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Behavioural effects of a giraffe public feeding programme on Masai giraffe *Giraffa tippelskirchi* and plains zebra *Equus quagga* in a mixed-species exhibit

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Abstract
Animal-visitor interactions are widely available in zoos and aquariums, yet the effects of these programmes on the welfare of the animals involved have only recently begun to be studied. The impact of one type of animal-visitor interaction, public hand feeding experiences, on the welfare of the participating Masai giraffe *Giraffa tippelskirchi* and the plains zebra *Equus quagga* co-housed with them was investigated, via behavioural observations before the public feeding season began and during the feeding season. A less time-intensive behavioural sampling method was used that allowed on-duty zookeepers to collect all the data. There were no negative behavioural effects of the public feeding experiences on the giraffe or zebra, including no effects of numbers of guests on rates of stereotypic behaviour and no increase in stereotypic behaviour over time. Rates of stereotypic behaviour were similar to those found previously using more time-intensive behavioural sampling methods. There were individual differences in rates of stereotypic behaviour in giraffe and differences in non-stereotypic behaviour between study phases in both species, which warrant further investigation. This study, for the first time, provides data on the behavioural effects of a public feeding programme on non-participating animals in a mixed-species exhibit, and further demonstrates a method of behavioural sampling that can be incorporated into the daily routine of zookeepers.

Introduction

As zoos and aquariums look to increase visitor attendance and awareness about conservation issues, opportunities for animal-visitor interactions have emerged as a possible solution. These opportunities provide a source of entertainment that some visitors expect from their zoo or aquarium experience (Fernandez et al. 2009; Tofield et al. 2003) and the chance to interact with wild animals, another appealing aspect for visitors (Hosey 2005; Kreger and Mench 1995). Animal-visitor interaction opportunities are now widely available: in a study of 1241 member and associate member facilities of the World Association of Zoos and Aquariums (WAZA), 75% advertised at least one animal-visitor interaction experience on their website (D'Cruze et al. 2019). However, the effects of these programmes on the welfare of the animals involved have only recently begun to be studied, with various cases demonstrating positive, negative, mixed or no discernible effects on welfare (D'Cruze et al. 2019; Spooner et al. 2021)

The impact of one type of animal-visitor interaction, public hand feeding experiences, on the welfare of the participating Masai giraffe *Giraffa tippelskirchi* and the plains zebra *Equus quagga* co-housed with them was investigated. Hand feeding experiences, which involve guests directly handing food to animals, are relatively widespread and available at nearly a quarter of the WAZA member and associate member facilities examined by D'Cruze et al. (2019). They offer the opportunity for close contact with wild animals, making them highly attractive to visitors (Swanagan 2000; Woods 2002) but potentially more detrimental to animal welfare. Indeed, increased guest density, which would be expected to accompany public feedings, has been found to negatively impact ungulate welfare (Mansour et al. 2000; Rajagopal et al. 2011; Sekar et al. 2008; Shen-Jin et al. 2010). Research on the effects of public feedings on giraffe welfare has yielded mixed findings. No negative behavioural effects were found in giraffe in zoos where public feedings occurred at designated times (de Mori et al. 2019; Normando et al. 2018; Orban et al. 2016), but increased rumination and idleness were observed in giraffe in zoos where public feedings occurred throughout the day (Orban et al. 2016). Moreover, greater visitor frequency at all-day feedings correlated with decreased locomotion and increased oral stereotypy (Lynn 2018). Conversely, discrete public feedings were associated with increased amicable social interactions and no change in faecal glucocorticoid metabolite concentrations (Acaralp-Rehnberg 2019), a measure of stress (Keay et al. 2006).

The current study extends this body of research by examining giraffe behaviour before and during the period of the year when public feedings were held. In addition to investigating stereotypic behaviour as a measure of poor welfare (Broom 1991; Mason and Rushen 2006; Wolfensohn et al. 2018), non-stereotypic behaviours such as locomotion, eating and ruminating were also examined, as changes in these behaviours can signal changes in welfare (Bristow and Holmes 2007; Fureix and Meagher 2015; Herskin et al. 2004). Of particular interest was whether stereotypic behaviour varied with the number of guests at the feeding experiences, as it was suspected that an increase in guests could be stressful to the giraffe. Changes in giraffe behaviour over time as the pre-feeding and feeding season periods progressed were also investigated, because the giraffe could have become more accustomed to the public feedings.

The giraffe in the current study lived in a mixed-species exhibit with zebra. Since the zebra had access to the feed deck and the surrounding outdoor exhibit during public feedings, and were thus exposed to the attendant increase in visitors during those times, it was important to include them in the welfare impact assessment of feedings. The little research done on visitor effects on zoo-housed zebra found no behavioural indications of worse welfare when zoos were re-opened to visitors after COVID-19 closures (Williams et al. 2021). To the authors' knowledge, this is the first study to investigate the welfare of animals in proximity to, but not participants in, giraffe public feeding experiences.

Finally, because all the data were collected by on-duty zookeepers, a behavioural observation method adapted from Margulis et al.'s (2005) multi-point scan method was used, which the zookeepers could easily conduct daily. Prior research has shown that, for more frequently observed behaviours (>15% of activity budget), the multi-point scan method yields similar results to more time-intensive scan sampling (Canino and Powell 2010; Margulis et al. 2005; Margulis and Westhus 2008). Importantly, the multi-point scan data in these previous studies were collected by zookeepers. Studying welfare using methods that can be incorporated into the daily routines of zookeepers drastically reduces the time and financial burdens that usually limit this kind of research to external researchers. To the authors' knowledge, this is the first zookeeper-conducted study of the effects of a giraffe public feeding programme on the welfare of the animals involved.

Methods

Study animals, habitat and husbandry

Data collection took place at Seneca Park Zoo (Rochester, NY) from 23 April 2021 to 13 July 2021, and involved three Masai giraffe *Giraffa tippelskirchi* (two females, one male; average age=4.33 years) and three plains zebra *Equus quagga* (three females; average age=5.58 years) that shared their mixed-species habitat. These giraffe and zebra were the only occupants of the habitat.

The giraffe and zebra shared an outdoor yard (3700 m^2), indoor yard (305 m^2) and four stalls (total 132 m^2) (Figure 1). Animals usually had full access to all areas with occasional restrictions related to husbandry and weather. The zebra also occasionally had access to four stalls (total 75 m^2), predominantly during their mealtimes. All animals were provided with specially formulated grain twice per day (around 0845 and between 1500 and 1700), as well as ad libitum access to hay and water. Enrichment was provided multiple times per day and consisted of combinations of fillable enrichment toys, fresh browse, fresh and/or dried herbs, spices, scented lip balm and diluted flavour/plant extracts.

Public feeding procedure

Public feedings took place from May to September, five days per week (Wednesday–Sunday), twice per day (1145 and 1430), except in inclement weather. During the feedings, ticketed guests were allowed onto a designated 'feed deck' (Figure 1) and provided with three whole romaine lettuce leaves to feed to the giraffe. To minimise the chances of the giraffe being startled by guests, only three parties of guests were allowed on the deck at a time. To acclimate the giraffe, the total number of guests at each feed was limited to 20 at the beginning of the feeding season, gradually increasing to 100 guests by midseason. The giraffe were free to approach and leave the feed deck at any time. During feedings, the zebra had full access to the outdoor yard, including the area around the feed deck. They often stood and walked around near the feed deck, likely attracted by lettuce dropped by the giraffe and guests. This behaviour occasionally caused the giraffe to move away from the feed deck. Partway through the feeding season (and data collection), a timed hay feeder on the other side of the outdoor yard (Figure 1) was programmed to release hay to the zebra shortly before and during the giraffe feedings, reducing the amount of time the zebra spent around the feed deck. Feedings typically lasted 15–20 minutes and were cancelled (if the giraffe did not approach the feed deck) or ended early (if the giraffe left the feed deck and did not return) at the discretion of the zookeepers.

Data collection

Scan sampling (Altmann 1974) was conducted three times per day, with each scan falling within one of three specified time windows that were roughly evenly spaced before and after the public feeding times (1000–1100 (AM), 1245-1345 (MD), 1530–1630 (PM)). At each timepoint, one zookeeper recorded the behaviour of each animal and the time. On days with giraffe feedings, they recorded the number of guests at each feeding. They used ethograms to classify and record behaviour. The giraffe ethogram was adapted from Seeber et al. (2012) and Razal et al. (2017) (Table 1). The zebra ethogram was developed by the SEK, based on the giraffe ethogram and prior observations of the zebras' behaviour (Table 1), in order to make the behavioural categories as comparable as possible between the species and to simplify recording for the zookeepers.

Across this study, data were collected by six zookeepers (though only one zookeeper recorded behavioural data at each time point). Before data collection, SEK explained the data collection procedure and behavioural categories in the ethogram to the other zookeepers.

Approximately one month before the feeding season, zookeepers began acclimating the giraffe to the feed deck and the public feeding procedure. This involved offering the giraffe portions of their daily allotment of grain and romaine leaves from the feed deck to encourage them to approach. Gradually, small

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numbers of guests were invited to feed the giraffe. These training sessions differed from the feedings during the season in that they occurred at various times throughout the day (rather than at the same scheduled times) and in that guests were chosen randomly from the viewing area near the feed deck (rather than forming a line in front of the exhibit beforehand). Data collected on these sessions were informal and incomplete, but the general trend was that the number of guests increased over time.

The numbers of behavioural observations for each animal at each timepoint and study phase are shown in Table 2. Nine additional observations per animal occurred outside the designated windows and were excluded from analyses. Data for one morning was excluded because the giraffe refused to approach the feed deck for the AM feeding due to the presence of a large plastic bag in the outdoor yard. The giraffe spent a long time before and after plastic bag removal standing in an alert posture oriented toward the plastic bag's location (or prior location). Given the effect that this event had on the giraffes' behaviour, AM and MD observations and first feeding data for that day were discarded. On another day, all feedings were cancelled due to the weather; since the cancellation occurred well before the time of the first feeding (and thus before any indicators that a feeding would occur, such as guests lining up near the feed deck), that day was reclassified as a non-feeding day. The number of guests at each feeding was recorded for each day that behavioural observations were made, except for three feedings.

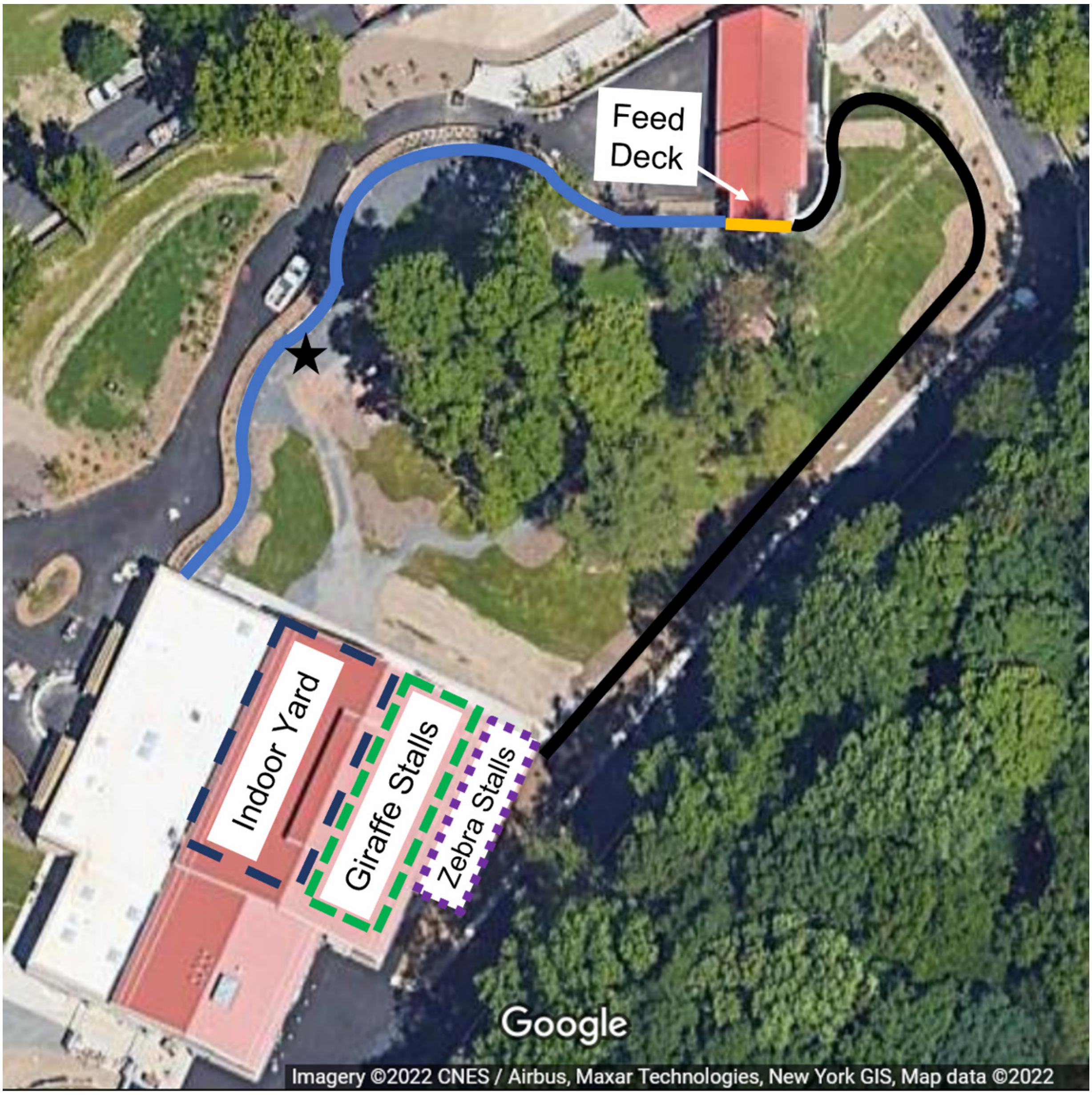

Figure 1. Image of the giraffe and zebra habitat, showing the outdoor yard (black and blue outline), indoor yard (dark blue dashed outline), giraffe stalls (green dashed outline), zebra stalls (purple dashed outline) and feed deck. The yellow line indicates where guests could feed the giraffe during public feedings. The blue outline of the outdoor yard indicates where guests could approach and view the outdoor habitat; the black outline indicates areas only accessible to zoo staff. The black star on the left side of the outdoor yard shows the approximate location of a hay feeder that released hay for the zebra shortly before and during giraffe feeds.

Table 1. Giraffe and zebra ethogram used for behavioural observations. Differences in behaviour descriptions for the species are indicated by G (giraffe) and Z (zebra); otherwise the behaviour descriptions are the same. Giraffe ethogram was adapted from Seeber et al. (2012) and Razal et al. (2017). Zebra ethogram was developed by SEK, based on the giraffe ethogram and prior observations of the zebras' behaviour.

Behaviour	Code	Description
Feeding (hay feeders)	HAY	G: Ingesting hay at hay feeders (inside or outside) Z: Ingesting hay at hay bags or on ground
Feeding (enrichment)	ENR	Ingesting hay, browse, produce, grain at enrichment (inside or outside)
Feeding (grain buckets)	GRB	G: Ingesting grain from buckets in stalls or day yard Z: Ingesting grain from bowls in stalls
Resting	RES	G: Lying down Z: Lying down with head upright, or lying on side with head on ground
Stationary	STAT	G: Standing, no ruminating Z: Standing with head and ears relaxed, no eating
Drinking	DRI	Drinking at waterers
Scratching	SCR	Scratching body part against an object
Salt lick	SALT	Using tongue on a salt lick
Object licking	LIC	Using tongue on an object that is neither food nor a mineral donator, repeatedly and persistently over a lengthy period of time Abnormal repetitive behaviour
Pacing	PAC	Walking a definite short path, repeatedly and without a discernible purpose. Abnormal repetitive behaviour
Displacing	DIS	Driving a conspecific off. Note if aggressive
Staff	STAF	Interacting with staff
Interacting with giraffe	GIR	G: Interacting with other giraffe e.g. Flehmen response, following, grooming, other. Not including displacing or mane biting. Note specific behaviour observed and animals involved in interaction Z: Interacting with giraffe e.g. following, chasing or being chased. Note specific behaviour observed and animals involved in interaction
Out of sight	OOS	
Giraffe-only behaviours		
Locomotion	LOC	Non-repetitive walking or running, no pattern to locomotion observed
Ruminate –standing	RSTA	Chewing of cud, cud visible outside of throat and chewing motion is observed while animal is standing in a stationary position
Ruminate – resting position	RRES	Chewing of cud, cud visible outside of throat and chewing motion is observed while animal is in resting position
Ruminate – during locomotion	RLOC	Chewing of cud, cud visible outside of throat and chewing motion is observed while animal is walking or running non-repetitively
Ruminate – during pacing	RPAC	Chewing of cud, cud visible outside of throat and chewing motion is observed while animal is walking in definite short path, repeatedly and without a discernible purpose. Abnormal repetitive behaviour
Tongue playing	TON	A persistent twisting movement of the tongue outside the animal's mouth; not licking an object, and not during or shortly after feeding. Abnormal repetitive behaviour
Mane biting	MAN	Biting or chewing the mane of a conspecific for more than some seconds, repeatedly, and not in a grooming context. Abnormal repetitive behaviour
Zebra-only behaviours		
Walking	WAL	Moving forward by lifting one hoof at a time
Running	RUN	Moving forward faster than a walk, lifting multiple feet at a time. May include instances of kicking not directed toward another animal.
Alert	ALER	Rigid stance, neck elevated and head oriented toward stimulus. Ears are held stiffly upright and forward, and nostrils slightly dilate.
Rolling	ROLL	Lying on back and moving around, with hooves in air
Grooming others	GRO	Using mouth to scratch a conspecific's fur or skin
Grooming self	GRS	Using mouth or hoof to scratch own fur or skin
Biting	BITE	Biting the fur or skin of a conspecific aggressively, accompanied by a negative response from the conspecific
Kicking	KICK	Kicks out with hind legs at another animal aggressively
Interacting with other zebra	ZEB	Interacting with other zebra e.g. following, touching noses, other. Not including displacing, grooming or biting. Note specific behaviour observed and animals involved in interaction

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Table 2. Number of behavioural observations for each animal, at each study phase and time point. On feeding days during the feeding season, public feedings occurred at 1145 and 1430.

		AM (1000–1100)	MD (1245–1345)	PM (1530–1630)	Total
Pre-feeding period (April–May 2021; 26 days)		23	23	18	64
Feeding season (May–July 2021; 52 days)	Feeding days	29	22	25	76
	Non-feeding days	10	11	9	30

Coding and analyses

The giraffe and zebra ethograms coded walking and running differently; for zebra, these behaviours were coded separately, whereas for giraffe, they were both coded as locomotion. In order to directly compare behaviour between species, zebra walking and running behaviours were re-coded as locomotion. A behaviour was classified as stereotypic if it was an abnormal repetitive behaviour: pacing (while ruminating or not), object licking, tongue playing or mane biting. Some ethogram codes corresponded to multiple behaviours (e.g. RPAC for ruminating while pacing). These were treated as two behaviours within the same observation, so these observations were classified twice (e.g. counting towards the proportion of both ruminating and pacing). Percentages of behaviours thus add up to more than 100%. The proportion of each behaviour observed for each species was calculated by first dividing the number of times that behaviour was observed by the total number of observations for each individual, then calculating the mean and standard error of the mean of that behaviour across all individuals of that species.

In order to examine the effect of time in the pre-feeding phase and feeding season separately, the date of each observation was converted to an integer corresponding to that date's position in its respective phase. Thus, the first day of the pre-feeding phase became one, the second day became two, and so on up to the last day of the pre-feeding phase, which became 26. Likewise, the first day of the feeding season became one, and so on up to the last feeding day of data collection, which became 52.

For the feeding season, in addition to examining the effect of time across the season, the effect of time across the week was also explored. Feedings occurred on five consecutive days each week (Wednesday–Sunday), followed by two days without feedings (Monday–Tuesday). To investigate whether behaviour changed across those five feeding days, a variable was created to indicate which consecutive feeding day of the week it was. Wednesdays, as the first day with feedings in the week, were assigned the value one, followed by Thursdays as two, and so on up to Sundays as five. In one week, feedings were also held on Monday, which was assigned the value six. In another week, feedings were cancelled on Friday due to inclement weather, and feedings were also held on Monday. For this week, Wednesday=one, Thursday=two, Saturday=one, Sunday=two, and Monday=three.

Statistical analyses were conducted in R v.4.1.1 (R Core Team 2021) using the logistf, performance and ggplot2 packages (Heinze et al. 2020; Lüdecke et al. 2021; Wickham 2016). Chi-squared tests were used to compare behaviour between subjects and between study phases. Fisher's exact test was used when there were insufficient observations for a chi-squared test. For post-hoc comparisons, P values were adjusted using the Holm correction (Holm 1979) to control the family-wise error rate. Logistic regression (generalised linear model with a logit link function and binomial error structure) was used to examine factors relating to stereotypic behaviour. Firth's bias-reduced logistic regression was used when there were fewer than 10 cases with the least frequent outcome for each independent variable in the model. The significance of each main effect was determined using a likelihood-ratio test comparing the full model to a model with that effect omitted. To account for repeated measurements, subject was included as a fixed effect in regressions, as there were too few subjects to include it as a random effect. Continuous variables were standardised before being entered into regressions. After testing the statistical assumptions for each model, all models were found to have possible influential values. The models were re-run after excluding data points that exceeded the thresholds for both Cook's distance (4/n) and DFBETA (>0.2 or <-0.2) for all continuous variables. The models met all other statistical assumptions.

Results

Stereotypic giraffe behaviours

Across the entire study period, giraffe were observed performing an average of 8.24% (±2.23%) stereotypic behaviours (Table 3). In the pre-feeding phase, 8.33% (±2.90%) of recorded behaviours were stereotypic. In the feeding phase, 9.65% (±1.58%) of recorded behaviours on feeding days were stereotypic and 4.44% (only observed in one giraffe) of recorded behaviours on non-feeding days were stereotypic (Figure 2). The proportion of stereotypic behaviours was not significantly different across the three phases (χ^2(2, n=510)=2.32, P=0.31). Examining the stereotypic behaviours individually, there was no significant difference in pacing (P=1, Fisher's exact test) or licking behaviour (χ^2(2, n=510)=3.21, P=0.20) between the phases.

The proportion of stereotypic behaviours observed was significantly different among the giraffe (χ^2(2, n=510)=6.69, P=0.04; Figure 2). Post-hoc tests revealed that a significantly greater proportion of stereotypic behaviours were recorded for Iggy than Parker (χ^2(1, n=340)=6.37, P=0.04). There were no other significant differences (all P>0.05). Fisher's exact tests indicated no significant differences in the proportion of stereotypic behaviours in each phase (Iggy: P=0.78; Kipenzi: P=0.10; Parker: P=0.45). In the pre-feeding phase, zookeepers conducted training to encourage the giraffe to approach the feed deck and take lettuce leaves from zookeepers, which progressed to taking lettuce leaves from increasing numbers of guests. To examine whether this training affected the likelihood of stereotypic behaviours by giraffe, a logistic regression of behaviour type (stereotypic or not) on day in the pre-feeding season and subject was conducted, and showed no effect of day (b=0.13, χ^2(1)=0.12, P=0.72). This indicates that giraffe stereotypic behaviour did not change in

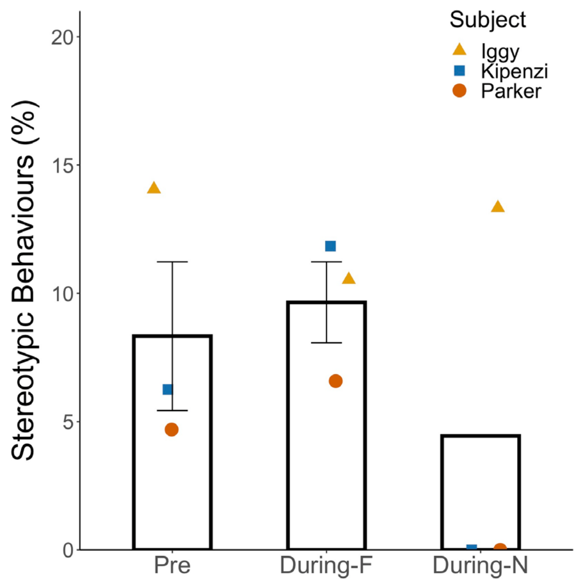

Figure 2. Proportion of giraffe stereotypic behaviours out of all observations recorded in each phase. Dots indicate proportions for each individual giraffe. Error bars are standard error of the mean (±2.90, ±1.58 and NA, respectively). Pre, pre-feeding season; During-F, feeding day during the feeding season; During-N, non-feeding day during the feeding season.

Table 3. Counts of behaviours observed in giraffe and zebra for the entire study period. [s] denotes behaviours classified as stereotypic.

Behaviour	Giraffe	Zebra
Alerting	0	1
Drinking	2	3
Enrichment	58	19
Interacting with giraffe	2	0
Eating hay	167	344
Lickings	29	0
Locomotion	76	35
Locomotion and licking[s]	1	0
Pacing[s]	11	0
Resting	9	31
Ruminating	1	0
Ruminating and locomotion	4	0
Ruminating and pacing[s]	1	0
Ruminating and resting	14	0
Ruminating and stationary	53	0
Scratching	2	2
Interacting with staff	7	6
Stationary	73	69

response to training at the feed deck, which included exposure to an increasing number of guests.

The likelihood of stereotypic behaviours by giraffe during the feeding season was also examined. As the feeding season progressed, the giraffe could exhibit fewer stereotypic behaviours, suggesting that they were becoming more accustomed to the feedings and experiencing less stress. Conversely, they could exhibit more stereotypic behaviours, suggesting that they were experiencing increasing stress from the feedings, especially because the number of guests tended to increase over the course of the feeding season. Since feedings did not occur every day of the week, these trends could occur at the week level, with stereotypic behaviours increasing or decreasing with each successive feeding day of the week. These possibilities were examined using a Firth's bias-reduced logistic regression of behaviour type (stereotypic or not) on day in the feeding season, feeding day in the week, average number of guests participating in feeds that day and subject. There was no effect of number of guests (b=-0.20, $\chi^2(1)=0.26$, P=0.61), day in the feeding season (b=-0.24, $\chi^2(1)=0.55$, P=0.46) or feeding day in the week (b=-0.47, $\chi^2(1)=3.34$, P=0.07). This analysis included AM observations, which occurred before guests arrived for feedings, and used the average number of guests across both feedings in a day, so the relationship between stereotypic behaviours and number of guests could be underestimated. To examine the effect of number of guests on giraffe behaviour more directly, the same logistic regression model was applied, including only MD and PM observations and using the actual number of guests at the feed preceding the observation. There was no effect of number of guests (b=1.16, $\chi^2(1)=2.59$, P=0.11) or feeding day of the week (b=-0.69, $\chi^2(1)=2.43$, P=0.12), but there was a significant effect of day in the feeding season (b=-1.77, $\chi^2(1)=9.45$, P=0.002), suggesting that the likelihood of stereotypic behaviour decreased as the feeding season progressed.

Non-stereotypic giraffe behaviours

The most common non-stereotypic behaviour observed was eating hay (32.75±2.26%), followed by stationary (24.71±2.78%), locomotion (15.88±3.24%), ruminating (14.31±1.37%), interacting with enrichment (11.37±1.53%) and resting (4.51±2.83%). The non-stereotypic behaviours of drinking, scratching and interacting with other giraffe or staff were observed fewer than 10 times each over the course of the study (Table 3). No aggressive displacing or other interactions were observed.

Proportions of the more frequently observed non-stereotypic behaviours, by phase, are shown in Figure 3. Observations of eating hay were significantly different among the three phases ($\chi^2(2, n=510)=6.82$, P=0.03). However, post-hoc comparisons revealed no significant differences between the phases after controlling the family-wise error rate (all P>0.05). There were no significant differences in observations between phases for the other behaviours (all P>0.05).

Non-stereotypic zebra behaviours

No stereotypic behaviours were recorded for the zebra. The

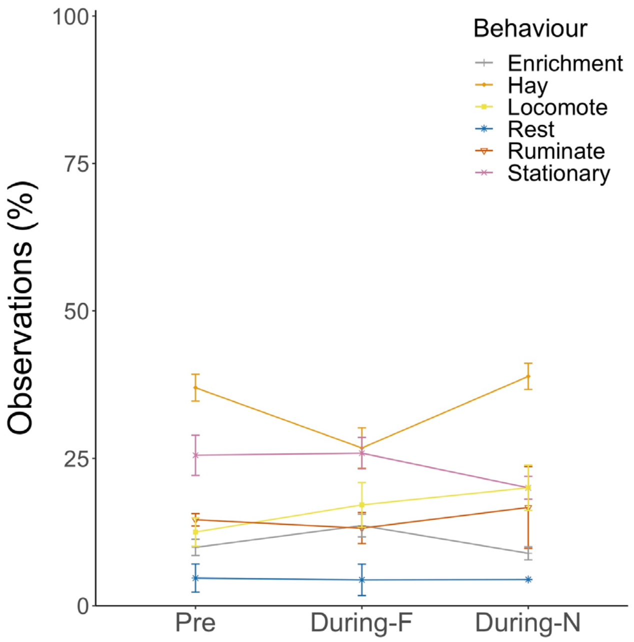

Figure 3. Proportion of non-stereotypic giraffe behaviours out of all observations recorded in each phase. Error bars are standard error of the mean. Pre, pre-feeding season; During-F, feeding day during the feeding season; During-N, non-feeding day during the feeding season.

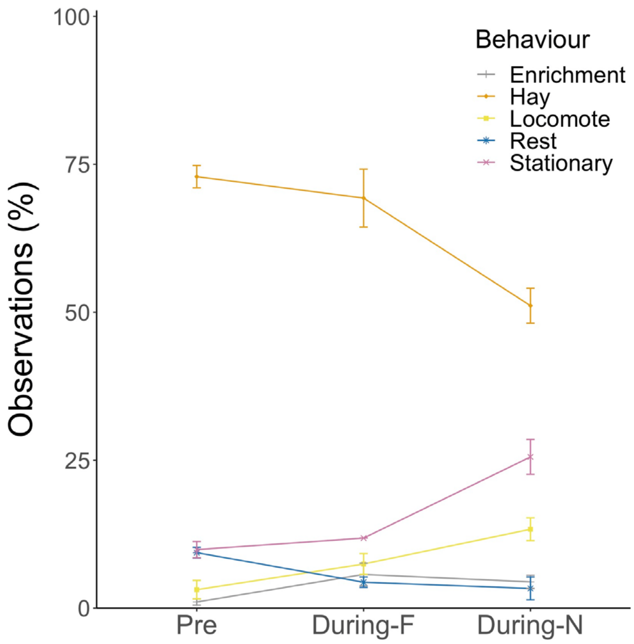

Figure 4. Proportion of non-stereotypic zebra behaviours out of all observations recorded in each phase. Error bars are standard error of the mean. Pre, pre-feeding season; During-F, feeding day during the feeding season; During-N, non-feeding day during the feeding season.

most common non-stereotypic behaviour observed was eating hay (67.45±2.93%), followed by stationary (13.53±0.90%), locomotion (6.86±0.85%), resting (6.08±0.20%) and interacting with enrichment (3.73±0.85%). The non-stereotypic behaviours of alert, drinking, scratching and interacting with staff were observed fewer than 10 times each (Table 3). No aggressive behaviours were observed. Proportions of the more frequently observed behaviours, by phase, are shown in Figure 4. Observations of all behaviours were significantly different between the phases, except for resting (Table 4).

Table 4. Tests of the difference in the proportion of a behaviour among the three study phases, for zebra. Fisher's exact test was used for enrichment, which had insufficient observations for a chi-squared test.

Behaviour	χ^2	df	n	P
Hay	13.91	2	510	<0.001
Locomotion	10.22	2	510	0.006
Rest	5.99	2	510	0.050
Stationary	13.85	2	510	<0.001
Enrichment	Fisher's exact test			0.025

Post-hoc comparisons of zebra interacting with enrichment revealed significantly more observations of this behaviour on feeding days than in the pre-feeding phase (χ^2(1, n=420)=6.57, P=0.03), but no other significant differences (all P>0.05). There was significantly less hay-eating behaviour on non-feeding days than on feeding days (χ^2(1, n=318)=9.28, P=0.005), and than in the pre-feeding period (χ^2(1, n=282)=12.98, P=0.001). There was no significant difference in hay eating behaviour between the pre-feeding phase and feeding days (χ^2(1, n=420)=0.66, P=0.42). There was significantly more locomotion on non-feeding days than in the pre-feeding phase (χ^2(1, n=282)=10.69, P=0.003), but no other significant differences (all other P>0.05). Finally, there was significantly more stationary behaviour on non-feeding days than on feeding days (χ^2(1, n=318)=9.16, P=0.005), and than in the pre-feeding period (χ^2(1, n=282)=11.86, P=0.002). There was no significant difference in stationary behaviour between the pre-feeding phase and feeding days (χ^2(1, n=420)=0.40, P=0.52).

Discussion

This study investigated how public giraffe feedings affected the behaviour of all animals in a mixed-species exhibit. Importantly, there was no increase found in giraffe stereotypic behaviour over time, including the pre-feeding season training period and the public feeding season. There was also no relationship between the number of guests at a feeding session and the likelihood of observing giraffe stereotypic behaviours, in contrast to prior findings that greater visitor frequency at all-day feedings correlated with increased oral stereotypy (Lynn 2018). The current findings suggest that these discrete public feeding experiences were likely not stressful to the giraffe, as measured by their behaviour.

When examining stereotypic behaviours observed at midday and in the afternoon during the feeding season, stereotypic behaviours were significantly less likely to occur as the season progressed. However, because this effect was not found when morning observations were included in the analysis, it could reflect a shift in stereotypic behaviour to the morning from later in the day over time. Additionally, because the behavioural observation windows occurred approximately 45 minutes before and after the feedings, it was not possible to capture any stereotypic behaviours that occurred immediately before and after the feedings. Prior research has found anticipatory pacing before feeding in zoo-housed giraffe (Duggan et al. 2016), so further observations should be made closer to the times of the public feedings to examine whether stereotypic behaviours increase during those time periods.

The data show low incidences of stereotypic behaviour overall: just 8.24±2.23% of giraffe behavioural observations. There were comparable rates of pacing (2.35±0.34%) to a prior study (1.4%; Orban et al. 2016), and lower levels of oral stereotypy (5.88±1.89%) than previous studies: 5–15% (Acaralp-Rehnberg 2019), 7.0% (Lynn 2018) and 12.5–17% (Orban et al. 2016), though it should be noted that these studies used different sampling methods.

There were significantly different rates of stereotypic behaviour between individual giraffe, indicating the importance of examining data from individual animals separately in future studies, as has been previously suggested (Gold and Maple 1994; Polgár et al. 2017; Sellinger and Ha 2005; Stoinski et al. 2012). There was no difference in stereotypic behaviour before and during the feeding season at the individual level, but there were only between 8 and 21 observations of stereotypic behaviour per individual. More data are needed to further investigate individual differences in stereotypic behaviour before and during the public feeding season.

For non-stereotypic giraffe behaviours, a significant difference between study phases was only found for hay eating, with less hay eating observed on feeding days compared to non-feeding days and the pre-feeding phase, although these post-hoc pairwise comparisons were not significant. This could have been due to the addition of lettuce leaves to the giraffes' diets on feeding days. From the data, it is unclear whether the overall quantity of hay eaten each day was different between the study phases, or whether hay eating behaviour merely shifted to unobserved times of day on feeding days; future studies should collect data on the amount of hay eaten each day in order to investigate this.

The giraffe in this study are part of a mixed-species exhibit with zebra, and as zebra had access to the outdoor exhibit and the feed deck area during feeding sessions, their behaviour was also examined. Critically, no stereotypic behaviours were observed during the study period, suggesting that the public feedings did not cause stress to the zebra, as measured by their behaviour. However, these results could reflect a limitation of the zebra ethogram, which may not have included all behaviours indicative of poor welfare. For example, yawning—which was not in this study's ethogram—has been found to relate to aggression in Przewalski's horse *Equus ferus przewalskii*, and has been proposed as a displacement activity to reduce social tension (Górecka-Bruzda et al. 2016). Finding no stereotypic behaviour in zebra also does not preclude the potential for other negative effects of the feedings on the welfare of non-participating species. For example, the zebra in the current study were drawn to the feed deck during feedings by lettuce dropped by the giraffe and guests. This put the zebra in closer proximity to the giraffe, occasionally startling the giraffe and potentially increasing the chance of agonistic interactions between individuals. Thus, although the data suggest that public giraffe feedings do not cause an increase in stereotypical behaviours by cohabiting zebra, other aspects of feedings should be examined for negative welfare impacts on cohabiting animals.

There were significant differences between the study phases in many non-stereotypic zebra behaviours. First, significantly more interaction with enrichment was observed on feeding days than in the pre-feeding phase. This could be due to seasonal changes in enrichment, particularly an increase in the use of browse as it became more available starting in late spring. The addition of browse to enrichment could have increased the duration or number of occasions on which the zebra interacted with enrichment. In the future, quantity and type of enrichment, and the time it was given, should be incorporated into analyses of behaviour to better determine the cause of any changes in behaviour.

Other significant differences in non-stereotypic zebra behaviours included fewer instances of hay eating and more instances of being stationary on non-feeding days compared to the other time periods. Once a timed hay feeder was programmed to release hay shortly before and during feedings, zookeepers and giraffe going to the feed deck on feeding days could have served as a cue to hay being available at that feeder, leading to more hay eating on feeding days than on non-feeding days, when that cue did not occur. Additionally, it is possible that on feeding days and in the pre-feeding phase, the movement to the feed deck by zookeepers and giraffe stimulated more locomotion by the zebra, but there was significantly more locomotion on non-feeding days than in the pre-feeding phase. The dataset consisted of only 30 observations per animal on non-feeding days compared to feeding days (76 per animal) and the pre-feeding phase (64 per animal), so more data are required to examine and draw robust conclusions from these particular comparisons.

With regards to the multi-point sampling method used, Margulis and Westhus (2008) advise that it may be less accurate than traditional scan sampling for rare behaviours (<15% of activity budget). However, they also note that by 50 observation sessions, the error rates for rare and common behaviours are similar. Thus, although stereotypic behaviour, for example, was rare in this study, 170 behavioural observations were collected per animal, so there is reasonable confidence in the accuracy of the data collected using this less time-intensive and more zookeeper-friendly method. Indeed, some researchers argue that collecting just a few observations per day over many days is more appropriate for behavioural monitoring than observing for a few long periods of time, and can yield valid results (Margulis and Westhus 2008; Watters et al. 2009).

One limitation of this study is that measures were not taken to assess and ensure that the zookeepers were labelling the animals' behaviours consistently. The zookeepers had varying degrees of experience in making behavioural observations and there was no training to confirm whether they made accurate and consistent judgments of the animals' behaviours. Ensuring good inter-observer reliability reduces bias and increases confidence in the accuracy of behavioural observations (Burghardt et al. 2012; Caro et al. 1979; Kaufman and Rosenthal 2009; Wark et al. 2021). Future studies involving multiple observers, including those where data are collected by zookeepers, should incorporate an initial training period where observers must meet an acceptable inter-observer reliability criterion before data collection begins. This is

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critical to ensuring that the data collected are accurate and the conclusions drawn from that data are meaningful.

Another limitation of this study is that data were only collected for three giraffe and three zebra. Although the data provide valuable information regarding the effects of this particular giraffe feeding programme on the behaviour of these particular animals, much more data are needed in order to determine the effects of public feeding programmes more generally. This includes investigating physiological measures ostensibly related to stress, such as glucocorticoid concentrations (Keay et al. 2006; Sherwen and Hemsworth 2019), as some research indicates that behaviour alone may not be an accurate proxy for stress, and it is still unclear how various measures relate to each other and more broadly to welfare (Mason and Latham 2004). Additionally, due to variety in giraffe feeding procedures, exhibits and husbandry practices between zoos, no single-zoo study will be able to provide definitive conclusions and recommendations regarding giraffe feeding programmes. However, these naturally-occurring differences can be leveraged to determine whether certain factors impact welfare. Thus, single-zoo studies like the one described here, which are more feasible for zoos to conduct than larger-scale studies, can collectively inform zookeepers about the effects of public feeding programmes on giraffe welfare.

In summary, using a zookeeper-friendly multi-point scan method, there was no evidence of negative impact of a giraffe public feeding programme on the behaviour of the participating giraffe and cohabitant zebra. The rate of giraffe stereotypic behaviour was unaffected by the number of guests at feedings and did not increase over time. There were individual differences in rates of stereotypic behaviour in giraffe, as well as differences in rates of non-stereotypic behaviour between study phases for both species, which warrant further investigation.

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References

Altmann J. (1974) Observational study of behavior: sampling methods. *Behaviour* 49(3-4): 227–266.

Acaralp-Rehnberg L. (2019) Human-Animal Interaction in the Modern Zoo: Live Animal Encounter Programs and Associated Effects on Animal Welfare. PhD thesis, University of Melbourne.

Bristow D.J., Holmes D.S. (2007) Cortisol levels and anxiety-related behaviors in cattle. *Physiology and Behavior* 90(4): 626–628.

Broom D.M. (1991) Animal welfare: Concepts and measurement. *Journal of Animal Science* 69(10): 4167–4175. doi:10.2527/1991.69104167x

Burghardt G.M., Bartmess-LeVasseur J.N., Browning S.A., Morrison K.E., Stec C.L., Zachau C.E., Freeberg T.M. (2012) Perspectives – Minimizing observer bias in behavioral studies: A Review and recommendations. *Ethology* 118(6): 511–517. doi:10.1111/j.1439-0310.2012.02040.x

Canino W., Powell D. (2010) Formal behavioral evaluation of enrichment programs on a zookeeper's schedule: A case study with a polar bear (*Ursus maritimus*) at the Bronx Zoo. *Zoo Biology* 29(4): 503–508.

Caro T.M., Roper R., Young M., Dank G.R. (1979) Inter-observer reliability. *Behaviour* 69(3–4): 303–315. doi:10.1163/156853979X00520

D'Cruze N., Khan S., Carder G., Megson D., Coulthard E., Norrey J., Groves G. (2019) A global review of animal–visitor interactions in modern zoos and aquariums and their implications for wild animal welfare. *Animals* 9(6): 332. doi:10.3390/ani9060332

de Mori B., Ferrante L., Florio D., Macchi E., Pollastri I., Normando S. (2019) A protocol for the ethical assessment of wild animal-visitor interactions (AVIP) evaluating animal welfare, education, and conservation outcomes. *Animals* 9(8): 487. doi:10.3390/ani9080487

Duggan G., Burn C.C., Clauss M. (2016) Nocturnal behavior in captive giraffe (*Giraffa camelopardalis*)-A pilot study. *Zoo Biology* 35(1): 14–

Fernandez E.J., Tamborski M.A., Pickens S.R., Timberlake W. (2009) Animal-visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science* 120(1–2): 1–8.

Fureix C., Meagher R.K. (2015) What can inactivity (in its various forms) reveal about affective states in non-human animals? A review. *Applied Animal Behaviour Science* 171: 8–24. doi:10.1016/j.applanim.2015.08.036

Gold K.C., Maple T.L. (1994) Personality assessment in the gorilla and its utility as a management tool. *Zoo Biology* 13(5): 509–522. doi:10.1002/zoo.1430130513

Górecka-Bruzda A., Fureix C., Ouvrard A., Bourjade M., Hausberger M. (2016) Investigating determinants of yawning in the domestic (*Equus caballus*) and Przewalski (*Equus ferus przewalskii*) horses. *The Science of Nature* 103: 72. doi:10.1007/s00114-016-1395-7

Heinze G., Ploner M., Jiricka L. (2020) *logistf: Firth's Bias-Reduced Logistic Regression* (1.24; p. 33). https://cran.r-project.org/web/packages/logistf/index.html

Herskin M.S., Munksgaard L., Ladewig J. (2004) Effects of acute stressors on nociception, adrenocortical responses and behavior of dairy cows. *Physiology and Behavior* 83(3): 411–420.

Holm S. (1979) A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics* 6(2): 65–70.

Hosey G.R. (2005) How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science* 90(2): 107–129. doi:10.1016/j.applanim.2004.08.015

Kaufman A.B., Rosenthal R. (2009) Can you believe my eyes? The importance of interobserver reliability statistics in observations of animal behaviour. *Animal Behaviour* 78(6): 1487–1491. doi:10.1016/j.anbehav.2009.09.014

Keay J.M., Singh J., Gaunt M.C., Kaur T. (2006) Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. *Journal of Zoo and Wildlife Medicine* 37(3): 234–244. doi:10.1638/05-050.1

Kreger M.D., Mench J.A. (1995) Visitor—animal interactions at the zoo. *Anthrozoös* 8(3): 143–158. doi:10.2752/089279395787156301

Lüdecke D., Ben-Shachar M.S., Patil I., Waggoner P., Makowski D. (2021) performance: An R package for assessment, comparison and testing of statistical models. *Journal of Open Source Software* 6(60): 3139. doi:10.21105/joss.03139

Lynn B.L. (2018) *Zoo Giraffe Welfare: A Literature Review and the Behavioral Effects of Guest Feeding Programs.* MS thesis, University of California Davis.

Mansour A.A.H., Zakaria A.H., Fraser A.F. (2000) Effect of enclosure quality on reactivity and welfare of captive Soemmerring's gazelle (*Gazella soemmerringii*). *Journal of Applied Animal Welfare Science* 3(4): 335–343. doi:10.1207/s15327604jaws0304_5

Margulis S.W., Rafacz M., Jacobs B. (2005) Quantifying the effectiveness of environmental enrichment: Lessons learned and rules of thumb. In: Clum N., Silver S., Thomas P. (eds.). *Proceedings of the Seventh International Conference on Environmental Enrichment*. Bronx, New York: Widlife Conservation Society, 219–226.

Margulis S.W., Westhus E.J. (2008) Evaluation of different observational sampling regimes for use in zoological parks. *Applied Animal Behaviour Science* 110(3–4): 363–376. doi:10.1016/j.applanim.2007.05.001

Mason G.J., Latham N.R. (2004) Can't stop, won't stop: Is stereotypy a reliable wefare indicator? *Animal Welfare* 13(1): 57–69.

Mason G., Rushen J. (eds.). (2006) *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare*. Second edition. Wallingford, UK: CABI.

Normando S., Pollastri I., Florio D., Ferrante L., Macchi E., Isaja V., de Mori B. (2018) Assessing animal welfare in animal-visitor interactions in zoos and other facilities. A pilot study involving giraffes. *Animals* 8(9): 153. doi:10.3390/ani8090153

Orban D.A., Siegford J.M., Snider R.J. (2016) Effects of guest feeding programs on captive giraffe behavior. *Zoo Biology* 35(2): 157–166.

Polgár Z., Wood L., Haskell M.J. (2017) Individual differences in zoo-housed squirrel monkeys' (*Saimiri sciureus*) reactions to visitors, research participation, and personality ratings. *American Journal of Primatology* 79(5): e22639. doi:10.1002/ajp.22639

Rajagopal T., Archunan G., Sekar M. (2011) Impact of zoo visitors on the fecal cortisol levels and behavior of an endangered species: Indian blackbuck (*Antelope cervicapra* L.). *Journal of Applied Animal Welfare Science* 14(1): 18–32. doi:10.1080/10888705.2011.527598

Razal C.B., Bryant J., Miller L.J. (2017) Monitoring the behavioral and adrenal activity of giraffe (*Giraffa camelopardalis*) to assess welfare during seasonal housing changes. *Animal Behavior and Cognition* 4(2): 154–164. doi:10.12966/abc.03.05.2017

Seeber P.A., Ciofolo I., Ganswindt A. (2012) Behavioural inventory of the giraffe (*Giraffa camelopardalis*). *BMC Research Notes* 5: 650.

Sekar M., Rajagopal T., Archunan G. (2008) Influence of zoo visitor presence on the behavior of captive Indian gaur (*Bos gaurus gaurus*) in a zoological park. *Journal of Applied Animal Welfare Science* 11(4): 352–357. doi:10.1080/10888700802330093

Sellinger R.L., Ha J.C. (2005) The effects of visitor density and intensity on the behavior of two captive jaguars (*Panthera onca*). *Journal of Applied Animal Welfare Science* 8(4): 233–244. doi:10.1207/s15327604jaws0804_1

Shen-Jin L., Todd P.A., Yan Y., Lin Y., Hongmei F., Wan-Hong W. (2010) The effects of visitor density on sika deer (*Cervus nippon*) behaviour in Zhu-Yu-Wan Park, China. *Animal Welfare* 19(1): 61–65.

Sherwen S.L., Hemsworth P.H. (2019) The visitor effect on zoo animals: Implications and opportunities for zoo animal welfare. *Animals* 9(6): 366. doi:10.3390/ani9060366

Spooner S.L., Farnworth M.J., Ward S.J., Whitehouse-Tedd K.M. (2021) Conservation education: Are zoo animals effective ambassadors and is there any cost to their welfare? *Journal of Zoological and Botanical Gardens* 2(1): 41–65. doi:10.3390/jzbg2010004

Stoinski T.S., Jaicks H.F., Drayton L.A. (2012) Visitor effects on the behavior of captive western lowland gorillas: The importance of individual differences in examining welfare. *Zoo Biology* 31(5): 586–599. doi:10.1002/zoo.20425

Swanagan J.S. (2000) Factors influencing zoo visitors' conservation attitudes and behavior. *Journal of Environmental Education* 31(4): 26–31. doi: 10.1080/00958960009598648

R Core Team (2021) *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Foundation for Statistical Computing.

Tofield S., Coll R.K., Vyle B., Bolstad R. (2003) Zoos as a source of free choice learning. *Research in Science and Technological Education* 21(1): 67–99. doi:10.1080/02635140308342

Wark J.D., Wierzal N.K., Cronin K.A. (2021) Gaps in live inter-observer reliability testing of animal behavior: A retrospective analysis and path forward. *Journal of Zoological and Botanical Gardens* 2(2): 207–221. doi:10.3390/jzbg2020014

Watters J.V., Margulis S.W., Atsalis S. (2009) Behavioral monitoring in zoos and aquariums: A tool for guiding husbandry and directing research. *Zoo Biology* 28(1): 35–48. doi:10.1002/zoo.20207

Wickham H. (2016) ggplot2: *Elegant Graphics for Data Analysis*. New York, New York: Springer-Verlag. https://ggplot2.tidyverse.org

Williams E., Carter A., Rendle J., Ward S.J. (2021) Impacts of COVID-19 on animals in zoos: A longitudinal multi-species analysis. *Journal of Zoological and Botanical Gardens* 2(2): 130–145. doi:10.3390/jzbg2020010

Wolfensohn S., Shotton J., Bowley H., Davies S., Thompson S., Justice W.S.M. (2018) Assessment of welfare in zoo animals: Towards optimum quality of life. *Animals* 8(7): 110. doi:10.3390/ani8070110

Woods B. (2002) Good zoo/bad zoo: Visitor experiences in captive settings. *Anthrozoös* 15(4): 343–360. doi:10.2752/089279302786992478