recommended to breed.

Very little is known about which areas of the ursid brain are activated when stereotypic behaviors are performed and which ursid brain structures are targeted by SSRIs, so at this point information must be extrapolated from what is known about other species. Whether fluoxetine specifically alters behavior by targeting the areas of the brain activated during stereotypy expression or whether it might have a more general affect (e.g., increased lethargy resulting in reduced activity) is unknown for sloth bears and is a question under ongoing investigation in other species. For example, fluoxetine treatment in deer mice has been shown to significantly attenuate stereotypies in high stereotypic animals and to reduce cortical cyclic adenosine monophosphate (cAMP) and phophodiesterase type 4 activity without noteworthy effects in the striatum (Korff, Stein, & Harvey, 2009). Fluoxetine treatment in bank voles was found to decrease stereotypy levels in high stereotypic animals but increase them in low stereotypic animals while no effect was found on general activity and food intake in either group (Meers & Odberg, 2005). In Francois' case, the behavioral changes we observed while he was on treatment with fluoxetine were not considered consistent with general lethargy/inactivity. Subjectively, he simply appeared to be more calm, more focused, more engaged in cognitively stimulating activities, less distracted, less anxious and less reactive.

Stereotypies like pacing may be linked to internal motivating forces, like hormone fluctuation (resulting in seasonal pacing), or issues with the serotonergic system (causing compulsive pacing), but they may also be linked to external environmental factors or acute stressful events. Some potential causes of stereotypic behavior may be difficult to mitigate in the zoo environment, such as limited choice and control, predictability in the daily routine, amount of available space, lack of privacy from human visitors, and noise. Continued research with sloth bears at NZP will attempt to investigate the effects of choice and control over the environment on pacing. Whatever the cause or motivation, stereotypies can quickly become self-reinforcing, making them far more difficult to eliminate from the behavioral repertoire (Mason, 1991); they can continue long after the animal is removed from the context in which the stereotypies first developed.

Zoo professionals most often find themselves dealing with stereotypic behavior which has been long established in particular individuals, as was the case in our studies of Merlin and Francois. More rare is the unfortunate opportunity to see a stereotypic behavior arise anew. Bala's case report demonstrates how quickly a behavior such as digging at a door to try to gain access to a conspecific can become an established stereotypy, and how difficult it can be to manage an animal as it experiences the stressful events that set the stage for the development of such a behavior. In hindsight, the decision to move Bala farther away from the individual he wanted to be with (his mother, Hana) may not have been the optimal approach. More distance was put between them in an effort to discourage the behavior, but continuing mesh access with Hana may have produced different and possibly better results. Hana's continued aggression at the mesh may have more appropriately reinforced the separation to better facilitate the weaning process for

Bala. It is also possible that introducing Bala to another social companion immediately after his maternal separation may have been beneficial, but this was not a viable option at the time. This sort of strategy has reportedly met with some success when implemented by North American bear rehabilitators (J. Beecham, personal communication, 2009). Based on the apparent positive response to pharmacological treatment in Francois and the published reports in a polar bear and a brown bear (Poulsen et al., 1996, Yalcin & Aytug, 2007), early medical management could also be considered as an adjunct tool in managing cases similar to Bala's to try to prevent the establishment of a stereotypy following a stressful situation.

A noteworthy factor in these studies of sloth bears is the apparent positive impact of social companionship outside of the breeding context in an otherwise solitary species. While it is important to consider management options that are appropriate based on the natural history of a species (e.g., providing digging opportunities for animals that dig, and providing feeding opportunities that mimic how the animals would feed in the wild), sometimes less natural options (e.g., social companionship for typically solitary animals) are available in the zoological setting and can be quite effective. For Merlin, increased social companionship correlated more closely with decreased pacing behavior than any of the enrichment strategies we employed when he was housed alone, even though those strategies were customized to be appropriate based on species-typical sloth bear behavior. As the Francois study has continued, we have collected evidence that even in the absence of drug treatment, strategies like 24-hour indoor-outdoor access (now considered a best practice in bear management, though rarely possible due to the design of most existing zoo facilities) and social companionship (for which options are also quite limited in zoos) can provide a similar if not better effect on pacing in a bear that would otherwise need to be managed with drug treatment. As stated above, social companionship may have prevented the development of Bala's now long-term stereotypy if that strategy had been employed immediately after maternal separation, even though young sloth bears do not typically pair with other social companions after weaning and maternal separation in the wild.

Stereotypic behaviors are complex in origin, and developing strategies to manage them is complicated and challenging, particularly when confronted with the diverse and often less thoroughly studied (non-domestic) species found in zoo settings. Behavioral monitoring was essential in determining the most appropriate management strategies to use with each of the individuals described here. Observations and documentation of behavioral patterns and management changes provided both insight into the possible motivational factors contributing to the expression of stereotypic behavior and information about what strategies were most effective for each of the individuals being monitored. Results also revealed the extent to which the causes, degree, and effective management of a single behavior such as pacing can vary by individual and circumstance, highlighting the need for individualized management plans to provide for each individual's well-being.

The more effective zoos are in reducing or eliminating stereotypic behavior and redirecting animals toward more natural behaviors, the better equipped zoos will be to educate the public accurately about the natural behaviors of the animals they exhibit and the role of those animals in their natural ecosystems. Behavioral researchers can provide invaluable support for programs that enhance zoo animal welfare, support public education, and inspire conservation action in zoo visitors. Together, all of these positive effects help to support the conservation goals of contemporary zoological institutions.

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