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DOI link to the version of record on the publisher’s website.
Understanding impacts of zoo visitors: Quantifying behavioural changes of two popular zoo species during COVID-19 closures

1 This paper is part of the Special Issue 'COVID-19: Rethinking confinement' based on the 2020 ISAE conference

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Abstract

Visitors are normally a prominent and constant feature in a zoo animals’ environment with more than 700 million people visiting zoos and aquariums worldwide, annually. Animal-visitor interactions can be enriching and stimulating and are now considered within the Five Domains of animal welfare assessment. Zoo closures as a result of COVID-19 provided a unique opportunity to monitor the impact of abrupt and prolonged removal of visitors on two popular zoo
species. Data were collected at four facilities (n=3 slender-tailed meerkats, n=1 African penguin) during COVID-19 zoo closures and up to one month following reopening to the public. Meerkats showed increased positive social interactions, increased alert behaviours, and reduced environmental interactions in the first month post-opening, as compared to closure periods. They also used more of their enclosures during periods of closure and spent longer than would be expected in zones furthest from visitor viewing areas when facilities reopened. African penguins showed no behavioural change between open and closure periods. Enclosure usage during both observation periods was relatively even and no differences were observed in enclosure use between open and closure periods. These results will enable an advanced understanding of the impact that people have on the behaviour of zoo animals, which has ramifications for animals used in close encounters and other ‘visitor experiences’ in the future.

Understanding relationships between animals and people is applicable in all managed animal settings. The results from this study are of practical use in managing visitor access to animals moving forwards, including enclosure location and design, to ensure a positive visitor experience that does not negatively impact animal behaviour.

Key words: penguins, meerkats, COVID-19, zoo, behaviour, welfare
Worldwide closure of zoos and aquariums during the COVID-19 pandemic led to an abrupt cessation in visitor interactions for a range of animal species. Visitors are a prominent and constant feature in a zoo animals’ environment with more than 700 million people visiting zoos and aquariums worldwide on an annual basis (WAZA, 2020). The animal-visitor relationship can be enriching and stimulating (Sherwen & Hemsworth, 2019). However, existing research provides limited ‘visitor free’ opportunities, and none of these are within ‘normal’ zoo opening hours. COVID-19 closures provided a unique opportunity to monitor the impact of abrupt (and prolonged) removal of visitors, and thus enhance our understanding of ‘visitor effects’ in this true presence/absence study.

Animal responses to visitors under normal zoo-opening hours are varied (Sherwen & Hemsworth, 2019), and even within species, individuals can respond differently (Davey, 2007). Since zoo closures were implemented, anecdotal zoo reports have also indicated mixed behavioural responses in a number of species. Some animals have been ‘hiding’ from staff due to a lack of people around their enclosures (Steger, 2020), some have been exploring their enclosures more (Gandhiok, 2020) and others have been calling to keepers to attract attention (Mack, 2020). Meerkats (Suricata suricatta) at Wellington Zoo were ‘keenly aware of the absence of visitors’ (Roy, 2020) and at Adelaide Zoo keepers employed novel forms of enrichment outside of the meerkat enclosure after they
noticed their meerkats were less active than normal (Eckert, 2020).

Meanwhile, Singapore State zoo took their African penguins (Spheniscus demersus) on tours around the zoo in a bid to counteract the lack of stimulation from the loss of zoo visitors (Fahey, 2020).

Slender-tailed meerkats and African penguins are common across zoological facilities (Sherwen et al., 2014; Saiyed et al., 2019) and frequently have high levels of interaction with members of the public. Worldwide there are 493 institutions housing meerkats and 297 housing African penguins registered on the ZIMS database, 323 and 162 of which are European facilities (Species 360, 2020). Not only are these species popular in terms of presence in zoos, they are also considered to be species that visitors are keen to see and are often used as ambassador species. In a study at Durrell Wildlife Park, 57/444 surveyed zoo visitors voted meerkats as one of their favourite animals at the zoo, coming fourth behind western lowland gorillas (Gorilla gorilla gorilla), Sumatran orangutans (Pongo abelii) and oriental short-clawed otters (Aonyx cinereus) (Carr, 2016).

Ambassador animals in zoos are those involved in personal experience or encounter programmes (Whitehouse-Tedd et al., 2018). Typically, they involve animals coming into close contact with the public either within their habitat or when brought into the public's space (Powell et al., 2020) and usually involve animals with which the public engage well. Personal experience/encounter programmes are becoming increasingly common in zoological
facilities (Ward & Sherwen, 2019), and many facilities that house meerkats and penguins run ‘animal encounters’ with these species.

Previous reports suggest that behavioural responses of meerkats and penguins to human-animal interactions during normal zoo opening hours are variable. Sherwen et al. (2014) found meerkats at three separate facilities to be ‘behaviourally unresponsive’ to changes in visitor behaviour, with no changes in behaviour or enclosure use observed. Others have reported increased faecal glucocorticoid metabolites in relation to increased visitors (Scott et al., 2017). When little penguins (*Eudyptula minor*) had their exhibit closed to the public on five randomised study days they displayed reduced aggressive social interactions and huddling behaviours and spent time closer to the visitor viewing area, which were presumed to be indicative of fear-responses to visitor presence during opening hours (Sherwen et al., 2015). Other research has shown more positive responses to humans. African penguins habituate to human presence after prolonged exposure (Ozella, 2015). Furthermore, controlling visitor behaviour and/or enabling penguins to have control over the interaction led to positive behavioural change in little penguins and African penguins. When visitors were 2m from the penguin enclosure and they were unable to make loud noises or threatening displays, fewer penguins were vigilant, huddling or retreating and more penguins were close to the visitor viewing area (Chiew et al., 2019). In programmes where African penguins have control over their interactions with visitors, positive behavioural
indicators of welfare are observed, with penguins spending longer interacting with the public than conspecifics (Saiyed et al., 2019). The novelty of visitors and diversity in their behaviour may also cause animals to seek out interactions (Hosey, 2005; Bloomfield et al., 2015).

Whilst behavioural responses to zoo visitors differ or may be dependent on the density of zoo visitors, animals may habituate to human visitors (Sherwen & Hemsworth, 2019). However, the prolonged absence of zoo visitors may lead to animals habituating to a lack of visitors and a quieter environment. Interactions with zoo visitors can be a source of enrichment or behavioural stimulation for species and there are anecdotal reports which suggest that zoo species engage in attention-seeking behaviours during zoo opening hours (Sherwen & Hemsworth, 2019). There are no published reports of either meerkats or penguins actively seeking interactions with human visitors, but their high frequency of interactions with visitors during ‘animal encounters’ makes them an excellent study species for determining whether the COVID-19 zoo closures and the consequential removal and reinstatement of visitors have impacted on their behaviour. Whilst zoo staff have anecdotally highlighted temporal behavioural shifts in animals (Colwill, pers comm) and reports in the media have suggested some animals were ‘seeking out’ interactions with zoo keepers during closure periods (Williams & Rendle, 2020); to date no research has been undertaken which
investigates the impacts of zoo closures in a systematic and repeatable manner.

The aim of this research was to systematically analyse data collected opportunistically by zoo staff during this unique period. This paper is presented as a case study, focusing on behaviour of two species which are traditionally used in public interactions and visitor encounters. The objective of this paper was to document behavioural changes in slender-tailed meerkats and African penguins between enforced closure periods and the first month of facilities reopening. We hypothesised that animals would show increased interest in public and would seek positive human-animal interactions. We also hypothesised that animals of these species would spend longer periods of time than were expected by chance in areas of their enclosure that were closest to the public once facilities reopened.

2. Methods

2.1. Subjects and study sites

Subjects were slender-tailed meerkats (n = 3 study sites, UK) and African penguins (n = 1 study site, South Africa). The level of public interaction pre COVID-19 facility closures varied across study sites and was only partially reinstated when facilities reopened (Table 1). Descriptions of the enclosures and visitor viewing areas are provided in Table 2.
2.2. Data collection

2.2.1. Behavioural observations

Zoo staff collected data whilst their facility was still closed to the public and during the first month after visitors were allowed back on site (June to August 2020). Once the sites were open, visitor numbers varied according to their local government restrictions, however all facilities had a significant decrease in visitor numbers compared to pre-COVID times. Behavioural observations were undertaken 1 to 4 times per day, according to staff availability (Table 1). Each observation period lasted five minutes. Number of observations per site in open and closed conditions were: Site A - 86 closed, 83 open; Site B - 12 closed, 57 open; Site C - 6 closed, 12 open; Site D - 29 closed, 50 open.

Time of behavioural observations varied between facilities, but observations were split relatively evenly throughout the working day to ensure that observations covered periods of time when facilities were open to visitors (sites A, B and C: pre 11:00, 11:00 – 13:00, 13:00 – 17:00, site D: 06:00 – 09:00, 09:00 – 12:00, 12:00 – 15:00, 15:00 – 16:00) and were kept consistent within facilities.

Observations were not taken during periods when keepers were interacting directly with the animals (e.g. for training or feeding). All observers were experienced with the study subjects and had extensive experience of behavioural observations as part of routine animal management protocols.
Table 1. Details of study sites, periods of data collection and interactions with the public* at each facility

| Study site | Species (number of individuals) | Period of data collection | Date of reopening | Frequency of observations | Number of observation days | Public interactions pre-facility closure | Public interactions post facility closure |
|------------|---------------------------------|---------------------------|-------------------|--------------------------|---------------------------|-----------------------------------------|-----------------------------------------|
| A          | Meerkats (n=2, 1M 1 F)          | June – August 2020        | Mid July 2020     | 3 per day                | 29                        | No encounters                           | No encounters                           |
| B          | Meerkats (n=7, 4M 3F)           | June – July 2020          | Mid-June 2020     | 2 – 4 per day            | 24                        | Public talks and encounters             | Encounters commenced but no public talks |
| C          | Meerkats (n=10, 10 M)           | June – July 2020          | Mid-June 2020     | 1 – 2 per day            | 8                         | Public talks and encounters             | Encounters commenced but no public talks |
| D          | African Penguins (n=58, 24M 34F)| August – September 2020  | Late-August 2020  | 1 – 3 per day            | 19                        | Public talks No encounters               | No public talks or encounters            |

*Public talks are sessions where zoo personnel (education staff and/or keepers) interact with visitors at designated times and locations to deliver relevant conservation education messages about specific species or topics. Encounters are an opportunity for visitors to pay for an exclusive experience whereby they safely meet, feed and/or clean particular animals within the zoo’s collection.

Table 2. Details of enclosures at the four study sites

| Site | Enclosure size (approx.) | Description of enclosure boundary | Visitor viewing area (approx.) |
|------|--------------------------|----------------------------------|--------------------------------|
| A    | 25m²                     | Wooden with glass window viewing areas | Two 2m glass viewing windows within the wooden boundary |
| B    | 258m²                    | Wooden half rounds with 2ft of gravel and an electric fence on | 32m of the 70m perimeter accessible to public |
At each 5-minute sampling period, behaviours being performed by the animals were recorded using instantaneous scan sampling with a one-minute inter-scan interval. Due to the number of individuals within the study groups the whole group was treated as one sample point. All behaviours being performed by individuals within the group were recorded which enabled identification of presence or absence of behaviours within the study group, at each behavioural scan. A sum total of frequency of behaviours at each five-minute scan was then used to create a single observation period for statistical analysis. Behaviours were recorded according to a pre-defined ethogram (Table 3).

Table 3. Ethogram of behaviours for meerkats and penguins recorded during the study period (adapted from Sherwen et al., 2014 and Sherwen et al., 2015)

| Behaviour                                      | Description                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| Vigilant                                       | Alert - showing a heightened awareness of their environment (including looking at visitors) |
| Human-animal interaction (positive)            | Moving towards or seeking interaction from humans                           |

| C     | 176m² | Stone wall with intermittent glass viewing panels. Wood and brick indoor/house with viewing window | Three 2m glass viewing windows within the stone boundary, one 1.5m viewing window within the indoor/house |
| D     | 83m² land, 155m³ water | Stone wall around the land section, blue walls with glass viewing areas next to water areas. | 21m of the 45m perimeter is around the water area. 10m of glass viewing windows including an underwater viewing window. |
| Human-animal interaction (negative) | Avoiding, moving away from or showing fear of humans |
|------------------------------------|-----------------------------------------------------|
| Foraging/feeding                   | Locating and consuming foodstuffs                    |
| Comfort                            | Any self-maintenance or self-grooming behaviour      |
| Social (positive)                  | Engaging in positive social behaviours (e.g. social play, grooming) |
| Social (negative)                  | Engaging in negative social behaviour (e.g. fighting, displaying) |
| Locomotion                         | Moving around the enclosure (on land or in water) in a non-repetitive pattern |
| Interaction with the environment   | Investigating or interacting with things in the environment (other than food). For meerkats this also included digging behaviour. |
| Resting/sleeping                   | Sitting or lying motionless with eyes closed. No other behaviour is being performed. |
| Abnormal repetitive behaviour (ARBs)| Repetitive behaviour with no obvious function or purpose |
| Vocalising<sup>p</sup>             | Production of a sound                                |
| Preening<sup>p</sup>               | Using beak to peck, stroke, or comb feathers in any region of the body |
| Other                              | Any other behaviour not detailed in the ethogram     |
| Out of sight                       | Animal out of sight of observer                      |

<sup>p</sup> Behaviour only recorded for penguins

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2.2.2. **Enclosure usage**

Meerkat enclosures were split into approximately three equal zones (closest third to visitors, middle third, third furthest away from visitors). Penguin enclosure usage was split into six zones: three on land (area 1: 49m², area 2: 24m², area 3: 10m²) and three in the water (62m³, 35m³, 58m³). Locations with animals in were recorded at the start of each observation period. All areas of the enclosure in which individuals were in were recorded.
Data was split into two periods for analysis: (i) during COVID-19 closures, no visitors and skeletal staff (hereafter ‘closed’), (ii) the first month post-reopening, visitors present but under local government social distancing restrictions i.e. reduced numbers compared to ‘normal’ (hereafter ‘open’). To account for variation in data collection periods, differences in site/local government restrictions, and potential numbers of visitors entering different facilities, all statistical analysis was done ‘within zoo’. Results are compared across facilities to aid in interpretation of findings. Significance values were set at 0.05, unless corrected for pairwise comparisons. Changes in frequency of behaviour when closed versus when open were assessed using R Studio Version 3.6.1 (R Core Team, 2019) using a Mann-Whitney U Test.

For meerkats inferential statistics were performed on vigilance, positive human-animal interactions, feeding, comfort, positive and negative social interactions, locomotion, interaction with the environment, resting, abnormal repetitive behaviours (ARBs) and out of sight. Negative HAI’s were not analysed due to low frequency of occurrence (n = 7 observations at Zoo B). For penguins, inferential statistics were performed on preening, resting, vocalising, positive social interactions and locomotion. Vigilance (n=5 observations) and HAI’s (n=1 observation) were not analysed due to low occurrence. ARBs were not observed during either open or closed periods.
Statistical analyses related to enclosure usage were undertaken using SPSS Version 26 (SPSS Inc., Chicago, IL). The spread of participation index (Dickens, 1955; Plowman, 2003) was used to evaluate enclosure zone usage using the formula: SPI = \( \frac{S | f_o - f_e |}{2(N - f_{e\min})} \) whereby \( f_o \) is the observed frequency of scans in each zone, \( f_e \) is the expected frequency for each zone and \( f_{e\min} \) the expected frequency in the smallest zone. A value of 0 suggests equal use of all zones, whereas a value of 1 suggests exclusive use of one zone. Differences in SPI values between closed and open periods were analysed using a paired samples \( t \)-test. To determine how enclosure use differed (in terms of use of enclosure zones) during the two data collection periods (open and closed) a chi-square test of independence with Bonferroni-corrected post hoc tests (corrected significance value of \( p<0.008 \)) was applied.

2.4. Ethics statement

All research protocols were approved by Nottingham Trent University, School of Animal, Rural and Environmental Sciences School Ethics Group (reference number ARE192042) and meets the ARRIVE guidelines where necessary. Permission to conduct the study was granted by the participating zoos prior to commencement of data collection.

3. Results

The frequency of observations during closed and open periods ranged across facilities (Site A: 86 closed, 83 open; Site B: 12 closed,
Changes were observed in behaviour and enclosure usage, although this varied across facilities. An overview of all meerkat behaviour is detailed in Figure 1 and penguin behaviour in Figure 2. A breakdown of meerkat and penguin behaviour per week after facility reopening are provided in Tables 4a and b. Statistically significant changes in frequency of behaviours are reported as mean observations per observation period ± standard deviation throughout. Each behaviour could have been recorded a maximum of six times per observation period.
Figure 1a and b. An overview of slender-tailed meerkat behaviour during facility closure and open periods. Mean values are based on frequency of behaviour performed by the study group per five-minute observation period (maximum frequency of observations was six per five-minute period). Error bars represent standard deviation.
Figure 2. An overview of African penguin behaviour during facility closure and open periods. Mean values are based on frequency of behaviour performed by the study group per five-minute observation period (maximum frequency of observations was six per five-minute period). Error bars represent standard deviation.
Table 4a. Mean±SD frequency of behaviour performed by the study group per 5-minute observation (maximum 6 scans per behaviour) for meerkats at Zoos A to C

| Behaviour                          | Zoo A                         | Zoo B                          | Zoo C                          |
|------------------------------------|-------------------------------|-------------------------------|-------------------------------|
|                                    | Closed | 1 | 2 | 3 | 4 | 5 | Closed | 1 | 2 | 3 | 4 | 5 | Closed | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Vigilant                           | 0.6±1.1 | 0.3±0.6 | 0.6±1 | 0.6±1 | 0.9±0.9 | 0.2±0.4 | 4.3±1.8 | 4±1.8 | 5.2±1.4 | 3.7±1.8 | 3.3±2.3 | 5.5±0.9 | 2.2±2.4 | 5.5±0.5 | 4±2 | 4.8±1.1 |
| HAI positive                       | 0 | 0 | 0 | 0 | 0.2±0.5 | 0 | 0.8±0.8 | 0.9±0.7 | 0.9±1.6 | 0.3±0.5 | 0.6±0.7 | 1.8±1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HAI negative                       | 0 | 0 | 0 | 0 | 0 | 0 | 0.1±0.3 | 0.1±0.3 | 0 | 0 | 0 | 1±1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feeding                            | 0.4±1 | 0.1±0.3 | 0.1±0.5 | 0.1±0.3 | 1±1.5 | 0 | 4.8±1.7 | 4±2 | 4.9±1.4 | 5±1.2 | 3.3±1.9 | 3.5±2.2 | 2.3±2.1 | 5.3±0.8 | 2±1 | 5±1.4 |
| Comfort                            | 0.4±0.7 | 1.1±1.5 | 0.4±0.8 | 0.4±1.1 | 0.1±0.4 | 0.6±1.2 | 0.9±1.7 | 1.4±1.6 | 0.6±1.1 | 1.1±2.1 | 2.3±2.4 | 1.8±1.8 | 0.2±0.4 | 0 | 1±0 | 0.3±0.5 |
| Positive social                    | 0 | 0 | 0 | 0.1±0.2 | 0.1±0.3 | 0.1±0.3 | 1.1±1.4 | 1.9±1.7 | 2.4±1.8 | 1.9±2 | 3.1±2.2 | 4.5±2.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Negative social                    | 0 | 0 | 0 | 0 | 0 | 0 | 0.3±0.6 | 0.8±0.7 | 1.4±1.3 | 0.7±0.7 | 0.2±0.4 | 0.8±0.8 | 0 | 0.3±0.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Locomotion                         | 0.1±0.3 | 0 | 0.1±0.2 | 0.2±0.4 | 0.2±0.5 | 0 | 4.5±1.7 | 4.7±1.9 | 4.6±2.4 | 4.9±1.6 | 4.6±2 | 1.5±2.6 | 2.5±2.3 | 3.5±2.3 | 6±0 | 4.5±2.1 |
| Interaction with the environment   | 2.2±1.4 | 1.9±1.3 | 1.6±1.2 | 1.3±1.2 | 1.4±1.1 | 2.5±1.6 | 2.1±2.3 | 2±2.2 | 4.6±2.4 | 3.9±2.2 | 3.6±2.4 | 2.3±2.5 | 1.2±1.5 | 2.3±1.5 | 0 | 0.2±0.4 |
| Resting                            | 0.9±1.4 | 1.3±1.2 | 1.6±1.6 | 1.9±1.5 | 0.4±0.8 | 1.5±1.7 | 1.3±1.9 | 1.8±2.4 | 1.1±1 | 1.4±2.1 | 3.1±2.1 | 2.5±1.7 | 3.8±2.7 | 1.5±2.6 | 5±1 | 1.2±1.2 |
| Stereotyping                       | 0.3±0.7 | 0.2±0.4 | 0.3±0.6 | 0.1±0.2 | 0.5±0.7 | 0.1±0.3 | 0 | 0.1±0.3 | 0.1±0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other                              | 0.1±0.3 | 0.1±0.3 | 0.1±0.3 | 0.2±0.5 | 0.1±0.3 | 0.1±0.3 | 0.3±0.4 | 0.3±0.6 | 0.1±0.5 | 0.3±0.7 | 0 | 0.3±0.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OOS                                | 0 | 0 | 0 | 0 | 0 | 0 | 0.3±0.6 | 0.3±0.7 | 0.7±1 | 0.6±0.9 | 0 | 1.5±2.6 | 0 | 0 | 0.5±0.5 | 1.2±2.2 |
Table 4b. Mean±SD frequency of behaviour performed by the study group per 5-minute observation (maximum 6 scans per behaviour) for African penguins at Zoo D

| Behaviour          | Weeks since reopening |
|--------------------|-----------------------|
|                   | Closed | 1  | 2  | 3     |
| Vigilant           | 0      | 0  | 0.2±0.9 | 0     |
| HAI positive       | 0      | 0.1±0.2 | 0  | 0     |
| Preening           | 4.2±2.3 | 4.1±2.6 | 4.6±2 | 5.1±1.9 |
| Positive social    | 0.1±0.4 | 0  | 0.2±0.5 | 0     |
| Locomotion         | 0      | 0.4±1.1 | 0.1±0.5 | 0.4±1.2 |
| Resting            | 4.2±2.5 | 4.9±2.2 | 4.2±2.1 | 5.1±1.9 |
| Vocalising         | 0.9±1.9 | 0.4±1.3 | 0.7±1.8 | 0.8±1.4 |

3.1. Behavioural change

3.1.1. Zoo A

Frequency of environmental interaction was higher during closed periods (2.2±1.4) than open periods (1.7±1.3) (W=4288.5, p=0.021).

Positive social interactions were higher when the facility was open (0.06±0.24), no positive social interactions were observed when closed (W=3354, p=0.022). Human-animal interactions (HAI) were also only performed when the zoo was open (0.06±0.29) (W=3397, p=0.04). No other significant behavioural changes were observed.

3.1.2. Zoo B

Positive social interactions were recorded more frequently when the facility was open (2.39±2.07) than closed (10.8±1.51) (W=214, p=0.039). No other significant behavioural changes were observed.
3.1.3. Zoo C

Meerkats displayed more vigilance behaviour when the zoo was open (4.92±1.31) than when it was closed (2.17±2.64) (W=14.5, p=0.043). No other significant behavioural changes were observed.

3.1.4. Zoo D

Penguins were only observed engaging in preening, resting, vocalising, locomotion and positive social behaviours. No behavioural differences were observed between observations undertaken when the site was closed or open (p>0.05).

3.2. Enclosure usage

On average, across all facilities, SPI values for enclosure usage were higher when facilities were closed (0.53±0.23) than when they were open (0.19±0.09) (t(3)=-3.944, p=0.029) (Table 5).

Table 5. SPI values during open and closed periods at the study zoos

| Facility | Spread of participation index |   |   |
|----------|------------------------------|---|---|
|          | Open | Closed |
| A        | 0.09 | 0.50   |
| B        | 0.20 | 0.57   |
| C        | 0.31 | 0.79   |
| D        | 0.15 | 0.24   |
3.2.1. Zoo A

Enclosure use differed for the meerkats at Zoo A between closed and open periods ($X^2 = 30.166, p < 0.001$). All areas of the enclosure were used by meerkats during both observation periods. However, during closed periods, meerkats spent longer in the period closest to the public viewing area ($Z = 5.47, p < 0.0001$), and less time in the middle ($Z = -4.27, p = 0.00002$) and furthest away zones ($Z = -2.68, p = 0.007362$) than when the facility was open.

3.2.2. Zoo B

There was no difference from what would be expected by chance between enclosure use of meerkats at facility B when the site was closed or open ($p > 0.05$). However, meerkats were only observed in zones furthest from the public during opening periods.

3.2.3. Zoo C

There was no difference from what would be expected by chance between enclosure use of meerkats at facility C when the site was closed or open ($p > 0.05$). However, as with Zoo B, meerkats were only observed in zones furthest from the public during opening periods.

3.2.4. Zoo D

There was no difference from what would be expected by chance between enclosure use of penguins when Zoo D was closed or open.
(p>0.05), and zone use remained relatively equal during both observation periods.

4. Discussion

The importance of understanding the impact of human-animal interactions (HAIs) in animal welfare assessment has recently been highlighted, and HAIs have been incorporated into the most recent Five Domains model (Mellor et al., 2020). Yet traditional research into the impact of zoo visitors on animal behaviour (Hosey, 2000; Davey, 2007; Sherwen & Hemsworth, 2019) does not usually encompass extended periods of time with ‘no visitors’. This research sought to investigate how enforced and extended facility closures during the COVID-19 global pandemic affected behaviour and enclosure usage of two popular zoo species; slender-tailed meerkats and African penguins.

Anecdotal reports had described meerkats and penguins as being among the species which were ‘missing’ zoo visitors (Roy, 2020; Fahey, 2020) and these species are commonly used in animal encounters. We thus anticipated that there would be high levels of interaction seeking behaviour when zoo visitors returned to zoos. Our results showed changes in behaviours performed and enclosure usage. However behavioural responses were variable across species and across collections and our findings were not as clear cut as we had predicted.
4.1. Meerkat behaviour and enclosure usage

Meerkats reduced environmental interaction post opening and increased vigilance, positive social interactions and positive HAIs when facilities were open. Previous researchers have suggested that if visitors are having a positive effect on zoo animals then increases may be seen in affiliative behaviours or increased time spent near visitor viewing areas (Yeates and Main, 2008). If visitors are deemed more negative by the animals then avoidance of visitor behaviours may be performed, with individuals spending larger periods of observations out of sight or further from public viewing areas (Hosey et al., 2009). Scott (2014) reported reduced vigilance in meerkats when higher numbers of visitors were present at the enclosure, alongside increased faecal glucocorticoid metabolites.

Enclosure use was significantly reduced when facilities reopened to the public, and meerkats showed increased use of zones furthest from the public. The reasons for this are unclear but principally we propose three potential theories for this behavioural change: (i) meerkat behaviour during closures was being impacted by the range of enrichment techniques employed by facilities during closures, e.g. scattering of food, to minimise the impacts of reduced visitor presence and prevent boredom (ii) meerkats increased the use of the zones closest to the public during facility closures as they were ‘looking for’ humans as was anecdotally reported by a number of facilities, (iii) the return of visitors has made meerkats retreat to the rear of their enclosures as they are showing some level of fear of
visitors. Meerkat association networks can be affected by the size and complexity of the enclosure (Pacheco Pacheco, 2017) and thus it may be that individual enclosure usage is affected by social relationships and proximity to conspecifics within the group. In order to control for the impact of size and complexity of enclosures, in addition to differences in visitor regulations, enclosure use has been compared within facility for consistency.

Meerkats engage in sentinel behaviour as a form of coordinated vigilance (Rauber & Manser, 2017). Whilst increases in vigilance behaviour were observed there was not a significant increase in period of time spent out of sight of observers. Vigilance behaviour could be indicative of natural curiosity in meerkats. Given the long period of absence of zoo visitors, their presence at enclosures may have been stimulating and interesting (Sherwen & Hemsworth, 2019). The presence of indicators of positive welfare within the group, including positive social interactions and engaging in positive human-animal interactions, suggest the return of visitors was a positive and engaging experience for the meerkats.

4.2. Penguin behaviour and enclosure usage

Penguins did not exhibit any significant behavioural changes, nor was there any difference in their enclosure use or periods of time spent out of sight between open and closed periods. Published reports of penguin responses to visitors are highly variable, which could be due to species differences or enclosure designs. The
majority of HAI in penguins is focused on investigating variation in visitor number and behaviour, rather than looking at prolonged periods of absence. Collins et al (2016) noted increased behavioural diversity, including increased pool use, in a group of gentoo penguins (*Pygoscelis papua*), in response to increased visitor presence. Whilst in little penguins, covering a visitor window led to behavioural changes indicative of improved welfare (e.g. reduced vigilance, increased preening) and increased time spent in front of the visitor viewing area (Chiew et al., 2020).

Visitor numbers were not reported for this study as facilities were undergoing phased reopenings at the time of data collection; the number of visitors on site and individuals at enclosures at any one time were limited due to COVID-19 safety requirements (Rendle, pers comm). Public access at facilities may have been variable due to social distancing guidelines. While private encounters had commenced for meerkats, the penguins studied did not engage in private encounters, either before or after the closure periods. Furthermore, the enclosure had not fully reopened to the public and so the presence of members of the public near their enclosure may not have been so apparent to them. Research into little penguins has found Increasing the distance of zoo visitors from the enclosure leads to reduced fear responses (Chiew et al., 2019).
4.3. Implications for animals, study limitations and areas for further research

The absence of behavioural indicators of negative affective state and in some instances absence of behavioural change, suggests that whilst animals changed how they used their enclosures and behavioural repertoire when visitors returned to facilities, the return of visitors was not necessarily negative for the species studied.

Public talks had not commenced at the study facilities and private encounters were only undertaken at two facilities. The absence of public talks and necessity for social distancing are likely to have led to a reduction in large groups of visitors at any one point in time, which could mitigate the negative effects of large groups of zoo visitors, which have been previously reported in the HAI literature (Davey, 2007). This theory is supported by the absence of behavioural change in the African penguins, whose enclosure was not fully open to the public, and who did not have any private encounters. However, in order to capture general behaviour and minimise potential bias from keeper interactions during feeding times, observations were not taken during feeding times, when there is the potential for slightly larger visitor groups to be at enclosures. The results reported here should be investigated further, to increase our understanding of ‘the visitor effect’ and to ascertain the impact of visitors (and number of visitors at enclosures) on animal behaviour and welfare throughout the day.
Collection of data a minimum of two months after facility closures enabled the opportunity to understand impacts of visitor removal, beyond immediate responses to the novel, quieter environments that zoo animals were presented with immediately after site closure. Analysis of animal behaviour immediately post reopening was designed to capture initial reactions to the return of zoo visitors, which may have been viewed by animals as a novel environment. Unfortunately, due to the absence of data from pre-facility closures it is not possible to state whether behaviours changed during facility closures and indeed whether behaviour post-opening replicates pre-closure behaviour. Future research should seek to continue to monitor long-term changes in animal behaviour in order to understand how animals habituate to human visitors within zoological facilities, and to determine if there is an optimum number of visitors for these popular species. If meerkats do not return to ‘during closure’ enclosure usage then thoughts should be given to enclosure design/visitor access to ensure animals continue to use their enclosures widely, despite the presence of zoo visitors. Work should also seek to understand whether other species, who may have had differing levels of relationships with visitors pre-closure periods, displayed more variable responses, as was anecdotesly reported by media outlets. Finally, due to group size and difficulty in identifying individuals, study populations were treated as a ‘study group’. Future research should seek to investigate whether individual differences are observed where possible, in
recognition of the impact of individual differences on animal experiences within a zoo (Watters & Powell, 2012).

Due to the nature of this project and the need to quantify behavioural responses of animals in an unprecedented situation, observations had to be undertaken opportunistically. Facilities were operating on minimal staffing due to being closed to visitors and this meant that observations could not always be conducted multiple times per day, and more importantly that different members of staff were sometimes needed to undertake the observations. Inter-rater reliability assessments could not be undertaken due to staffing restrictions. Whilst there is the potential for observer discrepancy, all observers were very experienced with the species they were observing and were experienced in behavioural observations, which they undertake as part of routine welfare assessments (BIAZA, 2021).

It is important to note that the methods employed were designed to provide a snapshot assessment of behaviour and thus do not represent ‘full’ activity budgets of the observed animals. Validation of the accuracy of the sampling method would be required in order to determine the representation of full daytime activity. However, consistency of the observations and analysis ‘within facility’ enables an opportunity to investigate accurately behavioural change within these study populations, to determine impacts on group behaviour of facilities closing for a prolonged period of time and reopening.
The limitations described here are inherent in zoo research and where possible and appropriate, measures were put in place to minimise the effect of them (e.g. conducting ‘within zoo’ analysis). However, they must be borne in mind in interpretation of the results. This study sought to use two popular zoo species as a case study to explore the behavioural response of animals that had been anecdotally reported to be ‘missing’ zoo visitors during the COVID-19 global pandemic, when zoo visitors returned. Research such as this is paramount in aiding evidence-based management of animals, which ensures optimum welfare. Whilst this work is a case study over a short period of time, it contributes significantly towards our understanding of the impacts of zoo visitors (or absence of zoo visitors) on animal behaviour. Further work should seek to build on this research, over prolonged periods of time, and in a range of species.

Conclusions

Meerkats and penguins are commonly used in animal encounters and they are a popular species within zoos. The animal-visitor relationship is complex and difficult to quantify, and research typically does not incorporate observations during periods of time when there are ‘no visitors’. The aim of this research was to document behavioural change in slender-tailed meerkats and African penguins, when zoo visitors were absent during COVID-19 facility closures, and facility reopenings. The absence of changes in
behaviour or enclosure use for the penguins suggests that neither lack of visitors during lockdown nor return of visitors post facility closures had a negative effect. Meerkats increased the period of time they spent in zones furthest from zoo visitors but there was not a corresponding significant increase in out of sight behaviour. Conversely, they also engaged in behaviours indicative of positive valence; increased social interactions and positive HAs. Due to the mixed behavioural responses it is not possible to identify in this instance whether visitor presence was ‘stressful’ or ‘enriching’ for the meerkats after a long period of absence from visitors or whether meerkats were showing naturally inquisitive behaviour on the return of zoo visitors. It is advocated that this research is conducted over a longer period of time, to begin to answer the fundamental question of how animals habituate to zoo visitors. Whilst this work is only a pilot study, it highlights the need to further understand the ‘true’ nature of the potential effects of zoo visitors on animal behaviour. Research such as this is extremely important in evidence-based approaches to the management of zoo animals moving forwards, including consideration of enclosure location and design, to ensure positive visitor experiences which do not negatively impact on animal behaviour and welfare.

Acknowledgements

Special thanks are extended to Knowsley Safari Park, Plantasia, Twycross Zoo and uShaka Sea World, a division of the South African Association for Marine Biological Research, who took part in this
research and to Sarah Armstrong, Naomi Davies and other staff members who spent time collecting data under very difficult circumstances, this work would not have been possible without their support. Analysis and report writing has been supported by funding from Nottingham Trent University, for which the authors wish to extend their gratitude.

Conflict of interest

The authors declare no conflict of interest.

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