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THE ZOOLOGICAL GARDEN

A new feeding concept offering species-appropriate animal enrichment and visitor attraction at the same time

Fütterung durch Besucher: Raufutter für im Zoo gehaltene Pflanzenfresser

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Abstract

Zoological gardens are considered important institutions for human-animal interactions. Facilitating human-animal contacts and the simultaneous protection of the animals from possible distress by visitors represent an important task of zoological gardens. We investigated the effects of a new roughage feeding setup for zoo-kept domestic herbivores on both, animals and visitors. In the setup, visitors are provided with roughages to put into feeding troughs for the animals. Data collection via video monitoring of domestic cattle (*Bos primigenius taurus*, *B. p. indicus*) enclosures and associated visitors' areas took place over a 30-day period for two consecutive years at three different zoological gardens. In one zoo the setup was in place in both years, and in the two others it was introduced in the second year prior to data recording. At the two zoos where the feeding regime was introduced, the average daily number of visitors and the overall time they spent together with animals (but not the average time per visitor) increased, as did the number of times that an animal approached a visitor. While there was no difference

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between the years in overall feeding time, feeding was more evenly distributed across the day after the introduction of visitor feeding, with a higher number of feeding bouts per animal. The setup offers possibilities for enhancing welfare of certain animals and simultaneously offering an individual visitor feeding experience.

Keywords: Human-animal interactions, animal welfare, enrichment, visitor feeding experience, activity budget

Introduction

Modern zoological gardens aim to contribute to four main goals: education, scientific research, wildlife conservation and public recreation (Anderson et al., 2003; Fernandez et al., 2009; AZA, 2020). Yet, people are mainly motivated to visit zoos because of entertainment, recreation, or a general passion for animals, rather than for educational reasons (Morgan & Hodgkinson, 1999). According to the European Association of Zoos and Aquariums (EAZA), an effective way of educating visitors and raising their awareness about conservation needs is ensuring that they have a great day out with lots of enjoyment (EAZA, 2013). Thus, zoological gardens cannot meet their goals without entertaining and attracting their visitors. The possibility to be physically close to animals, and possibly even have some actual interaction with them, typically makes a zoological garden very attractive for visitors (Kreger & Mench, 1995; Hosey, 2005). However, visitors may themselves represent a source of distress for the animals on display (Hosey, 2005, 2008). Therefore, zoological gardens have to find a compromise between making animals accessible for their visitors, and protecting their animals from potential negative impacts by the visitors (Hosey, 2000; Davey, 2007; Hosey, 2008; Fernandez et al., 2009).

A traditional way of facilitating positive animal-visitor interaction is to allow feeding by the visitors. In Europe and all over the world, zoos developed different approaches to visitor feeding of their animals (D'Cruze et al., 2019). On the one hand, uncontrolled visitor feeding is prohibited by zoo associations for their members (e.g. EAZA, 2019), but on the other hand, zoos have the ambition to let the zoo experience contain a greater variety of non-traditional ways of engaging with animals, including more complex touch and feeding experiences (Kemper, 2016). Among other enrichment tools, feeding is considered an interactive opportunity that benefits humans and animals alike (Kemper, 2016).

In order to achieve these goals, some institutions sell bags filled with popcorn or pelleted feeds; others use vending machines (typically filled with pelleted feeds), for example near a petting zoo (Michel, pers. obs.). There has been a trend in recent years towards guided visitor feeding experiences by which zoos allow a group of people to feed animals like giraffes (Orban et al., 2016), elephants, hippos, tapirs, meerkats, penguins, sea lions, rainbow lorikeets or tigers together with an animal keeper during a specified time (all authors, pers. obs.; cf. website offerings on zoological gardens' homepages). According to studies that surveyed visitor satisfaction via questionnaires relating to different live animal demonstrations, this approach creates a positive emotional experience (Swanagan, 2000; Anderson et al., 2003; Powell & Bullock, 2014; Luebke et al., 2016). Further evaluation of the questionnaires showed that these interactive experiences also led to educational or conservation advocacy benefits for visitors (Sherwood et al., 1989; Kidd et al., 1995; Swanagan, 2000; Powell & Bullock, 2014; Close & Newbolt, 2017; Martens et al., 2019).

With this background, guided feeding concepts seem to represent a useful strategy to enable animal-visitor contact that may, depending on the approach adopted, also generate additional income for the zoo. However, this additional offer may be difficult to realize during daily routine, especially for smaller zoos. Long-established feeding regimes with low personnel assistance,

such as machines that sell feeds, often rely on attractive, highly digestible and hence potentially unhealthy food items. Because of the begging behavior easily triggered by such regimes and potential negative consequences in terms of obesity, malfermentation and acidosis, this kind of visitor feeding is generally regarded as an undesired activity. In order to address these concerns, pelleted feeds with a high fiber content (with or without the addition of a buffer to prevent acidosis) have more recently been produced and marketed for the use in petting zoos (Odongo et al., 2006; V. Michel & M. Clauss, pers. obs.).

To our knowledge, the educational consequence of feeding such food items to animals has not been explored. Arguably, visitors feeding pelleted feeds or items such as popcorn may not reflect on the nature of the diet items they are using; additionally, they are likely not aware that the items they are feeding are not the natural diets of the respective animals. But even if the latter is the case, they might again not reflect further on the fact, or alternatively trust the zoological institution that these items have been selected to be nutritionally adequate. In any case, the potentially positive interaction with the animals will not include an educational value about their feeding biology. Ironically, the natural diet of many herbivores – forage – is of such a nature that overfeeding, and excessive energy density, are comparatively unlikely. In other words, if visitors fed a grass hay to a grazing herbivore, we would not expect any immediate negative effects, we would still expect positive interaction to occur, and we would additionally assume a more educational experience compared to the feeding of more artificial items. These reflections triggered the present study.

For these reasons, the Naturschutz-Tierpark Görlitz initiated a new visitor feeding concept for herbivores such as cattle (*Bos primigenius*), yaks (*Bos mutus*), sheep (*Ovis aries*), goats (*Capra aegagrus hircus*), ibex (*Capra ibex*), alpacas (*Vicugna pacos*), Bactrian camels (*Camelus bactrianus*), pigs (*Sus scrofa domesticus*), donkeys (*Equus asinus*) and guinea pigs (*Cavia porcellus*), where a limited amount of roughage, as grass hay or fresh grass, is deposited on the visitor side of an enclosure, and visitors can place this in a trough on the enclosure fence. In the case of low visitor numbers, animal keepers ensure that the intended daily amounts are fed. Apart from teaching about the natural diet of the animals, this setup appeared to increase positive associations with visitors on the side of the animals.

In order to investigate the effects of such a feeding regime, we collected data for two consecutive years at three different zoological gardens. At the domestic cattle (*Bos primigenius taurus*) of Görlitz, the described visitor feeding had been in operation in both years. By contrast, a similar visitor feeding system had been introduced at the beginning of the second year only, for domestic cattle at Tierpark Zittau and for zebus (*Bos primigenius indicus*) at the Bergzoo Halle, facilitating a direct comparison between the two treatment years in these two zoos. In our comparison, we focused on both visitor and animal behavior.

Material and methods

Study groups and enclosures

We studied three groups of domesticated cattle at different zoological gardens with different annual visitor numbers, ranging on an annual basis from about 65’000 visitors at Tierpark Zittau (with 70 species on display; 2015: 65’900 visitors, 2016: 64’300 visitors)), 142’000 visitors at the Naturschutz-Tierpark Görlitz (105 species; 2015: 140’111 visitors, 2016: 143’403 visitors)) to 370’000 visitors at the Bergzoo Halle (250 species; 2015: 328’733 visitors; 2016: 409’632 visitors) (all visitor numbers provided by the respective zoos themselves). Unfortunately, more detailed visitor number information (such as the number of visitors present

during study days) was not available. In Görlitz, the animals investigated belonged to the endangered cattle breeds Rotes Hoehenvieh and Altdeutsches Schwarzbuntes Niederungsrind; in Halle animals were dwarf zebus, and in Zittau Fjall cattle. These studies did not constitute animal experiments, and therefore did not require an experimental license. At each zoo, the study was considered either without consequences (Görlitz) or beneficial for the animals. In consultation with the Saxon State Ministry of the Interior, data protection for humans recorded by camera was implemented as indicated in § 6b BDSG (Federal Data Protection Act). In order to avoid behavioral changes of the visitors in front of the monitored enclosures, the legal requirements of signs for camera observation were installed at the entrances of the zoological gardens; the photographic data were deleted after the termination of the study. Details of the different zoos and enclosures are given in Table 1. All cattle groups were kept in enclosures comprising a stable and a paddock/outdoor area. The visitors had access to the front of the enclosures, and in Görlitz and Halle also to parts alongside the lateral fence.

In Halle, the dwarf zebus were associated with Goettingen minipigs, and in Zittau the Fjall cattle were kept together with Romanov-sheep. In Görlitz, cattle were kept without other animals, but with the possibility to get in contact with sheep, goats and alpacas through the fences.

According to the different numbers of animals being kept in the enclosures, the zoos offered varied numbers of roughage feeding places. In 2015, there were three feeding places in Halle and two in Zittau – both without the opportunity for visitor-animal interactions. In 2016, these two zoos established one additional feeding trough at the boundary to the visitors. In Görlitz, there was one feeding trough allowing visitor-animal contacts in each year, and two feeding places inside the stable that were only filled by animal keepers.

The roughage feeding setups for visitors were built following a common principle. One feed trough was installed inside the enclosure of the animals, and another container on the visitors' side (Fig. 1A). Animal keepers filled both troughs with roughage. The three institutions built this "double trough" system in different designs. In contrast to the situation in Görlitz (Fig. 1B) and Halle (Fig. 1C), Tierpark Zittau (Fig. 1D) built a stone slab inside the enclosure instead of a feed trough. The Naturschutz-Tierpark Görlitz (Fig. 1B) and the Tierpark Zittau (Fig. 1D)

Tab. 1: Details about the enclosures, animals and feeding concepts at the Naturschutz-Tierpark Görlitz, the Bergzoo Halle and Zittau Zoo.

Location		Study Year 2015	Study Year 2016
Görlitz	Animals of the study group	0.2 adults 1.0 calf	0.2 adults 1.0 calf
	Visitor feeding setup	1	1
	Feeding places distant from visitors	2	2
	Enclosure area	370 m²	
Halle	Animals of the study group	1.3 adults 1.1 calves	1.3 adults 1.0 calf
	Visitor feeding setup	0	1
	Feeding places distant from visitors	3	3
	Enclosure area	390 m²	
Zittau	Animals of the study group	0.2 adults	0.1 adult
	Visitor feeding setup	0	1
	Feeding places distant from visitors	2	2
	Enclosure area	730 m²	

provided an open box at the visitors' side, and the Bergzoo Halle (Fig. 1C) a closed box with two holes on the upper side to complicate the food removal for visitors. In addition to the food at the visitors' feeding setup, further feedings places without visitors' contact were offered inside the enclosures (zone C, Fig. 2 A-C). Twice a day, all feed troughs were filled with fresh grass, grass hay or a mixture of both.

Data collection

Data on animal and visitor behavior were collected in Autumn/October, November 2015 and Autumn/October, November 2016 over a period of 27 - 34 days. Year 2015 was regarded

Fig. 1: A Basic structure of the roughage feeding setups for visitors: "double trough" system. A large trough is located inside the enclosure of the animals, a smaller one on the visitor's side. **B** Roughage feeding setup at the cattle enclosure at the Naturschutz-Tierpark Görlitz. **C** Roughage feeding setup at the zebu enclosure at Bergzoo Halle. **D** Roughage feeding setup at the cattle enclosure at Tierpark Zittau. Photos: Viktoria Michel.

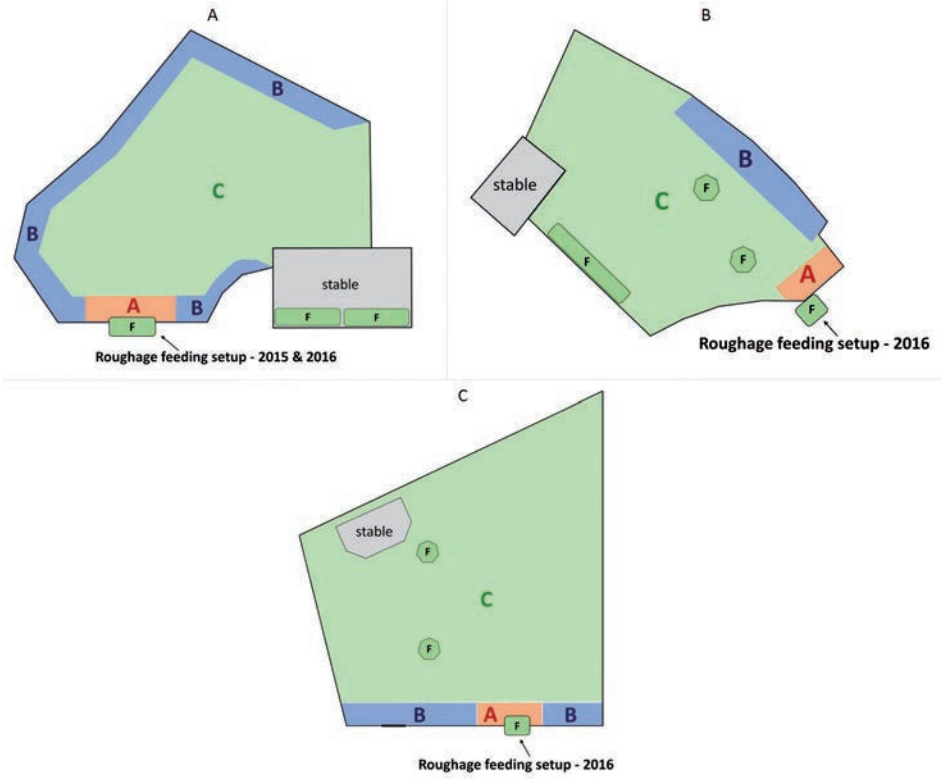

FIGURE 2 Ground plans of the enclosures of the present study. **A** Naturschutz-Tierpark Görlitz, **B** Bergzoo Halle, **C** Tierpark Zittau. Area A: visitor roughage feeding setup and visitor contacts possible, area B: visitor contacts possible, area C: no visitor contacts possible, F: feeding places.

as a previous condition without providing feeding regimes for visitors in Halle and Zittau. In Görlitz, the feeding regimes for visitors already existed in 2015. In Summer 2016, the roughage feeding setups for visitors were established also in Halle and Zittau. This took place three months before the second data monitoring started, to allow the animals to become habituated to the new situation.

The enclosures and associated visitor's areas were monitored via observation cameras (Wild-Vision Full HD 5.0, 12 MP, c/o digame mobile GmbH, 19/06/15). The cameras recorded the surveillance area with ten-second intervals during the opening hours (9:00 am – 6:00 pm). Approximately 180 hours of data were gathered on each enclosure per year. We divided the enclosures into three areas. Area A: visitor feeding station at the enclosure boundary to visitors – inside the enclosure twelve square meters around the feeding station; area B: other regions of boundary to visitors; area C: enclosure parts remote from visitors. Due to limited camera field of vision, the stable and parts around the stable in area C were not observed. In case of heavy rain, animals were entirely fed inside the stable. These days were excluded in the statistical analysis concerning feeding behavior. To record visitor-animal interactions, areas A and B were combined because both regions allowed visitor-animal contacts. The feeding setup in area A indirectly affected area B, as visitors often did not

Tab. 2: The definitions of the measures used to describe animal and human behavior parameters used in this study. All parameters were recorded in numbers (n) and durations (t).

	behavior	animal-visitor contact	areas
Visitor	visitor in front of the enclosure	together with animal	area A area B
		without animal	area A area B
Animal	animal approaches visitor		area A area B
	animal stands	together with visitor	area A area B
	animal stands and eats		area A area B area C
	feeding bouts		area A area B area C

stay exactly in front of the feeding station but looked for contact with animals in area B by luring with food, or watched other people feeding animals in area A from area B.

We did not note individual identities of the animals, but simply recorded the number of animals performing specific behaviors and their duration. The behavior of visitors and their position were recorded in the same way. On each individual photo, we scored the measures in numbers (n); using a sequence of photos, we determined durations (t) (Table 2). We defined one "feeding bout" as a continuous feeding sequence. After a period of at least 20 seconds of alternative behavior, the next feeding bout was counted. We also counted one "feeding bout" when an animal walked towards a feed trough and looked inside for food, even though the trough was empty.

Data were recorded continuously at ten-second intervals, and daily averages were calculated. For both years, the same number of days was evaluated for each zoo, using consecutive days of similar weather conditions, matching weekdays and weekends. Because data were generally not normally distributed, comparisons of daily averages (for all pair-matched days) between the years were performed by non-parametric Wilcoxon signed-rank test using R (R Core Team, 2015), with the significance level set to 0.05.

Results

The attractiveness of the enclosures for visitors

After installing the visitor feeding setups in Halle and Zittau in 2016, the average number of daily visitors who stayed in front of the enclosure increased. In Görlitz, there was no significant change. Correspondingly, the daily visitor presence at the enclosure showed an increase in Halle and Zittau; in Görlitz, by contrast, there was a significant decline. The average stay per visitor did not change in Halle and Zittau, but decreased in Görlitz (Table 3). When dividing the number of year visitors by 365 to estimate the average daily visitor number, and expressing the number of visitors counted at the enclosures in percent of that number, 94% of all visitors stayed at the enclosure in Görlitz in 2015 compared to only 69% in 2016. In Halle, the percentage increased from 27% of all visitors who stayed at the cattle enclosure in 2015 to 50% in 2016 after

the instigation of the new feeding scheme. At Zittau, the increase was of a similar magnitude, from 48% in 2015 to 77% in 2016.

In Halle, the average daily number of visitors that stayed at the enclosure without animals present in the respective zones, as well as the total time spent by these visitors, increased dramatically in 2016. Many visitors were observed trying to lure animals, waving the grass. No change was evident in Zittau, and both measures decreased in Görlitz. In Görlitz, the average time spent per visitor in the absence of animals even decreased, but showed no difference in the other zoos (Table 3).

Visitor-animal interactions

The average daily number of visitors that stayed with animals, and the overall time they spent together with animals, increased in Halle as well as in Zittau in 2016. In Görlitz, there was no significant change. Again, the time spent per visitor together with the animals decreased in Görlitz but did not change in Halle and Zittau (Table 3).

Considering the animals, similar effects appeared. The daily average time animals spent together with visitors in area A and B increased in Halle and Zittau in 2016, but did not change in Görlitz between the years (Fig. 3A). This corresponded to the increase in the average daily number of times that an animal that stood in enclosure parts remote from visitors (zone C) ap-

Tab. 3: Daily mean values of selected data records.

			Görlitz (n=22 days)		Halle (n=20 days)		Zittau (n=17 days)	
		area	2015	2016	2015	2016	2015	2016
Visitor behavior								
Number of visitors staying at the enclosure	n/day	A+B	360.4 ± 247.0	269.8 ± 165.4	**246.0 ± 199.0** ***	**564.6 ± 449.6**	**85.8 ± 72.3** *	**135.6 ± 86.8**
Visitor presence at the enclosure	min/day	A+B	**723.2 ± 431.6** *	**462.4 ± 262.5**	**427.7 ± 376.1** ***	**912.4 ± 521.5**	**153.6 ± 105.2** *	**259.6 ± 178.5**
Average presence per visitor at the enclosure	min/visitor[1]	A+B	**4.2 ± 1.2** **	**3.1 ± 0.7**	3.2 ± 1.3	3.5 ± 0.7	3.7 ± 1.4	3.3 ± 1.1
Number of visitors staying at the enclosure without animals	n/day	A+B	**90.0 ± 73.3** ***	**19.6 ± 20.6**	**111.3 ± 85.8** **	**334.5 ± 353.5**	68.5 ± 65.1	55.3 ± 36.2
Visitor presence at the enclosure without animals	min/day	A+B	**112.2 ± 88.4** ***	**21.5 ± 29.4**	**161.5 ± 147.6** *	**376.8 ± 362.8**	76.3 ± 55.2	68.8 ± 49.3
Average presence per visitor at the enclosure without animals	min/visitor[1]	A+B	**2.9 ± 1.3** ***	**1.3 ± 1.1**	2.6 ± 1.1	2.8 ± 0.7	2.4 ± 1.1	2.3 ± 0.6
Number of visitors staying at the enclosure together with animals	n/day	A+B	270.4 ± 183.6	250.2 ± 151.6	**134.8 ± 142.9** *	**230.1 ± 138.1**	**17.4 ± 13.6** **	**80.4 ± 62.0**
Visitor presence at the enclosure together with animals	min/day	A+B	612.9 ± 370.0	441.8 ± 246.0	**266.2 ± 273.3** **	**533.9 ± 306.7**	**48.7 ± 37.9** ***	**176.6 ± 131.1**
Average presence per visitor at the enclosure together with animals	min/visitor[1]	A+B	**4.5 ± 1.6** *	**3.2 ± 0.8**	3.7 ± 1.9	4.1 ± 1.3	4.3 ± 2.5	2.7 ± 1.8
Animal behavior								
Animals' presence at the fence together with visitors	min/day	A+B	93.0 ± 44.9	81.3 ± 35.7	**25.8 ± 23.8** ***	**72.2 ± 38.8**	**9.5 ± 7.3** ***	**47.5 ± 37.1**
Number of animals approaching visitors	n/day	A+B	10.6 ± 5.7	15.0 ± 9.1	**2.1 ± 2.6** ***	**21.3 ± 9.9**	**2.2 ± 1.8** **	**9.6 ± 7.7**
Animals' presence in area A & B – visitor contact is possible	min/animal	A+B	264.1 ± 57.1	248.7 ± 39.0	90.2 ± 56.4	107.0 ± 47.0	**30.7 ± 15.4** ***	**105.9 ± 60.3**
Time animals spent feeding	min/animal	A+B+C	**210.6 ± 61,4** ***	**152.0 ± 33,8**	127.1 ± 92.7	137.7 ± 40.0	85.7 ± 56.1	127.8 ± 72.1
Number of daily feeding bouts per animal	n/animal/day	A+B+C	30.3 ± 5.4	30.0 ± 6.2	**17.5 ± 8.3** ***	**46.9 ± 9.6**	**12.0 ± 3.6** ***	**41.6 ± 16.3**

Results of pair-wise nonparametric comparison (Wilcoxon signed-rank test): *** <0.001; * <0.01; *<0.05.
[1]note that 'min/visitor' is not calculated by dividing the mean duration per day by the mean number of visitors per day, but is calculated as the mean of the 'min/visitor' of each individual day; values may therefore appear not to be converging.

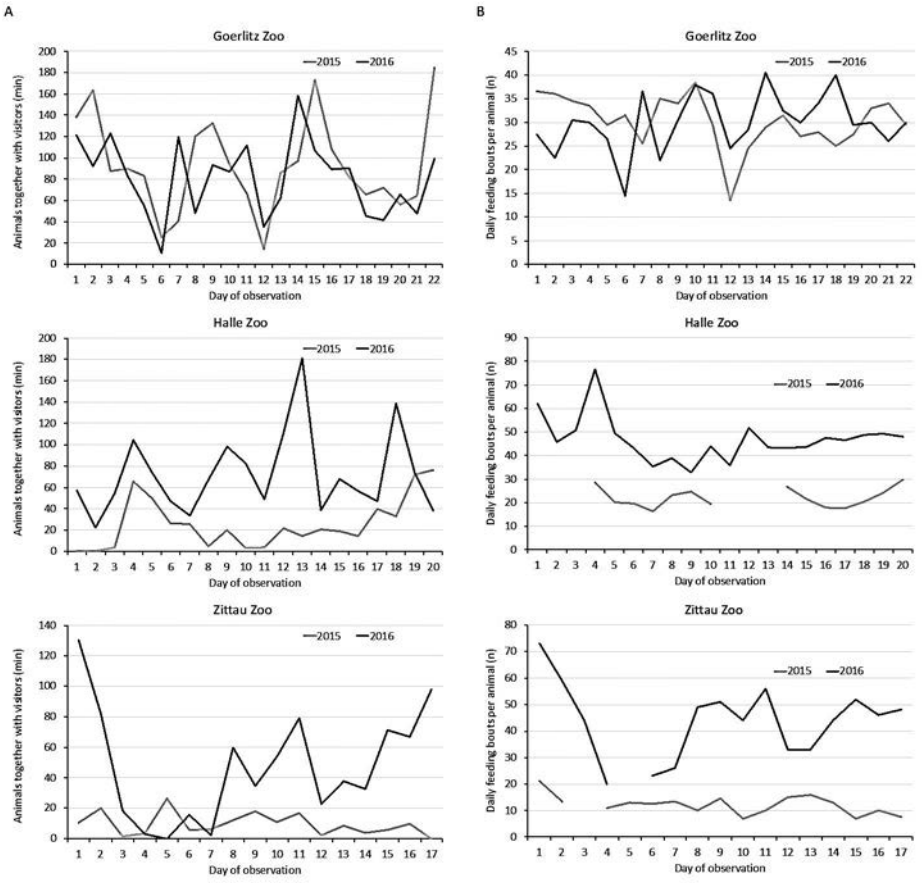

Fig. 3: A Time animals were observed together with visitors per day, and **B** number of daily feeding bouts per animal at three zoos compared between two different years. At Halle and Zittau, a visitor feeding station was established in 2016 prior to the recording of the observations for that year. Missing data indicate days when feeding took place only outside the camera range.

proached a visitor in zone A or zone B in Halle and Zittau. In Zittau, the animals additionally spent more time at enclosure area boundaries that facilitated visitor contact (Table 3).

Animal behavior

The absolute time that animals were observed feeding did not differ significantly between the years for Halle and Zittau, but was shorter in 2016 in Görlitz. The average number of daily feeding bouts per adult animal clearly increased in Halle and Zittau in 2016, but did not change in Görlitz between the two years (Table 3; Figure 3B). Note that at Görlitz, the number of feeding bouts was generally higher than at the other zoos when visitor feeding was not yet in place. Comparing the distribution of feeding across the individual opening hours of the day, there was no visible difference between the years in Görlitz (Fig. 4). In Halle, and especially

in Zittau, the feeding times were more clustered around the keeper feeding schedule in 2015 and more evenly distributed across the day in 2016 (Fig. 4). The difference between the maximum and minimum percentage of feeding time (according to hours of the day) correspondingly decreased distinctively in Zittau (2015: 32%; 2016: 14%), and the variation in feeding times between the hours of the day decreased (measured as SD, 2015: 10.1; 2016: 4.8). These differences were not distinct in Halle (2015: 8%, 3.5; 2016: 9%, 3.1) and inverse in Görlitz (2015: 9%, 3.3; 2016: 16%, 5.6).

Discussion

The attractiveness of the enclosures for visitors

A major constraint of the present study was that the number of visitors visiting the zoos during the days of data recording were not available; the only information that could be used was the yearly number of visitors. For the two zoos where the visitor feeding was introduced, the data indicated an increase in the attractiveness of the enclosures for visitors; however, unexpectedly, they also indicated a decrease of interest at the zoo where visitor feeding had already been introduced prior to this study.

At the Naturschutz-Tierpark Görlitz, there was a snack car near the enclosure of the cattle in 2015. Visitors used to wait for their group members buying snacks in front of the cattle enclosure, and an estimated 94% of all day visitors stayed at the cattle enclosure. But in 2016, that snack car was replaced by a new snack restaurant at another location in the zoo. This circumstance very likely led to a decline of the duration time visitors spent in front of the enclosure, regardless of the presence of animals. A further possible reason for this decline could be the fact that in 2016, the Naturschutz-Tierpark Görlitz had established more visitor feeding setups at additional animal enclosures throughout the zoo, for example at the Bactrian camels', the yaks' or sika deer's enclosure. Especially owners of annual season tickets noticed that shyer animals, like the sika deer, got used to the new setup and started to accept that feeding concept. For many visitors, feeding more exotic animals possibly represented a more attractive experience than feeding cattle.

In this context it must be mentioned that the number of visitors spending time at the cattle enclosure in Görlitz in 2016, even without the snack car nearby (5 936 visitors, or 69% of the estimated day visitors), was higher than at the zebu enclosure at the Bergzoo Halle in 2015 (4 920 visitors, 50%), even though the annual number of visitors to Halle (2015: 328 733 annual visitors) was more than twice as high as in Görlitz (2016: 143 403 annual visitors). This may indicate that visitor feeding setups represent a greater chance for smaller zoological gardens without broader animal collections.

In particular, our study suggests that visitor feeding setups provide the opportunity to raise the attractivity of specific animal enclosures. In zoos, domestic animals often are outshone by more "interesting" nondomestic animals such as tigers, elephants or bears. But especially domestic animals offer the chance to easily facilitate animal-visitor contacts without too much effort or risk for visitors or animals. As shown at the Bergzoo Halle or Tierpark Zittau, the development of the visitor feeding setups led to a significant increase in total visitor numbers and the total duration of time visitors spent at the enclosures - in Halle even regardless of whether animals were present close to the fence or not. We consider this remarkable due to the high number of popular zoo animals such as tigers (*Panthera tigris*), lions (*Panthera leo*), elephants (*Elephantidae*), penguins (*Spheniscidae*), meerkats (*Suricata suricatta*) or red pandas (*Ailurus fulgens*) kept at the Bergzoo Halle. Nevertheless, visitors gladly accepted the roughage feeding setup at the dwarf zebus. However, while the setup attracted more visitors, it did not induce those that

came to spend on average more time than prior to visitor feeding. In that respect, the attention span for the cattle exhibit did not seem to be influenced.

Visitor-animal interactions

In contrast to livestock farming, the routine of animals kept in zoos involves daily contact with both familiar and unfamiliar people (Claxton, 2011). The presence of visitors as unfamiliar people is a fixed component of life in zoological gardens (Davey, 2006). Different studies on animal behavior in correlation with visitor density in zoos have shown that visitors (besides positive or neutral) can have negative impacts on animal welfare (Davey, 2007; Sade, 2013; Cole & Fraser, 2018; Sherwen & Hemsworth, 2019). Depending on the animal species, negative responses to visitors are likely driven by fear (Sherwen & Hemsworth, 2019) as a natural response of wild animals to avoid harmful situations (Rushen et al., 1999). Most of these studies, however, focused on primates. Shen-Jin et al. (2010) investigated the effects of visitor density on sika deer (*Cervus nippon*) and found that the behavior of captive sika deer is influenced significantly by the presence of visitors: high visitor density led to deer spending less time foraging and more time being watchful, resting and 'non-visible'. Reducing fear has obvious welfare benefits for many species (Claxton, 2011). One solution for reducing the negative impacts of visitors is to allow the highly nervous sika deer to move out of view more easily, or by increasing the distance between visitor and exhibit (Hosey, 2000). Another possible option is to create a positive association with visitors' presence. The Naturschutz-Tierpark Görlitz also keeps sika deer and decided to establish a visitor feeding setup at that enclosure with regard to the positive impacts of this feeding system with different other species. We did not investigate the visitor roughage feeding setup at the sika deer's enclosure statistically, but first impressions indicate positive results. Although the enclosure offers different possibilities of retreat, the sika deer started to seek contact to visitors and accepted the new feeding system.

Besides possible benefits for animal welfare, positive human-animal interactions also contribute to another role of modern zoological gardens - that of education in the sense of enhancing empathy and respect. Already multiple decades ago, Kellert (1979) regarded zoos as the most important source of contact between humans and animals in society. Increased urbanization and expanding growth of metropolitan areas intensify the meaning of zoos as an institution facilitating these contacts (Morgan & Hodgkinson, 1999). Also, the reform of agricultural structures with the development towards larger farms with strict access limitation makes it more difficult for people to get into contact with farm animals. Yet, different surveys came to the conclusion that interactions with live animals enhances a deeper appreciation of animals (Sherwood et al., 1989; Kidd & Kidd, 1996; Martens et al., 2019); this includes situations where parents want to teach respect and appreciation for animal life (Kidd et al., 1995).

With annually more than 700 million visitors worldwide the zoo community has the potential to play an important role in both environmental education and wildlife conservation (Gusset & Dick, 2011; Lancaster, 2013). Fernandez et al. (2009) suggest that visitors enjoy learning about and observing natural behavior in captive animals, but visitors often want to observe and interact with the animals in close proximity. By giving people the possibility to interact with certain species via feeding natural food to herbivores, zoos are able to respond to these needs and support the positive effects of interactions with animals at the same time.

Animal behavior and welfare

During the daily routine most animals in zoos are provided food at certain times – in the case of the cattle of the present study, routinely twice a day. Thus, a large amount of food is given

at once, which leads to a high intake per unit time in a short period immediately after feeding (Hummel et al., 2006; Ritz et al., 2014), whereas the physiological food intake in large herbivores would be more spread throughout the day. Consequently, compared to conspecifics in natural habitats, zoo animals often spend less time feeding, which leads to larger amounts of spare time (Koene, 1999). Hence, Koene (1999) concluded that there is a need for zoo animals for more time-consuming food-gathering activities. In the present study, the distribution of food intake throughout the day changed after the introduction of visitor feeding from a high food intake concentrated around the keeper feeding times in 2015 to a more evenly distribution of feeding periods spread over the day in 2016 (Figure 4). Similarly, the number of feeding bouts per day increased distinctively with the introduction of the new feeding system (Figure 3B). After eating a greater amount of food given by animal keepers first, they started to move between the feed troughs in area C and the feed trough filled by visitors in area A. By their presence, visitors contribute to the environmental enrichment for zoo animals (Davey, 2007; Sherwen & Hemsworth, 2019), and food presentation is another common way to offer enrichment for animals (EAZA, 2013). In general, environmental enrichment is seen as a standard tool for improving the welfare of animals in zoos (Fernandez & Timberlake, 2019). Hence, visitor feeding setups could be a good combination of these two aspects. No effect was observed on the total feeding time per day in the present study, most likely because the diet itself – natural forages in fresh or dried form – did not differ between the treatments. Additionally, the increased time that the animals voluntarily spent in close vicinity to visitors could be interpreted as facilitating a more enriched daily routine, where visitors were part of the attractive stimuli for the animals.

The investigated visitor feeding systems consist of two parts. One feed trough is located inside the enclosure and is immediately and completely available for the animals after being filled by animal keepers. The second trough is located on the visitors' side, also filled by animal keepers, but its content is fed by visitors throughout the day. The daily feed ration is split depending on expected visitor numbers. This means that on a rainy day, during the week, animal keepers put more food directly in the animals' trough. Besides the predictable feeding by animal keepers, the less predictable feeding by visitors in smaller amounts translates into more incentive for the herbivores to remain active, possibly indicated by the higher number of feeding bouts in the present study under the visitor feeding regime. A potential additional feature to improve the effect of visitor roughage feeding is a setup with at least two different troughs at different locations of the enclosure, to increase the probability that the animal moves between troughs.

World-wide the prohibited uncontrolled public feeding of zoo animals is an universal and often serious problem for zoo management (Bitgood et al., 1988). Several zoological gardens report that visitors often pick plants around the enclosures of herbivores in order to feed the animals. In some cases, also poisonous plants were fed and caused clinical incidents in different herbivore species (Rietschel, 2006; Rietschel, 2018). At all three zoos of the present study, visitors were observed picking plants to feed the animals during the monitoring period. At the most extreme, the plants around the zebus' and the donkey's enclosure were devoid of their leaves during the summer of 2015 due to (prohibited) visitor feeding. At all investigated zoos, we noted that visitors stopped picking plants around the enclosure after the establishment of visitor roughage feeding setups. In other situations, visitors were observed to feed items that they brought into the zoo, most likely primarily as snacks for themselves. Anecdotally, personnel of the Naturschutz-Tierpark Görlitz also reported that visitors stopped bringing bread and similar products into the zoo for animal feeding after the possibility to feed different herbivores with roughage had been introduced.

During the study time, we did not observe intraspecific aggression as sometimes observed in petting zoos, when visitors feed pellets (all authors, pers. obs.). As visitors only feed grass, animals do not react aggressively towards conspecifics. Still, new grass fed by visitors, even though it is exactly the same as that remaining in the trough from a previous feeding by the an-

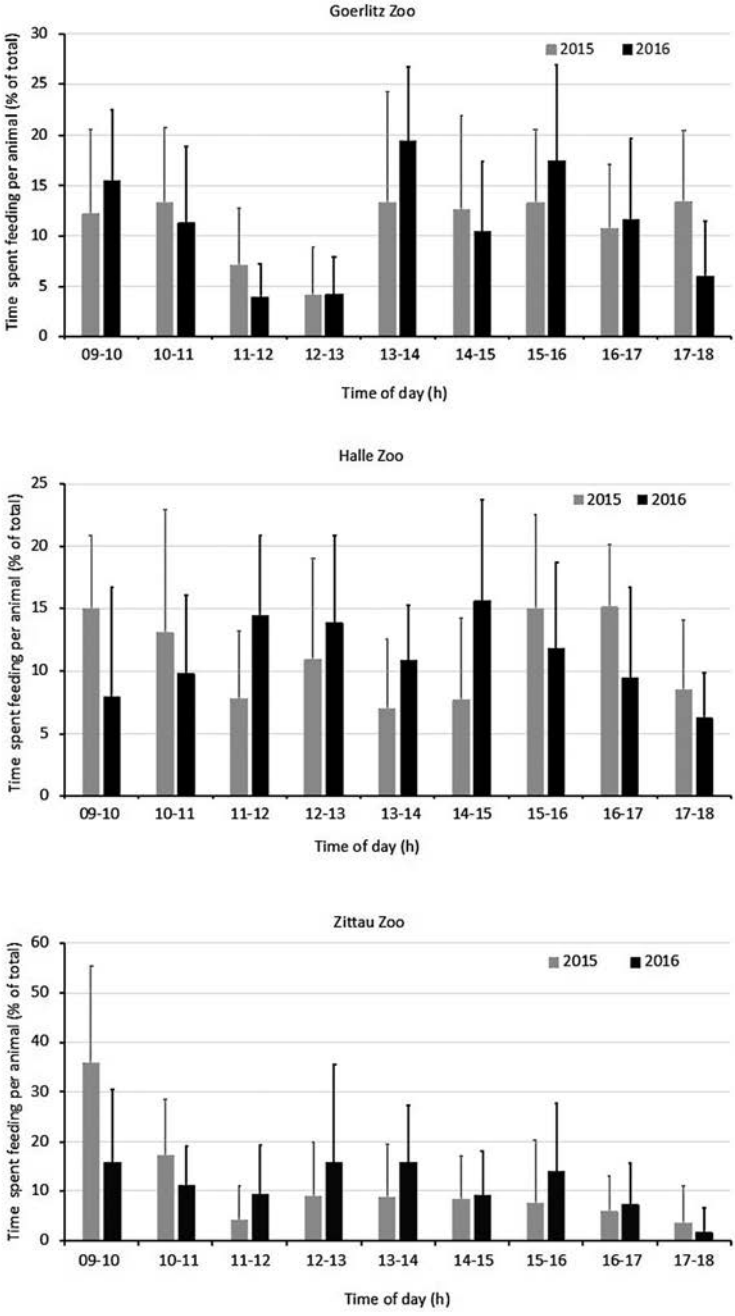

Fig. 4: Average time per animal per hour animals were observed feeding (in % of total daily feeding time) at three zoos compared between two different years. At Halle and Zittau, a visitor feeding station was established in 2016 prior to the recording of the observations for that year.

imal keepers, appears to be more attractive for animals. Due to these circumstances zoological gardens are able to offer adequate diets in an unpredictable feeding regime for grazers with the help of visitors, who also profit by positive individual experiences due to the human-animal interactions facilitated by the investigated feeding system.

Conclusions

According to the increasing numbers of visitors staying in front of the investigated enclosures after installing the feeding setups, we conclude that some zoos should be able to raise the attractivity of certain animal enclosures by offering individual feeding experiences without greater financial or personnel efforts. By offering roughage instead of pellets, institutions ensure that this public feeding concept does not cause health problems such as ruminal acidosis, and is also instructive about natural feeds of herbivores.

The present study indicated that the investigated roughage feeding setups had significant effects on the behaviour of visitors as well as of animals. Both accepted the feeding setups, and animals spent more time closer to visitors. Especially the increase of cases where animals approach visitors demonstrates the positive association of visitors for the animals.

Involving visitors in animal enrichment offers new possibilities for improving animal welfare. In this way more evenly spaced feeding in smaller amounts, depending on the number of daily visitors, is provided for herbivores. The increasing numbers of daily feeding bouts per animal, and the changing periods of food intake from two main bouts around keepers' feeding time to a more evenly distribution all over the day, may represent enrichment adequate for herbivores.

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Zusammenfassung

Zoologische Gärten fungieren in unserer zunehmend urbanisierten Welt als wichtige Kontaktstelle zwischen Mensch und Tier. Für Zoologische Gärten ist es eine Herausforderung, einerseits dem Bedürfnis der Besucher nachzukommen, Tiere zu füttern, und gleichzeitig den Tierbestand vor den negativen Einflüssen der Besucher zu bewahren. In der vorliegenden Studie wurde untersucht, welche Effekte ein neues Raufutter-Fütterungskonzept für in Zoos gehaltene Pflanzenfresser, sowohl auf die Tiere als auch auf die Besucher hat. Bei diesem Konzept erhalten Zoobesucher die Möglichkeit, Raufutter in Form von Gras oder Heu an verschiedene Tiere zu verfüttern. Für die Datenaufnahme wurden die Gehege von Hausrindern und Zwergzebus (*Bos primigenius taurus, B. p. indicus*) mit den dazugehörigen Besucherbereichen mittels Kameraaufnahmen über einen Zeitraum von jeweils 30 Tagen in zwei aufeinander folgenden Jahren dokumentiert. Die Aufnahmen fanden zeitgleich in drei verschiedenen Zoologischen Gärten statt. Während in einem dieser Zoos das Fütterungskonzept bereits in beiden Jahren existierte,

wurde die Fütterungsanlage in den anderen beiden Zoos im zweiten Jahr vor der Datenaufnahme errichtet.

In den zwei Zoos, in denen die Fütterungsanlage erst im Folgejahr gebaut wurde, stieg die durchschnittliche tägliche Anzahl der Besucher vor den jeweiligen Gehegen, genauso wie die Anzahl der Fälle, in denen ein Tier gezielt auf einen Besucher zukam. Auch die Gesamtzeit, die Besucher und Tiere zusammen verbrachten, verlängerte sich. Während im Vergleich der beiden Jahre kein Unterschied bei der Gesamtzeit feststellbar war, die ein Tier mit der Nahrungsaufnahme verbrachte, ergab sich nach dem Einbau der „Besucher-Fütterungsstation" eine gleichmäßigere Verteilung der Futteraufnahme über den Tag. Die untersuchte Fütterungsstation eröffnet damit die Möglichkeit einer Verbesserung des Tierwohls für bestimmte Tierarten und ermöglicht den Zoobesuchern gleichzeitig eine individuelle Tier-bzw. Fütterungserfahrung.

References

Anderson, U.S., Kelling, A.S., Pressley-Keough, R., Bloomsmith, M.A., & Maple, T.L. (2003). Enhancing the zoo visitors' experience by public animal training and oral interpretation at an otter exhibit. Environment and Behavior, 35, 826-841.

AZA (2020). The accreditation standards and related policies. American Association of Zoos and Aquaria.

Bitgood, S., Carnes, J., Nabors, A., & Patterson, D. (1988). Controlling public feeding of zoo animals. Visitor Behavior, 2, 6.

Claxton, A.M. (2011). The potential of the human-animal relationship as an environmental enrichment for the welfare of zoo-housed animals. Applied Animal Behaviour Science, 133, 1-10.

Close, A., & Newbolt, J. (2017). The educational value of visitor feeding experiences at Paignton zoo and Living Coasts. Annual BIAZA Research Conference, 19, 38.

Cole, J., & Fraser, D. (2018). Zoo animal welfare: the human dimension. Journal of Applied Animal Welfare Science, 21(Suppl. 1), 49-58.

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, 332.

Davey, G. (2006). Visitor behavior in zoos: A review. Anthrozoös, 19, 143-157.

Davey, G. (2007). Visitors' effects on the welfare of animals in the zoo: a review. Journal of Applied Animal Welfare Science, 10, 169-183.

EAZA, (2013). The modern zoo: foundations for management and development. European Association of Zoos and Aquaria, Amsterdam

EAZA, (2019). EAZA standards for the accommodation and care of animals in zoos and aquaria. European Association of Zoos and Aquaria, Amsterdam

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, 1-8.

Fernandez, E.J., & Timberlake, W. (2019). Selecting and testing environmental enrichment in lemurs. Frontiers in Psychology, 10, 1-12.

Gusset, M., & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. Zoo Biology, 30, 566-569.

Hosey, G.R. (2000). Zoo animals and their human audiences: what is the visitor effect? Animal Welfare, 9, 343-357.

Hosey, G.R. (2005). How does the zoo environment affect the behaviour of captive primates? Applied Animal Behaviour Science, 90, 107-129.

Hosey, G.R. (2008). A preliminary model of human-animal relationships in the zoo. Applied Animal Behaviour Science, 109, 105-127.

Hummel, J., Nogge, G., Clauss, M., Norgaard, C., Johanson, K., Nijboer, J., & Pfeffer, E. (2006). Energetic nutrition of the okapi in captivity: fermentation characteristics of feedstuffs. Zoo Biology, 25, 251-266.

Kellert, S.R. (1979). Zoological parks in American society. Proceedings of the American Association of Zoological Parks and Aquariums, 88-126.

Kemper, J. (2016). Designing zoos and aquariums as conservation organisations. WAZA Magazine, 17, 20-23.

Kidd, A.H., Kidd, R.M., & Zasloff, R.L. (1995). Developmental factors in positive attitudes toward zoo animals. Psychological Reports, 76, 71-81.

Kidd, A.H., & Kidd, R.M. (1996). Developmental factors leading to positive attitudes toward wildlife and conservation. Applied Animal Behaviour Science, 47, 119-125.
Koene, P., (1999). When feeding is just eating: how do farm and zoo animals use their spare time. Pp. 13-19 in: van der Heide, D., Huisman, E.A, Kanis, E., Osse, J.W.M & Verstegen, M.W.A (eds): Regulation of feed intake. CAB International, Wallingford, UK.
Kreger, D.K., & Mench, J.A. (1995). Visitor-animal interactions at the zoo. Anthrozoös, 8, 143-158.
Lancaster, S. (2013). A study evaluating what best inspires visitor behaviour and attitude changes in zoos, with a small botanical garden comparison: addressing zoos educational and subsequent conservation values. The Plymouth Student Scientist, 6, 289-331.
Luebke, J.F., Watters, J.V., Packer, J., Miller, L.J., & Powell, D.M. (2016). Zoo visitors'affective responses to observing animal behaviors. Visitor Studies, 19, 60-76.
Martens, P., Hansart, C., & Su, B. (2019). Attitudes of young adults toward animals – the case of high school students in Belgium and the Netherlands. Animals, 9, 88.
Morgan, J.M., & Hodgkinson, M. (1999). The motivation and social orientation of visitors attending a contemporary zoological park. Environment and Behavior, 31, 227-239.
Odongo, N.E., Valdes, E.V., & McBride, B.W. (2006). Acidogenicity value and rumen acid load of common zoo animal feeds. The Professional Animal Scientist, 22, 194-199.
Orban, D.A., Siegford, J.M., & Snider, R.J. (2016). Effects of guest feeding programs on captive giraffe behavior. Zoo Biology, 35, 157-166.
Powell, D.M., & Bullock, E.V.W. (2014). Evaluation of factors affecting emotional responses in zoo visitors and the impact of emotion on conservation mindedness. Anthrozoös, 27, 389-405.
R Core Team, (2015) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.
Rietschel, W., (2006). Poisoning of zoo animals y the gardener, or: an unsuspicious method of population control in zoo collections. Pp. 185-192 in: Fidgett, A., Clauss, M., Eulenberger, K., Hatt, J.M., Hume, I., Janssens, G. & Nijboer, J. (eds): Zoo animal nutrition III. Filander Verlag, Fürth.
Rietschel, W. (2018). Unsere Wilhelma – ein Park zum Vergiften? 38 Arbeitstagung – Verband der Zootierärzte (VZT) Tagungsbericht, 38, 23-27.
Ritz, J., Codron, D., Wenger, S., Rensch, E.E., Hatt, J.-M., Braun, U., & Clauss, M. (2014). Ruminal pH in cattle (*Bos primigenius* f. *taurus*) and moose (*Alces alces*) under different feeding conditions: a pilot investigation. Journal of Zoo and Aquarium Research, 2, 44-51.
Rushen, J., Taylor, A.A., & Passillé, A.M. (1999). Domestic animals' fear of humans and its effect on their welfare. Applied Animal Behaviour Science, 65, 285-303.
Sade, C. (2013). Visitor effects on zoo animals. Plymouth Student Scientist, 6, 423-433.
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, 61-65.
Sherwen, S.L., & Hemsworth, P.H. (2019). The visitor effect on zoo animals: implications and opportunities for zoo animal welfare. Animals, 9, 366.
Sherwood, K.P., Rallis, S.F., & Stone, J. (1989). Effects of live animals vs. preserved specimens on student learning. Zoo Biology, 8, 99-104.
Swanagan, J.S. (2000). Factors influencing zoo visitor's conservation attitudes and behaviour. Journal of Environmental Education 31, 26-31.