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Behavioral Monitoring of Big Cats Involved in 'Behind-the-Scenes' Zoo Visitor Tours

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While interactive tours have been argued to hold great conservation potential for zoo visitors, the influence on the participating animal's behavior is often ignored. To investigate this, we observed the behavior of one Sumatran tiger (*Panthera tigris sumatrae*) and three African lions (*Panthera leo leo*) involved in a protected contact tour, as well as that of three cheetahs (*Acinonyx jubatus*) involved in a hands-on tour, at Zoos South Australia. Instantaneous scan sampling (30-s intervals) was used to record animal behavior before, during, and after behind-the-scenes tours, as well as for equivalent times on non-tour days, over a three-month period. Estimated proximity (close, < 2 m; moderate, 2-5 m; and distant, > 5 m) to humans was also recorded as an indirect measure of interaction. The animals in the protected contact tour displayed decreased inactivity and increased feeding and pacing during the tours, compared to before and after. We suggest that the increased pacing is more associated with the animals being fed during the tours, rather than the tours being a stressful experience. Those in the hands-on tour showed variation in proportions of multiple behavior categories and primarily these were shifts in species-typical behaviors. In contrast to those in the protected contact tour, they showed decreased pacing during the tour sessions. No aggressive or otherwise antagonistic behaviors directed at humans were observed by animals in either tour, with these animals typically spending more than half of their tour times in distant proximity to keepers and visitors. Combined, these findings indicate that large felid behavior may be altered by participation in interactive tours, but that these changes are not necessarily indicative of compromised well-being. Additional research is needed to determine the impact that these experiences are having on the welfare of the animals. This study reinforces the potential for behavioral monitoring to be used as a method for assessing the influence of visitors on zoo animals.

The primary goal of modern zoos is to protect animals from extinction. This is addressed not only through captive breeding programs, research, and in-situ conservation work but also through the education and engagement of the visiting public. In order to combine the needs of animals (optimal well-being) and visitors (primarily, recreation and education), as well as zoo staff, recent decades have seen a shift in the way animals and visitors interact and encounter each other. Today's exhibits are becoming increasingly naturalistic (Fernandez, Tamborski, Pickens, & Timberlake, 2009), aiming to address the psychological and physical needs of the animals, whilst providing visitors with a more realistic experience. Further breaking the barrier to traditional exhibit viewing, zoo visitors are being offered various interactive experiences – including behind-the-scenes tours of off-exhibit zoo facilities, entering animal enclosures, touching animals, and

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having photographs taken with them. Although there is currently a paucity of information about the influence of these interactive animal experiences on visitors, research tends to suggest that the education and conservation value of experiences that allow visitors to do more than simply view an animal's exhibit (such as witnessing keeper talks) is high (Ballantyne & Packer, 2005; Broad & Weiler, 1998; Lindemann-Matthies & Kamer, 2006; Povey & Rios, 2005; Visscher, Snider, & Vander Stoep, 2009). Moreover, the influence on the animals is rarely considered in the literature and, in order to support the continued use of animals in these programs, it is vital to understand how participation might alter their well-being.

Of particular interest is the use of larger, potentially dangerous animals in these encounters: namely, big cats (or large felids, *Felis* ssp.). At present, zoos and wildlife parks world-wide offer various visitor-big cat encounters and the opportunity for people to engage in these appears to be increasing. What makes this particularly controversial is that these animals rarely have direct physical contact with humans in the wild, and many of the recorded interactions (portrayed in both the scientific literature and the media) document injuries and fatalities sustained by humans as a result of 'attacks' from these animals (Packer, Ikanda, Kissui, & Kushnir, 2005). Further, these species are typically solitary, with the exception of lions and, to a lesser extent, some male cheetah (Macdonald, Loveridge, & Nowell, 2010). Therefore, regular contact and interaction with zoo visitors could result in negative repercussions for these animals.

Information surrounding the influence of visitors on zoo-housed animals has focused almost exclusively on visitors at exhibits, as opposed to interactive tours. It is generally agreed that zoo visitors can act as a source of stress for animals (Claxton, 2011; Davey, 2005, 2006, 2007; Fernandez, et al., 2009; Hosey, 2005, 2008; Morgan & Tromborg, 2007), however it has been argued that visitors may also be enriching, particularly due to the variability they provide (Davey, 2007). Of note, the majority of the visitor-impact research has focused on primates and Davey (2007) argues that we cannot generalize this information to other species. In reviewing research on the effects of unfamiliar humans on different taxonomic groups, Hosey (2008) concluded that, compared to primates, felids are much less susceptible (behaviorally) to the presence of zoo visitors.

Only a small handful of studies have investigated the influence of visitors in relation to large felids and the results are conflicting (Claxton, 2011; Hosey, 2008). On the one-hand, O'Donovan, Hindle, Mckeown, and O'Donovan (1993) found no significant changes in the behavior of female cheetahs and their cubs in response to visitor presence. Similarly, Margulis, Hoyos, and Anderson (2003) investigated the behavior of six zoo-housed felid species (including lions, leopards, tigers and snow leopards) in response to visitors and found no variation in activity based on the presence or absence of visitors. The authors concluded that these animals do not appear to respond to visitor disturbance or attempts to engage. In contrast, Mallapur and Chellam (2002) observed that leopards (n = 14) at four zoos in southern India displayed higher levels of activity and lower levels of resting on visitor absence days compared to visitor presence days. Likewise, Sellinger and Ha (2005) found that both visitor density (number of visitors) and intensity (behavior of visitors, ranging from quiet – no loud talking, to extreme – loud talking and/or shouting) influenced the behavior of two jaguars at Woodland Park Zoo, Seattle. However, their findings were somewhat different to Mallapur and Chellam's (2002) since they found that lower visitor density was associated with increased time spent out-of-sight by both animals compared to higher densities, and that the female displayed higher pacing at low visitor intensity (characterized by relatively quiet talking among visitors) compared to higher intensities. Moreover, although non-significant, aggressive behavior in the male showed a trend to increase

with higher visitor densities. Based on only two animals, more research is needed to substantiate these finding. Regardless, this information indicates that the visiting public can influence big cat behavior in various ways.

In addition to this lack of conclusive knowledge regarding the impact that visitors have on big cats at their exhibits, research to date does not appear to have explored the influence of interactive tours. Indeed, very little is known about the visitor effect during close encounters involving any species, with aquarium-housed dolphins participating in 'swim-with-dolphin' programs being the primary focus of such research (Brensing & Linke, 2003; Kyngdon, Minot, & Stafford, 2003; Samuels & Spradlin, 1995; Trone, Kuczaj, & Solangi, 2005). Overall, these studies have concluded that the animals are not being adversely influenced by their participation in such experiences, both in the short- and long-term. Since dolphins are social animals, these findings cannot be generalized to other, less social species like big cats. What these studies do highlight, however, is that behavioral analysis of animals in such programs can be an efficient and effective method for measuring animal welfare, just as it has been for big cats in both enrichment-related and visitor-impact studies (for example, Bashaw, Bloomsmith, Marr, & Maple, 2003; Sellinger & Ha, 2005).

Aims of the Current Study

At present, big cat tours in zoological organizations appear to be taking the form of either protected or hands-on contact. Protected contact refers to situations where people indirectly interact with big cats through some form of barrier, such as mesh fencing, whilst hands-on contact refers to situations where there is no barrier between the two and direct physical interaction is possible. Zoos South Australia (Zoos SA; including Adelaide Zoo and Monarto Zoo) is one Australian organization currently offering big cat encounters to their visitors, including both a protected contact tour of the tiger and lion facilities at a city zoo, and a hands-on cheetah tour at an open-range zoo. It therefore serves as an ideal place in which to explore the impact of such practices on the animals involved.

In this case study, we sought to empirically examine the behavior of three groups of big cats (tigers, lions, and cheetah) during these behind-the-scenes zoo visitor tours, in order to determine whether any behavioral changes were exhibited that may indicate altered welfare. Species-typical behaviors were used as indicators of positive well-being, while stereotypic behavior (pacing) indicated the possibility of stress or compromised well-being. In addition, we were interested in documenting the nature of interactions between these animals and humans (including both keepers and visitors), since little is understood about how big cats respond to people and the behaviors they engage in during interactive tours. As an indirect measure of interaction, we investigated physical proximities of big cats to humans during tours.

Method

Subjects

The subjects involved were three separate groups of adult big cats currently participating in interactive tours: one Sumatran tiger (*Panthera tigris sumatrae*) and three African lions (*Panthera leo leo*) involved in the protected contact tour at Adelaide Zoo, and three African cheetah (*Acinonyx jubatus*) involved in the hands-on tour at Monarto Zoo (see Table 1 for individual details). The tiger and lions have been involved in the protected contact tour for approximately the last four years, whilst the cheetah have been participating in hands-on visitor experiences since they were cubs (eight years).

Table 1
Individual subject details

Species	Names (Gender)	D.O.B	Place of birth	Approximate age of arrival at Zoos SA	Rearing history
Sumatran tiger	Tuan (M)	12.03.1998	Lisbon Zoo, Portugal	8.5yrs	Mother
African lion	Mujambi (M)	26.03.2005	Mogo Zoo, Australia	2yrs	Mother
	Yizi (F) & Amani (F)[a]	06.05.2001	Auckland Zoo, New Zealand	1yr	Mother
African cheetah	Skukuza (M), Tsotsie (M) & Askari (M)[b]	11.09.2004	Monarto Zoo, Australia	N/A	Human

Note: a = lionesses born in same litter; b = cheetah born in same litter

Subject Housing and Feeding Routines

Adelaide Zoo. Although Adelaide Zoo houses one male and two female Sumatran tigers, only the male was observed due to the two females alternating between being housed on-display and off-display for the tours, limiting data consistency. All tigers are housed solitarily and the individual of interest is typically housed in the same on-exhibit enclosure on a daily basis[1]. Overnight, this tiger is given access to an off-exhibit enclosure and is then put on-exhibit in the mornings – the timing of this varies depending on enclosure maintenance, but is usually around 8.15am on tour days and before zoo opening hours (9.30am) on non-tour days. The on-exhibit enclosure is approximately 225m^2 and contains a moat, a pool, and various naturalistic plants and substrate. There are a number of shaded and retreat locations, as well as logs and rocks for elevation.

The lion facility at Adelaide Zoo is comprised of four adjacent enclosures (three are ~35 m^2 each in size and the other ~170 m^2). Fences connecting the enclosures can be opened to provide the animals with access to more than one enclosure at a time; usually, the fences between the three smaller enclosures remain open (totalling ~100 m^2). Each of these enclosures contain mostly dirt-based flooring, with various trees and/or small plants in each, and raised platforms or rocks for elevation. The larger exhibit also contains a raised, grassy mound and a large tree for climbing. Since the male lion experiences a medical condition, which has made him prone to seizures in the past and therefore vulnerable around other animals, he is housed separately from the two females. The animals are maintained in the on-exhibit enclosures throughout the day and night. During exhibit maintenance on non-tour day morning's (usually between 9.00am-9.30am), they are switched between the smaller and larger enclosures (usually giving them two days in each exhibit at a time). This typically requires the male lion to be kept in a lock-away area whilst the females are shifted, which results in him being off-exhibit during these times.

In order to replicate natural feeding in the wild, these animals are not fed every day. The tiger and lions are typically fed on Tuesdays, Thursdays, Saturdays, Sundays and public holidays. Whilst the proportion of food provided to each animal varies according to their individual weights, horse meat forms a major part of their diet. They are also fed chicken quite regularly, with kangaroo, rabbit, turkey and goat provided when available. Meat is usually given as partial carcasses, with Big Cat supplement added. These animals are usually fed in their on-exhibit enclosures, at around 2.30pm for the tiger and 2.00pm for the lions. During the tours, these animals are also fed a small portion of meat (e.g., a turkey neck), as part of the experience involves visitors' having the opportunity to feed an animal.

Monarto Zoo. This zoo currently houses two groups of male display cheetahs (as well as breeding females off-exhibit), however only one of these is involved in visitor tours. The on-exhibit facilities are comprised of three adjacent exhibits. The main exhibit (which has a visitor viewing platform attached) is where the three subjects are housed each day, as well as most nights of the week. This exhibit is approximately 4500 m^2 and contains various naturalistic plants and substrate, providing various shaded locations for the animals. It also includes a small 'hut' filled with hay, a low platform, a large tree log and raised platform for climbing, as well as a small drinking pond. Several nights per week, the animals are housed in one of the other on-exhibit enclosures, which contains similar features as

[1]Occasionally, one of the two female tigers is given access to this enclosure and the male is either housed off-exhibit or in another on-exhibit enclosure.

their regular exhibit, but is roughly seven times larger. When this occurs, the three cheetah are then shifted to their regular exhibit in the morning, usually before zoo opening hours (9.30am). Due to these animals being hand-raised, they have regular physical contact with their keepers, who enter the enclosure for routine maintenance on a daily basis. Usually this occurs before 10.00am on both tour and non-tour days.

A naturalistic feeding pattern is also adopted at this zoo, whereby the cheetah are usually only fed five days per week (with Monday and Thursday being non-feed days). Their diet includes portions of beef, horse, kangaroo and rabbit. Typically, each individual is fed 1.5-2.0 kg of meat each (including bone), but occasionally they will be given a 7.0-8.0 kg kangaroo carcass to consume together. Keepers like to avoid a set feeding time for these animals and, whilst they are often fed at around 3.00pm during a keeper talk, this can occur at any time of day. When tours are conducted on feeding days, these animals are usually given their daily feed during the tour.

Tour Details

Protected contact tour at Adelaide Zoo. This tour is conducted up to three mornings (Tuesday, Thursday and Sunday) per week. It starts prior to the zoo opening and runs for approximately one hour (8.45am-9.45am), during which up to six visitors (minimum age 12 years) are toured first through the tiger on- and off-exhibit facilities, and then through the lion on- and off-exhibit facilities. When visiting the tiger facilities, visitors view the animals from outside of the enclosures. Visitors view the tiger of interest housed in his regular on-exhibit enclosure, where he is also located before and after the tour. When visiting the lion facilities, one of the smaller lion exhibits is vacated of animals and visitors enter this enclosure, so that they can view the male lion on one side and the female lions on the other in their regular on-exhibit enclosures, where they are also housed before and after the tour. The tour group generally remains with each individual tiger for 15 min, and with the lions combined for another 15 min. Visitors are introduced to each of the individual animals, learn about their life at Adelaide Zoo, have a chance to feed them through mesh fencing, and take photographs of them.

To maintain visitor safety, visitors are asked by the keeper to remain approximately 1 m away from the exhibit fencing at all times. The only exception to this is when feeding an animal, during which time the keeper approaches the fence with the visitor and the visitor places a piece of meat through the exhibit fencing. Visitors are instructed not to place their hand through the fencing, to let go of the food once the animal has taken it, and to step back once they have done this. One keeper and one zoo volunteer are always present throughout the tour.

Hands-on tour at Monarto Zoo. This tour is conducted up to three mornings (Monday, Thursday and Saturday) per week, for approximately one hour (10.00am-11.00am). During this encounter, up to four visitors (minimum age 16 years) are taken into the cheetah exhibit with the animals present (with no protective barrier between them), where they meet the individual cheetahs, learn about their hand-rearing situation, and witness some positive-reinforcement training and animal feeding (on feeding days only). They are also able to pat the animals and have photographs taken with them. The cheetah remain in this exhibit before and after the tour.

Being a hands-on tour, a number of measures have been established to maintain visitor safety and these are explained to visitors before they enter the cheetah enclosure. They are instructed to remain standing at all times, and not to crouch down to the animal's level. They are also instructed not to approach the animals unless asked to do so by a keeper, and are told to remain still and to refrain from touching a cheetah if one approaches them. When a keeper does allow visitors to pat the animals, they are instructed not to touch the cheetahs' faces, nor to look the animals directly in the eyes. To promote safe interactions, the cheetah are positively reinforced (with a combination of verbal praise, patting, and various food pastes) when they are in close proximity to visitors. Moreover, two keepers are always present on this tour: one to conduct the tour and the other to monitor activities of the animals and visitors (e.g., to ensure that visitors are not leaving the tour group). As a precautionary measure, keepers also carry spray bottles filled with water, which may be used to deter any potentially dangerous animal behavior (anecdotal accounts from keepers indicate that this has never needed to be used during a visitor tour).

Behavior Observations

Behavior was coded according to an ethogram containing categories of felid behavior; definitions were adapted from past felid research (Skibiel, Trevino, & Knaugher, 2007; Umapathy et al., 2007; Van Metter, Harringer, & Bolen, 2008; Wielebnowski & Brown, 1998). These definitions were further refined based on behavior observed during preliminary observations, prior to formal data collection commencing (these observations were not included in the analysis). Individual behaviors were then condensed into behavior categories (Table 2). Estimated proximity between animals and people (keepers and zoo visitors), was recorded by visual inspection and divided into three categories: close (< 2 m), moderate (2-5 m), and distant (> 5 m). Any other occurrences and possible extraneous

variables, such as the presence of neighboring conspecifics, or keepers at exhibits (outside of tour times), were also noted informally on the data record sheets.

Table 2
Behavior categories with details of included behavior

Category	Included behaviors
Inactive	Sit, stand, or lay whilst not engaged in any other behavior (animal may be vigilant or not vigilant during any of these behaviors)
Active species-typical	Walk, climb, manipulate object, scratch ground/grass, crouch, sniff self, scratch self, groom self, vocalize, or any olfactory behavior (e.g., spray, flehmen)
Feeding	Any consumption behavior (e.g., eating, dragging food)
Conspecific interaction	Any direct affiliative interactive behavior with a conspecific, including head rub, sniff, paw at, play, 'present' or other sexual behaviors, groom (behaviors may be either direct or through fence, and may or may not include affiliative vocalizations)
Human interaction	Any direct affiliative interactive behavior with a human (keeper and/or visitor), including taking meat from (including other behaviors, such as stretching up to take food, or vocalizing), being patted (whilst engaged in any other behavior, such as sit, stand or eat; may include being rewarded), engage in training (such as sit on command), or routine health checks (such as being weighed on scales)
Pacing	Repetitive walk or trot around enclosure without an apparent goal (displaying at least two repetitions of the same pattern of movement; may or may not include vocalization)
Aggression	Banging on enclosure doors/fencing, striking at another animal (may or may not include aggressive vocalizations, such as growling or hissing)
Out-of-sight	Any instance where the animal/its behavior is not visible to observer
Other	Any behavior not listed above (e.g., defecate, urinate, drink, regurgitate, or engage with specific enrichment device)

Procedure

The study used an observational design, with data (animal behavior and proximity) being collected at 30-s intervals according to instantaneous scan sampling methods (Martin & Bateson, 2007). All observations occurred when animals were in their on-exhibit enclosures. Observations were usually collected for one hour before each tour (with the exception that only half an hour of pre-tour data was collected for the tiger, due to husbandry needs and the tour commencing close to the start of the work day), the duration of the tour (approximately 15 min for the tiger, 15 min for the lions, and one hour for the cheetahs), and the hour after the tour. As such, observations typically spanned from 8.15am – 10am for the tiger, 8.30am – 10.45am for the lions, and 9:00am – 12:00pm for the cheetah. Behavior was then observed for the same time periods on non-tour days (Mondays, Wednesdays and Fridays for the tiger and lions; Tuesdays, Wednesdays and Fridays for the cheetah). The data collection period spanned from October to December 2011; typically, one tour and one non-tour day were observed per animal group per week over this three month period[2]. This allowed for 12 tour and 12 non-tour days of data for each individual animal, with the exception that only 10 tour days were collected for the tiger due to not enough tours being conducted during the study period and changes to the on-exhibit management of this animal toward the end of the study.

One researcher (M.S.) conducted all behavior observations. To test the reliability of the ethogram and proximity estimates, an inter-rater assessment was conducted by a second, independent observer. Mean agreement between M.S. and this observer was 95% for behavior and 91% for proximity, achieved in one hour of simultaneous data collection for each species.

Analysis

To determine proportions of behaviors performed by each animal, counts were totalled for each individual animal across each condition (pre-, during and post-tour sessions on tour days, as well as equivalent pre-, during and post-tour time blocks on non-tour days). A mean value for the percentage of scans that each individual animal spent engaged in each behavior category was then generated. Where an individual was off-exhibit for any part of an

[2]Although this was the aim, it was not always possible to conduct one tour and one non-tour day each week for each group, due to factors such as heavy rain and tours not being on due to no visitor bookings.

observation period, these scans were excluded from the total number of scans for that period, such that behaviors were only calculated as proportions of on-exhibit scans.

Since two types of tours were observed in this study, analyses were conducted separately for animals in the protected contact tour and those in the hands-on tour. Data for each tour were analysed by combining the daily proportions of behaviors for each animal in that tour. Due to the data not meeting the assumptions for parametric analyses (particularly that the data were not normally distributed), non-parametric analyses were employed. Friedman's ANOVA was used to test for behavioral differences across the three tour day conditions (pre, during and post) for each tour type; where the tests were significant, post hoc tests were conducted using Wilcoxon signed-rank comparisons. These tests were also used to test for differences in proportions of scans spent in close, moderate and distant proximity to both keepers and visitors for both tour groups. All analyses were considered significant at the $p < 0.05$ level. These analyses included a total of 46 days of data for the protected contact tour and 36 days for the hands-on tour.

Wilcoxon signed-rank comparisons were also used to test for behavioral differences between the tour and non-tour day conditions (pre, during and post) for each tour type ($p < 0.05$ level of significance). When comparing tour days to non-tour days for the protected contact tour, data from the tiger were not included since this animal was often off-exhibit (due to husbandry and enclosure maintenance) until later in the morning on most non-tour days and it was thought that this might influence the behaviors displayed by this animal in the different time blocks. As such, these comparisons only included lion data, involving 36 tour days and 36 non-tour days. For the cheetah, these comparisons similarly included 36 tour days and 36 non-tour days. All statistical analyses were conducted in SPSS version 20.

Results

Analyses (behavioral differences between the three tour day sessions, between tour day and non-tour day sessions, and proximity to humans) are described separately for both tour groups herein. Observations of behavior categories that were considered very low (less than 5% of scans for all conditions in a given comparison) have not been included in the analyses.

Protected Contact Tour

Changes in behavior on tour days. Differences were seen in inactive, $\chi^2(2) = 50.91$, $p < 0.001$, feeding, $\chi^2(2) = 58.63$, $p < 0.001$, and pacing behavior, $\chi^2(2) = 32.59$, $p < 0.001$, across the three tour day conditions for the protected contact group (Figure 1). Inactive behavior was lower during tours compared to both pre-tour, $T = 29$, $p < 0.001$, $r = -0.58$, and post-tour, $T = 23$, $p < 0.001$, $r = -0.59$, as well as higher post-tour compared to pre-tour, $T = 329$, $p < 0.05$, $r = -0.34$. Feeding was higher during tours compared to both pre-tour, $T = 0$, $p < 0.001$, $r = -0.55$, and post-tour, $T = 50.50$, $p < 0.001$, $r = -0.51$, and higher post-tour compared to pre-tour, $T = 6$, $p < 0.001$, $r = -0.39$. Pacing was higher during tour compared to both pre-tour, $T = 119.50$, $p < 0.001$, $r = -0.43$, and post-tour, $T = 56.50$, $p < 0.001$, $r = -0.52$, and higher pre-tour compared to post-tour, $T = 29$, $p < 0.02$, $r = -0.31$. There was no difference in proportions of active species-typical behavior across the three conditions ($p = 0.523$).

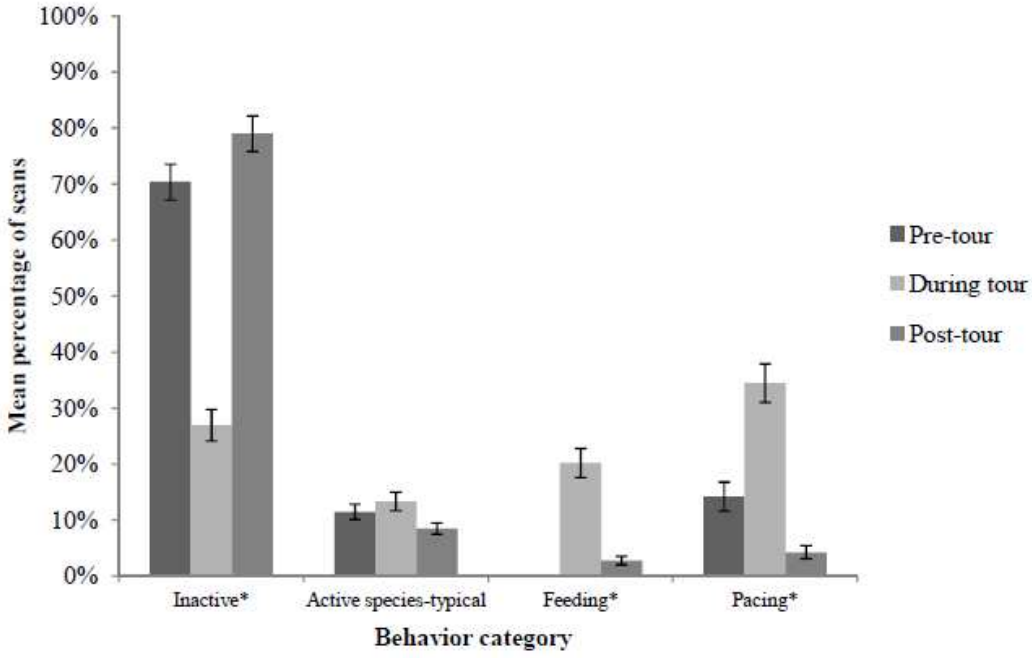

Figure 1. The proportion of scans observed as inactive, active species-typical, feeding and pacing across the three tour day conditions for the protected contact tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a behavior category.

Tour day versus non-tour day behavior. Comparisons of lion behavior during the pre-, during and post-tour time blocks on tour and non-tour days can be seen in Figure 2. Comparisons of the pre-tour block revealed that the only difference in behavior was that pacing was higher on tour days compared to non-tour days, $T = 84$, $p < 0.05$, $r = -0.38$ (inactive, $p = 0.25$; active species-typical, $p = 0.05$). Comparisons of the during-tour block revealed lower proportions of inactive behavior, $T = 6$, $p < 0.001$, $r = -0.61$, on tour days compared to non-tour days, but higher feeding, $T = 0$, $p < 0.05$, $r = -0.53$, and pacing, $T = 37$, $p < 0.05$, $r = -0.53$, on tour days compared to non-tour days. Proportions of active species-typical behavior in the during tour time block did not differ between the two days ($p = 0.13$). Comparisons between the post-tour block on tour and non-tour days revealed no differences in proportions of behavior (inactive, $p = 0.46$, active species-typical, $p = 0.77$, and pacing, $p = 0.09$).

Interactive behavior and proximity to humans. A minimal proportion of scans were spent interacting with humans for any of the animals during the protected contact tour (M = 0.98%; SE = 0.27%). A minimal amount of aggressive behavior was observed (M = 1.94%; SE = 0.66%) and none of this was directed at the tour group. As an indirect measure of interaction, proximities to humans were also recorded and can be seen in Figure 3. Animals in the protected contact tour varied in their observed proximities to keeper/s, $\chi^2(2) = 26.18$, $p < 0.001$, spending more scans in distant compared to both close, $T = 132$, $p < 0.001$, $r = -0.47$, and moderate, $T = 128$, $p < 0.001$, $r = -0.47$, proximity. A similar pattern was observed for proximity to visitor/s, with this varying in distance, $\chi^2(2) = 20.34$, $p < 0.001$, and the animals spending more scans in distant compared to both close, $T = 148$, $p < 0.001$, $r = -0.43$, and moderate, $T = 215.50$, $p < 0.001$, $r = -0.37$, proximity.

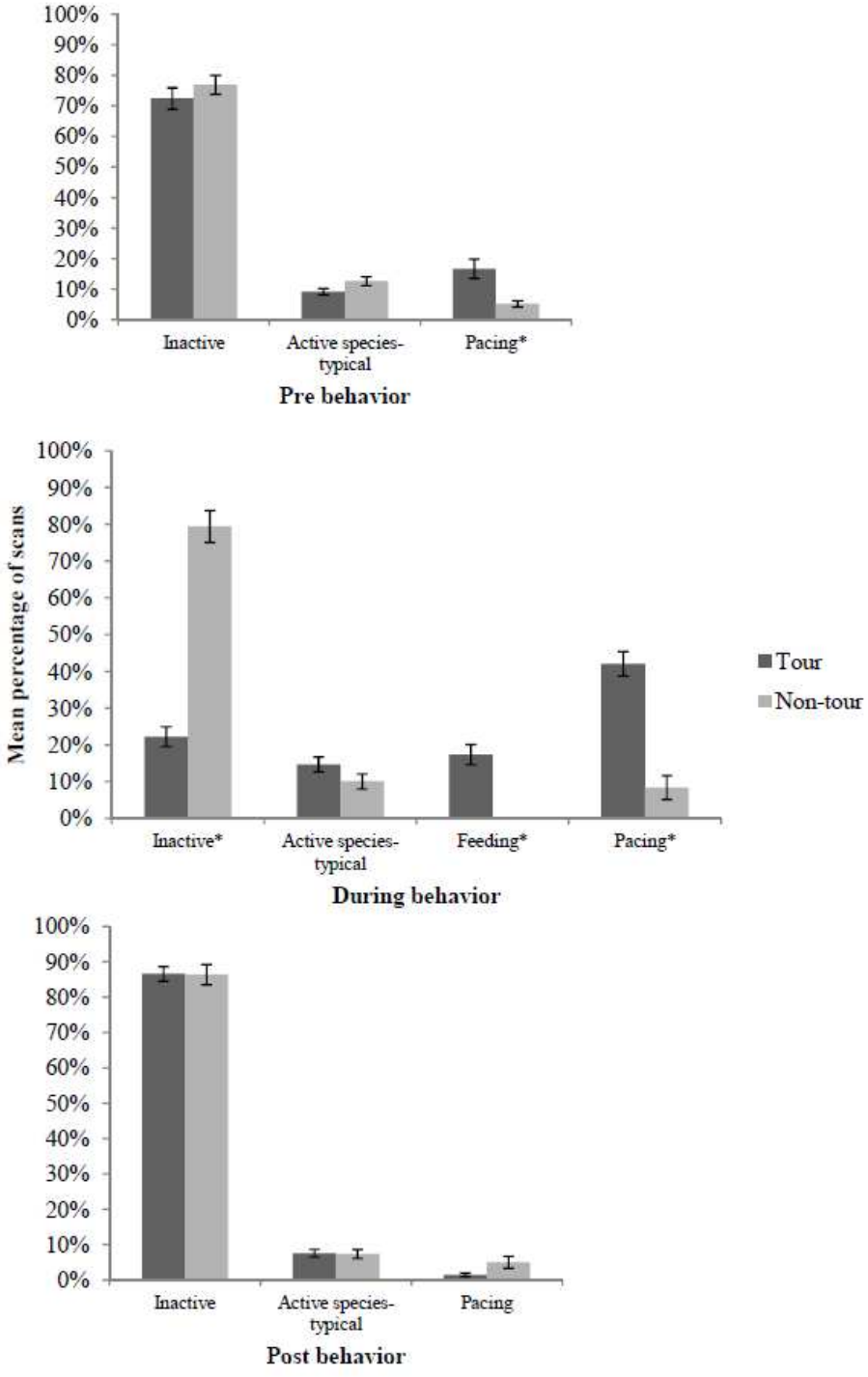

Figure 2. Comparisons of observed behavior during the three time periods (pre, during and post) on tour and non-tour days for the protected contact tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a behavior category.

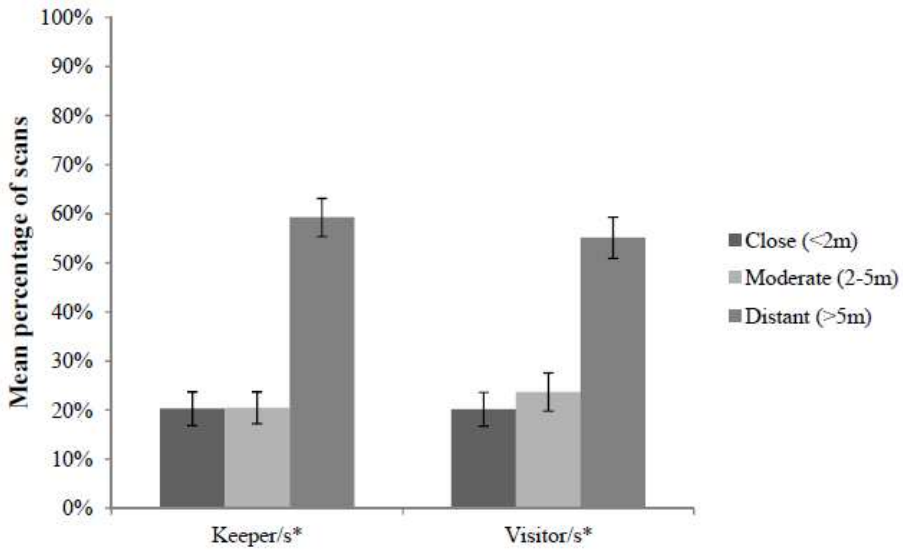

Figure 3. Estimated proximities to keeper/s and visitor/s during the protected contact tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a comparison.

Hands-on Tour

Changes in behavior on tour days. Differences were seen in inactive, $\chi^2(2) = 30.17$, $p < 0.001$, active species-typical, $\chi^2(2) = 15.17$, $p < 0.001$, feeding, $\chi^2(2) = 49.15$, $p < 0.001$, human interaction, $\chi^2(2) = 68.97$, $p < 0.001$, pacing, $\chi^2(2) = 60.07$, $p < 0.001$, and out-of-sight, $\chi^2(2) = 9.21$, $p < 0.05$, behavior across the three tour day conditions for the animals in the hands-on tour (Figure 4). Inactive behavior was higher post-tour compared to both pre-tour, $T = 58$, $p < 0.001$, $r = -0.51$, and during tour, $T = 115$, $p < 0.001$, $r = -0.40$. Active species-typical was higher pre-tour compared to post-tour, $T = 98$, $p < 0.001$, $r = -0.43$, and higher during tour compared to post-tour, $T = 121$, $p < 0.001$, $r = -0.39$. Feeding was higher during tours compared to both pre-tour, $T = 0$, $p < 0.001$, $r = -0.57$, and post-tour, $T = 60$, $p < 0.001$, $r = -0.43$, as well as higher post-tour compared to pre-tour, $T = 0$, $p < 0.05$, $r = -0.37$. Human interaction was higher during tours compared to both pre-tour, $T = 0$, $p < 0.001$, $r = -0.62$, and post-tour, $T = 0$, $p < 0.001$, $r = -0.62$. Pacing was higher pre-tour compared to both during tour, $T = 0$, $p < 0.001$, $r = -0.62$, and post-tour, $T = 4$, $p < 0.001$, $r = -0.61$, and higher post-tour compared to during tour, $T = 2$, $p < 0.001$, $r = -0.40$. Finally, the proportion of scans observed as out-of-sight for animals on this tour was higher during tour compared to pre-tour, $T = 156.50$, $p < 0.02$, $r = -0.31$.

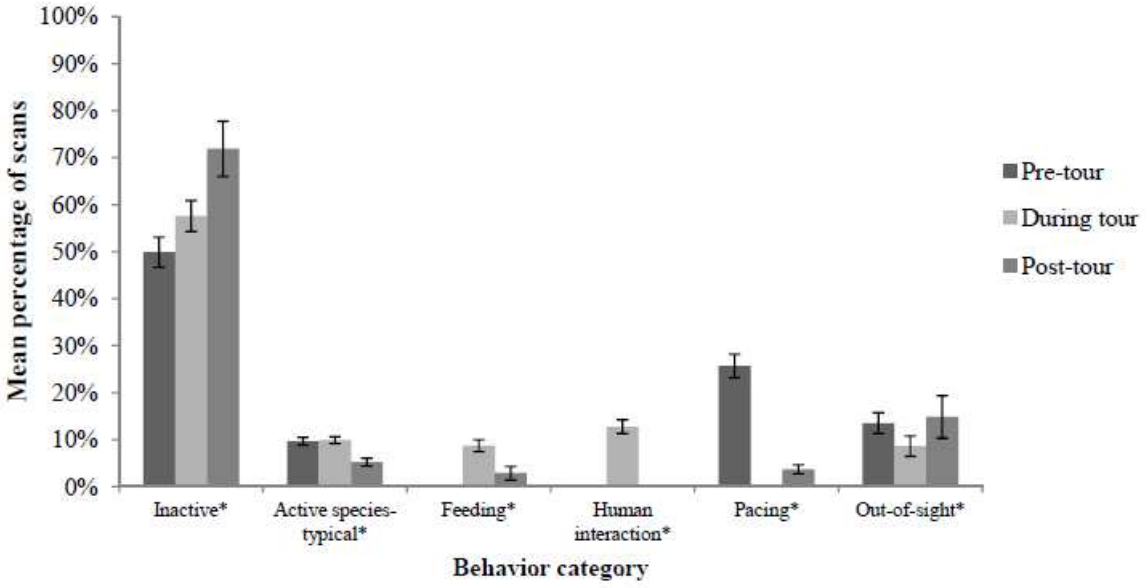

Figure 4. The proportion of scans observed as inactive, active species-typical, feeding, human interaction, pacing and out-of-sight across the three tour day conditions for the hands-on tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a behavior category.

Tour day versus non-tour day behavior. Comparisons of cheetah behavior in the pre-, during and post-tour time blocks on tour and non-tour days can be seen in Figure 5. Comparisons of the pre-tour block revealed that there was more inactive behavior on tour days compared to non-tour days, $T = 194$, $p < 0.05$, $r = -0.26$, and more feeding on non-tour days compared to tour days, $T = 0$, $p < 0.001$, $r = -0.44$. There were no other behavioral differences in this time block (active species-typical, $p = 0.46$; pacing, $p = 0.94$; out-of-sight, $p = 0.31$). A number of behavioral differences were observed in the during tour time block between tour and non-tour days. Inactive, $T = 112$, $p < 0.001$, $r = -0.41$, and pacing, $T = 9$, $p < 0.05$, $r = -0.36$, were lower on tour days compared to non-tour days, whilst active species-typical, $T = 71$, $p < 0.001$, $r = -0.48$, feeding, $T = 0$, $p < 0.001$, $r = -0.57$, and human interaction, $T = 0$, $p < 0.001$, $r = -0.62$, were all higher on tour days compared to non-tour days. There was no difference in scans spent out-of-sight during this time block on tour and non-tour days ($p = 0.05$). Comparisons of behavior in the post-tour block indicate that inactive behavior was lower on tour days compared to non-tour days, $T = 176.50$, $p < 0.001$, $r = -0.29$, whilst active species-typical, $T = 73$, $p < 0.001$, $r = -0.45$, and out-of-sight, $T = 113$, $p < 0.05$, $r = -0.27$, were higher on tour days compared to non-tour days.

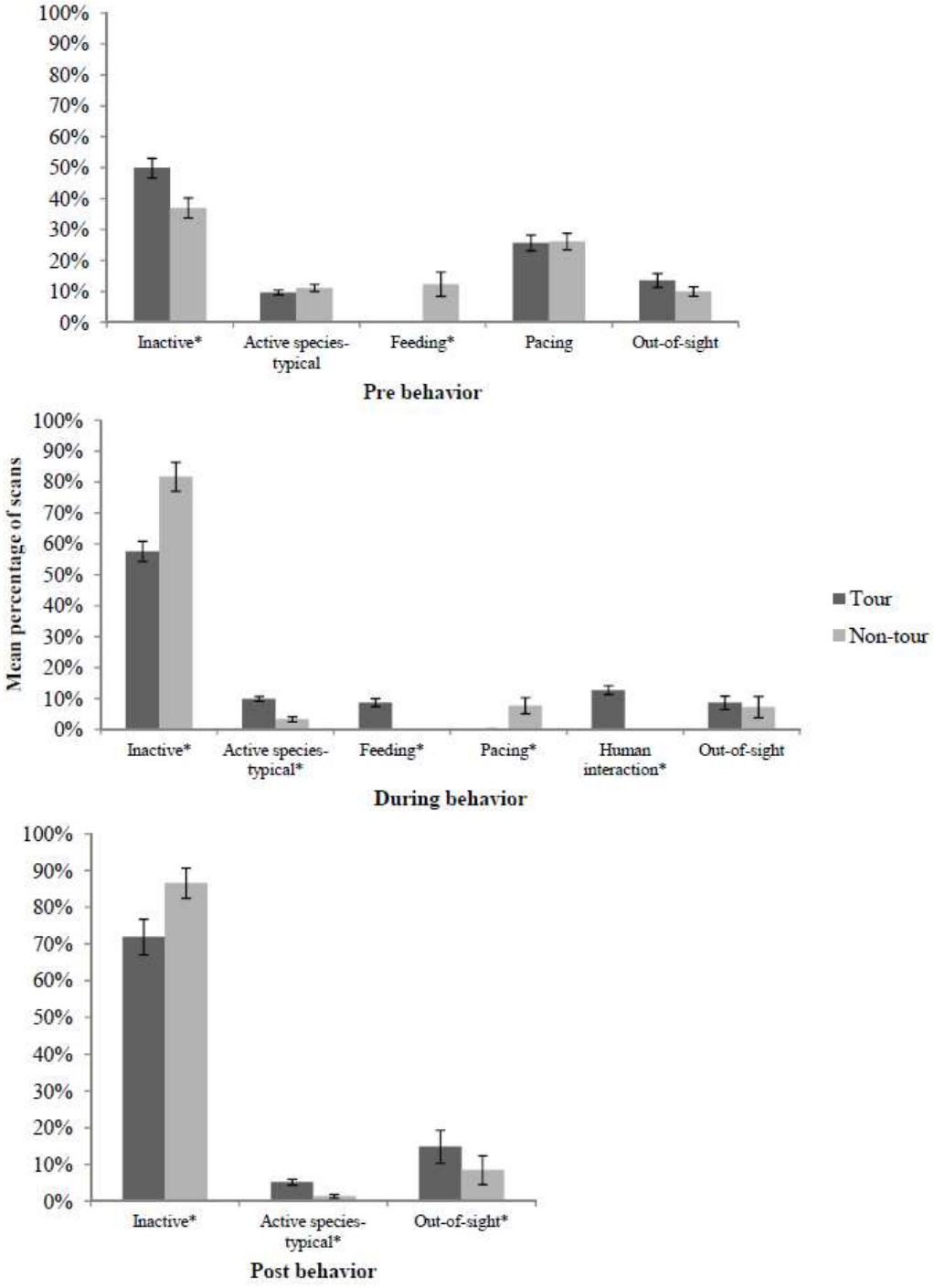

Figure 5. Comparisons of observed behavior during the three time periods (pre, during and post) on tour and non-tour days for the hands-on tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a behavior category.

Interactive behavior and proximities to humans. The prior analyses revealed that the animals in the hands-on tour spent a noticeable proportion of scans interacting with humans during the tours. All of these direct interactions were affiliative in nature and no aggressive behaviors towards humans were observed in this study. Analyses of proximity data (Figure 6) revealed that the animals on this tour varied in their observed proximities to keeper/s, $\chi^2(2) = 51.72$, $p < 0.001$, spending more scans in distant compared to both close, $T = 110$, $p < 0.001$, $r = -0.41$, and moderate proximity, $T = 0$, $p < 0.001$, $r = -0.62$, as well as more scans in close compared to moderate proximity, $T = 7$, $p < 0.001$, $r = -0.60$. A similar pattern was observed for proximity to visitor/s, with this varying in distance, $\chi^2(2) = 38.32$, $p < 0.001$, and the animals spending more scans in distant compared to both close, $T = 148$, $p < 0.001$, $r = -0.49$, and moderate proximity, $T = 215.50$, $p < 0.001$, $r = -0.42$.

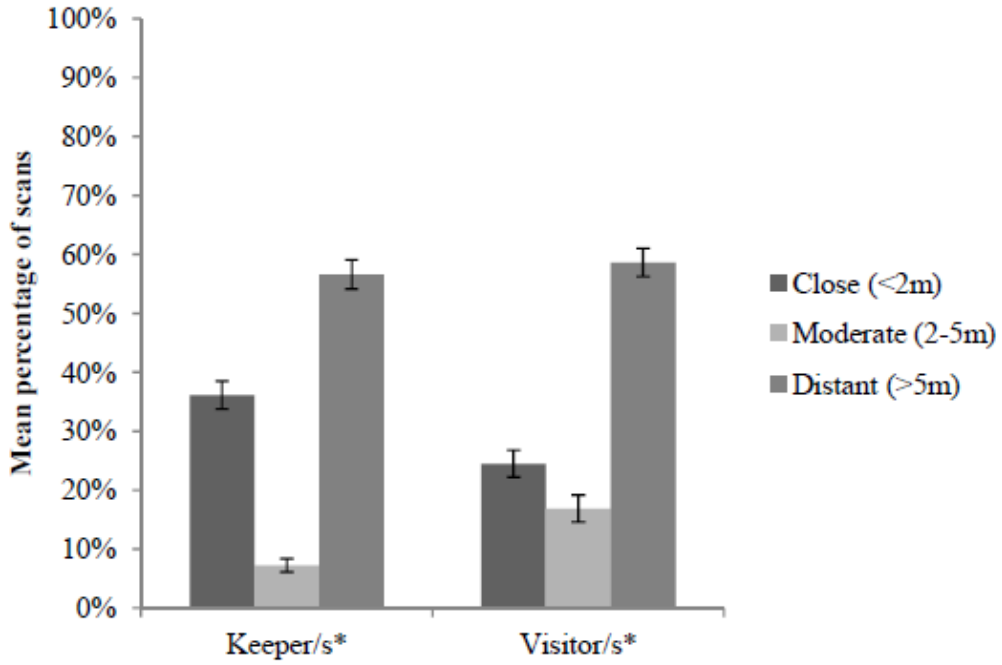

Figure 6. Estimated proximities to keeper/s and visitor/s during the hands-on tour. Bars indicate ±2SE and asterisks indicate that a statistically significant difference was found for a comparison.

Discussion

To date, little research has been conducted to understand how big cats might respond to interactive zoo visitor tours. The present study sought to investigate whether short-term behavior differs in tigers and lions involved in a protected contact tour, and in cheetah in a hands-on tour, as well as how the behavior of both of these groups differs on tour days compared to non-tour days. Differences in behavioral profiles primarily involved observations of inactive, active, pacing and feeding behavior for both groups, with the addition of human interaction and out-of-sight for the hands-on group. This study was also interested in determining the nature of interactive behaviors performed by these animals in relation to humans during the tours, with

estimated proximity to keepers and visitors additionally used as an indirect measure of interaction.

Changes in Behavior with the Protected Contact Tour

When combined, inactive and active species-typical behaviors accounted for a large proportion of behavior in any of the conditions examined for the tiger and lions in the protected contact tour. Given that these categories comprised of natural felid behaviors, this could be indicative of positive well-being. In particular, the high proportion of inactive behavior is consistent with research of these same species in other zoos (for example, see Jenny & Schmid, 2002; Margulis et al., 2003; Quirke & O'Riordan, 2011), as well as with their natural activity patterns (Guggisberg, 1975). However, some changes were observed in the proportions of behavior of these animals across conditions, particularly regarding inactivity, feeding and pacing. On tour days, there was a decrease in inactivity and an increase in feeding during the tour compared to before and after. When compared to the equivalent time periods on non-tour days, proportions of inactivity only differed during the tour block (being lower on tour days compared to non-tour days), indicating that participating in tours may decrease the amount of inactive behavior engaged in by these animals. This can largely be accounted for by feeding and pacing behaviors being significantly higher on tour days compared to non-tour days during the tour time block. However, since the animals were not usually fed on non-tour days, it is not possible to conclude whether participating in tours influences the performance of this behavior, nor how feeding might have altered other behaviors. Inactive behavior increased again after the tours, and feeding and pacing reduced. Moreover, there were no differences in inactive, active and pacing behavior in the post-tour condition on tour and non-tour days, indicating that their involvement in the tours may not be impacting their behavior pattern at these times.

The changes in pacing behavior among these animals are of some concern. Pacing is a common form of stereotypic behavior in big cats (Mason, Clubb, Latham, & Vickery, 2007) and, depending on circumstances, its presence can be suggestive of compromised animal well-being (Carlstead, 1998). In this study, pacing levels were highest during the tour compared to before and after, as well as higher before than after. Moreover, this behavior was higher in both the pre- and during tour time blocks on tour days compared to these time blocks on non-tour days, indicating that the tours appear to be influencing this behavior. We propose some reasons for this. For the lions, we suggest that this behavior may be associated with them being fed during the tours, when food was present. This behavior has been observed prior to other feeding times at this zoo (*personal observation – M.S.*), as well as in lions at Monarto Zoo who are also fed on behind-the-scenes tours (these lions were originally included in this study, but data collection was ceased due changes in group composition both on- and off-exhibit). Indeed, research indicates that animals may pace in association with feeding and Carlstead (1998) explains that temporally predictable feeding schedules have been linked to stereotypy in some carnivores. Bassett and Buchanan-Smith (2007) also argue that food anticipatory activity – characterized by increased arousal and activity – is typically seen in animals which are fed on a regular schedule. Since these animals are regularly fed (albeit a small amount of food) during the tours, this pacing could be a form of food anticipatory activity. That these animals paced less in the pre- and during tour blocks on non-tour days compared to tour days, and minimally in the post-tour block on both days, adds some support to this argument, since feeding only occurred during the tour condition. Before drawing a concrete conclusion about the causes of their pacing, it would be important to

observe their behavior on tours without feeding, as well as their feeding behaviors at other times of day.

Efforts to minimise this behavior could include altering the order in which these tours are conducted, to reduce the predictability associated with feeding at this time (for a more detailed discussion of the negative effects of predictable feeding, see Bassett & Buchanan-Smith, 2007). Another alternative could be to introduce a reliable feeding signal (such as a buzzer) to indicate to the animals when they will be fed (Bassett & Buchanan-Smith, 2007). The rationale behind this is that by knowing exactly when they will be fed, the lions could wait for this cue rather than rely on other cues (in this instance, the visual, auditory and olfactory cues that a tour group is present, which precede feeding). Since pacing levels were high during the tour (42% of scans for lions alone), and that this behavior has the potential to negatively impact the visitor experience (Miller, 2012), the importance of addressing it extends beyond individual animal well-being.

For the tiger, we believe that the pacing observed in all three tour day conditions was more related to the uncontrolled stimulatory access of neighboring conspecifics, since this individual's pacing predominantly occurred along the perimeters of his enclosures which are shared with female tigers. Although the tiger's behavior was not included in the comparison of tour and non-tour days in this study, pacing in the same locations was observed in this individual throughout the day in an earlier, unpublished study by the primary author. In addition, although he would sometimes engage in a few bouts of pacing along the fence where tours were conducted as the tour group was arriving, he would usually then lay by the fence (often chuffing) until he was fed. Pacing in response to conspecifics has been witnessed in tigers by other researchers and the use of visual barriers to block the view of neighboring conspecifics might reduce this behavior (Bashaw, Kelling, Bloomsmith, & Maple, 2007; Miller, Bettinger, & Mellen, 2008). Indeed, a visual barrier has now been put in place at this exhibit since this study was conducted, but research has not yet explored how influential this has been in reducing pacing behavior.

Interactive behavior and proximity to humans during the protected contact tour. The animals in the protected contact tour were observed to spend negligible proportions of scans interacting with humans during the tours (< 1% of scans). By definition, these interactions were affiliative in nature, occurring when the animals were fed by keepers or visitors through fencing. Similarly, very little (< 2% of scans) aggression was observed during the tour and is primarily accounted for by the lions banging on the doors at the back of their enclosures (with or without vocalization) when the tour group was arriving (a few scans also involved the female lions growling at each other over food). This behavior was also observed at other times when keepers walked through these areas alone. As with pacing, formal documentation of this behavior at other times of day would be needed to determine whether this is a response to the presence of the tour group, or an anticipatory behavior related to keepers being in the area and the possibility of feeding. Other than this, no direct aggressive behaviors were observed. Being a protected contact tour, there is obviously limited opportunity for direct physical interactions, either positive or negative, to take place. As such, proximity data was also used as an indirect interactive measure. These animals spent the majority of tour scans in distant proximity (> 5 m) from the tour group. When the animals were in close proximity, this was usually until and/or during feeding time. For example, the tiger would often lay right by the fencing until he was fed, after which time he would move away and consume his food. Obviously, this data cannot be used to draw conclusions about whether or not the animals preferred to be close to people, but it appears that they only remained close for the purpose of obtaining food. Conducting tours without feeding would again be useful in determining how this might influence proximity to keepers and visitors.

Changes in Behavior with the Hands-on Tour

Similarly to the protected contact tour, high levels of inactivity were observed in all conditions by the cheetah in the hands-on tour. Again, this is consistent with the natural activity pattern of this species (Guggisberg, 1975) and could be indicative of positive well-being. A number of changes in proportions of behaviors were witnessed, both on tour days and when comparing tour days to non-tour days, but these were largely shifts in types of natural behaviors; for example, increased activity and decreased inactivity. Again, similar to the protected contact group, there was an increase in feeding during the tour session, and this was higher in the during tour time block on tour days compared to non-tour days, since the animals are often fed during the tour. However, there was more feeding behavior during the pre-tour time block on non-tour days compared to tour days, as the animals were sometimes fed at this time on non-tour days. These differences in feeding routines make conclusions about behavior change associated with the tours quite difficult. Animals in this group also spent approximately 10% of scans out-of-sight during each condition and this means that some values for the other behaviors are probably underreported (e.g., when animals were out-of-sight for longer periods of time, it is thought that they were probably laying down in shaded locations).

These animals displayed varying levels of pacing behavior across conditions (< 26% of scans in any condition), which again are worthy of discussion. Like this behavior in the tiger, we propose that this is related to the presence of neighboring cheetah, since pacing always occurred along the boundary of their exhibit shared with conspecifics, either when the other cheetah were being shifted in or out of the adjacent enclosure, or when keepers were performing routine maintenance prior to the other cheetah being given access to the exhibit. These activities usually occurred in the mornings, roughly half an hour before the visitor tours started, which is consistent with the finding of higher pacing in the pre-tour condition compared to tour condition on tour days, as well as the lack of difference in the proportion of pacing in the pre-tour time block on tour and non-tour days. Moreover, these animals displayed no pacing during the tours, and significantly more during this time block on non-tour days compared to tour days. Being territorial animals, this may be an expression of their natural patrolling behavior. Visual barriers may again be useful here but, given the size of the enclosures at this zoo (being open-range), this is probably not feasible.

Interactive behavior and proximity to humans during the hands-on tour. Animals in this tour demonstrated a noticeable (> 10%) portion of scans engaged in human interaction behavior during the tours, which was highest during this time block compared to pre- and post-tour. These behaviors typically involved the animals sitting with, and being patted by, keepers and visitors, as well as engaging in training with keepers. Given the nature of this tour – being hands-on – there are opportunities for direct interactions, and so we would expect this to account for some of the activity budget of these animals. No aggressive or otherwise antagonistic behaviors were displayed by the cheetah toward humans during the tour (nor during any other condition), indicating no obvious threats of danger, despite the physical contact involved. In addition to these direct interactive behaviors, the proximity data can also contribute to our understanding of indirect interactions. Despite the proportion of scans spent engaged in direct interactions, these animals were in close proximity (< 2 m) to keepers for approximately 35% of scans, and to visitors for 25%. As such, they remained close for notable proportions of tour scans, despite not interacting physically the whole time. However, they also spent over 50% of scans in

distant proximity to humans (keepers or visitors) indicating that, despite being in a situation where direct physical interaction was possible, the animals showed a preference for being away from the tour group.

Positive Aspects of the Zoos SA Interactive Tours

Although these findings do suggest that interactive tours can alter the types and proportions of big cat behavior, both groups in this study often engaged in large amounts of species-typical behaviors, which is a positive finding. While some pacing was observed, this may not be the result of the tours being a stressful experience. As such is important to discuss some of the potentially positive factors of the tours. Firstly, predictability has been said to be an important factor in the captive environment, depending on the circumstance (Morgan & Tromborg, 2007). Both groups of animals have been participating in these tours for a number of years and the nature of the tours have remained relatively consistent, resulting in a high degree of predictability. Although different visitors participate in the tours, the predictability that tours do not pose threats to the animals may be important here.

Another factor is that none of the animals are forced to interact with visitors or to engage in specific behaviors, but are positively reinforced for their participation. This reinforcement can be direct (such as cheetahs receiving verbal praise for sitting on command whist visitors pat them), or simply feeding all animals at the end of a tour. Positive reinforcement training has been well-argued as the most successful and appropriate training technique, and has been suggested to be beneficial to animal welfare in the zoo setting, since it increases control and predictability over aversive events (Bassett & Buchanan-Smith, 2007; Laule & Desmond, 1998). Further, these animals have the opportunity to retreat if desired. Forced proximity to humans has been highlighted as potentially stressful for zoo-housed animals (Morgan & Tromborg, 2007), and there are many features in each of the enclosures which could be used by the animals to remove themselves from view and potentially reduce any stress associated with visitor presence. Indeed, we saw that animals in both tours spend most of their tour time in distant proximity to keepers and visitors. This is more so important in the cheetah tour, where visitors actually enter the exhibit. In many instances, the animals were not in close or moderate proximity to humans and would often interact for 5-10 min before walking away and laying down in the shade, away from the group. When the animals did this, they were never followed by keepers or visitors. Like predictability, having retreat spaces has been found to be important in other interactive programs, and in moderating animal behavior and improving animal welfare (Anderson, Benne, Bloomsmith, & Maple, 2002; Samuels & Spradlin, 1995).

One final factor is that these tours are always conducted by zoo keepers. Whilst it is unlikely that tours like this would ever occur without an experienced zookeeper present, a study of dolphins at various facilities in the United States found that potentially risky behavioral interactions were lower in sessions where trainers had direct control over the interactions between dolphin and visitor, compared to those without direct trainer control (Samuels & Spradlin, 1995). The presence of a familiar keeper will undoubtedly influence how the animal responds since there is an existing relationship. It may be that having a keeper present mediates the interactions, making it a more positive experience. Indeed, Claxton (2011) suggests that it may be possible for an animal's interactions/relationship with unfamiliar humans (e.g., zoo visitors) to be influenced by the relationship that they have with familiar humans (e.g., zookeepers). Alternatively, the animals in this study may not have been responding to visitor presence at all, since the animals

appeared to respond to the tour group in the same way as they would when keepers were present at other times of the day (for example, becoming alert upon keeper arrival, or pacing before a feed).

Confounding Variables and Directions for Future Research

When combining results from each of the tour types, it is evident that these tours were having some influence on animal behavior. This is consistent with the small amount of previous research that has shown big cat behavior to vary in association with regular zoo visitation (Mallapur & Chellam, 2002; Sellinger & Ha, 2005). The findings from this study add to this past research, by providing an understanding of the potential influence of closer visitor interactions on animal behavior. However, drawing conclusions about which aspects of the tours contributed to alterations in behavior is difficult. There are always likely to be a number of confounding variables in zoological studies, many of which are unavoidable if the purpose of the research is to observe animals behaving according to their regular routines. This often makes drawing conclusions about behavior change quite challenging, and so we have discussed some of these issues here and provided suggestions for how they might influence our results, as well as how they might be addressed in future research.

Firstly, since there was a difference in the feeding routines of these animals on tour and non-tour days, it would be important for future studies to consider keeping this potentially confounding variable consistent across conditions, in order to more fully understand the influence of tours. This was not possible in our study, since we did not want to make any changes to the regular routines of the animals involved. Moreover, it is suggested that it might be possible that the animals here responded to the tour group in the same way that they do to keepers alone, at other times of day. It would be imperative for future research to document animal responses to keepers at various times throughout the day, to determine whether such a similarity does exist and to draw more informed conclusions about animal responses to participating in tours. Hosey (2008) argues that both the quality and quantity of animal interactions with keepers differ from those with visitors, therefore separating these influences would also be important. Moreover, Phillips and Peck (2007) found that tiger keepers differ in their individual interaction style with their animals, so understanding if and how big cats respond to different keepers/keeping styles should be addressed.

Although two different types of tours (protected contact and hands-on) were explored in this study, the behavior of both groups of animals was not compared and so conclusions about which tour might have a greater influence of behavior, and welfare, cannot be made. Such a comparison was deemed inappropriate here, since there are various other differences in the histories and current husbandry of these two groups of animals which could account for behavioral differences. Addressing the influence of varying types of tours could be made possible at organizations where the same animals participate in different types of tours. Along these same lines, whether animals have been hand-reared and the amount of prior interaction that they have had with humans could account for behavioral differences during tours, so it would be useful to compare the same species with different levels of interaction, to determine whether any inter-species differences exist. This could allow zoological organizations to understand which big cat species are most suited to the different types of tours. It has been proposed that various factors will account for a particular animal's response to humans – such as species, extent of handling in early life, animal personality and temperament (Davey, 2007; Hosey, 2008). As such, the

investigation of how individual factors relate to interactive tours would also be useful in being able to predict which animals would be suitable for involvement in such programs.

As with many studies of zoo/aquarium-housed animals, this one was limited to a small number of subjects, at one organization. In order to generalize findings beyond these individuals, future research should consider a greater number of animals, at multiple institutions, as well as other big cat species. Moreover, the generalizability of these findings is limited in that the individual animals involved here have participated in the tours for a number of years (four years for the tiger and lions, and most of their lives – eight years - for the cheetah) and have likely adapted to interactive tours to some degree. Moreover, being hand-raised, the cheetah have daily physical interaction with their keepers, providing them with further opportunities to adjust to interacting with people. In this way, it was only possible to examine immediate, short-term behaviors associated with tours. It would be important for future research to examine long-term changes in animals who are not yet involved in such a program. In terms of gauging the influence of tours, although the use of multiple measures of well-being have been advocated (Szokalski, Litchfield, & Foster, 2012), behavior was deemed the most efficient method here. Since we were interested in immediate effects, and because many other factors in the zoo environment may contribute to stress, a corticosteroid analysis (or similar) did not appear suitable here, but may be of value to a longer-term investigation which focuses on the establishment of tours with new animals. As a result of focusing solely on behavior, our findings do not provide a complete picture of animal responses to tours, and this limits the conclusions drawn.

Beyond the behavior and welfare of animals involved in interactive tours, future research should also address the safety of zoo visitors during such experiences. Although no direct aggressive or otherwise antagonistic behaviors towards humans were observed in this study, there is a wealth of literature to indicate that big cats can cause both injuries and fatalities to people, in the wild and in various forms of captivity (Beier, 1991; Chapenoire, Camiade, & Legros, 2001; Cohle, Harlan, & Harlan, 1990; Hejna, 2010; Lazarus, Price, & Sorensen, 2001; Loe & Roskaft, 2004; Murphy, Dempsey, & Kneafsey, 2007; Nyhus, Tilson, & Tomlinson, 2003; Packer et al., 2005; Schiller, Cullinane, Sawyer, & Zietlow, 2007). Indeed, when surveying zoo keepers about their opinions of interacting with big cats, we found that safety was a major concern among participants (Szokalski, Litchfield, & Foster, in press). A number of these keepers discussed human safety as an issue when a hands-on style is adopted; they also expressed the concern that if an “attack” does take place, the animal involved is usually euthanized, highlighting the negative consequences for both people and animals when interacting. Typically, participants explained that a protected contact style is safer and more appropriate than hands-on. For these reasons, it will be important for research to continue to investigate the behaviors displayed by these animals during tours, and how the safety of both humans and animals might be preserved or compromised.

Conclusions

Ferndandez et al. (2009) argue that those interactions which meet the entertainment and education aims of visitors, whilst also being helpful for animal welfare, should be encouraged. Although more research is needed to determine whether visitors benefit from interacting with big cats, the results of this study provide a starting point for understanding how participation in interactive zoo visitor tours might influence animal behavior. The paper also supports the continued use of behavioral monitoring as an effective means to understand animal welfare. Differences in proportions of behaviors – both species-typical and stereotypic - were observed

between the conditions in this study; however, due to the multiple confounding variables inherent in this type of research, it is not possible to draw conclusions about how animal welfare might be influenced by these tours. In particular, it is important to acknowledge that it cannot be determined, from this investigation alone, which aspects of the tours are responsible for the changes observed. This will need to be explored in future research. Moreover, since the presence of stereotypic behavior can be indicative of compromised well-being, it will be of importance for future research to address this in order to support the continued involvement of big cats in interactive programs. However, we do suggest that the overall conditions under which these tours occur – such as predictability, allowing the animals choice to participate, the use of positive reinforcement, and the provision of retreat spaces – appear quite positive and should be encouraged elsewhere. There is clearly a need for more research in this area and it is hoped that this study will promote the investigation of big cats involved in interactive tours at other zoological facilities.

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