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Research article

Giraffe *Giraffa camelopardalis* feeding: How stereotypies and other behaviours changed at Kolmårdens djurpark in Sweden

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Abstract
Kolmården djurpark keeps one of the most northern living giraffe *Giraffa camelopardalis* groups in the world, and this comes with its challenges. For a long part of the year, the outside temperature is too cold for giraffes, resulting in extended periods spent indoors, combined with a shorter duration of trees bearing leaves than further south. In an attempt to reduce the stereotypical behaviours of Kolmården' giraffes, the effect of giving 70% of feed in slow-feeding barrels was compared with providing 100% of the feed in slow-feeding barrels. The results show a significant increase in feeding behaviours for most of the individuals along with a reduction in stereotypical behaviours. At the same time there was an increase in activity during the night. Kolmården djurpark practices a 'breed and cull' regime for the giraffe group. One of the reasons to do so is for the welfare of the animals. To investigate this, one female was studied before and after giving birth, along with one control animal. The results show a reduction in stereotypical behaviours, suggesting that the mother's welfare increased. Forcing zoo herbivores to 'work' for all of their feed, rather than just adding some enrichment diets for occupation alongside an otherwise easily accessible diet, and permitting natural reproductive behaviours, may be two strategies to improve welfare that should be considered and further investigated.

Introduction

Giraffes are charismatic zoo animals. Although breeding giraffes in zoos is generally not considered problematic, it has traditionally been considered challenging to keep giraffes alive until old age (Junge and Bradley 1993) and to maintain them in a state of high welfare (Veasey et al. 1996). In particular, stereotypical behaviour is common in zoo-managed giraffes (Bashaw et al. 2001). Stereotypic behaviour has an invariant pattern, serves no purpose, is repeated regularly (Keiper 1969) and is generally interpreted as an indicator of suboptimal welfare. A survey by Bashaw et al. (2001) found that 80% of all giraffes *Giraffa* spp. and okapis *Okapia johnstoni* in the participating zoos performed stereotypical behaviour, with oral stereotypic behaviours being the most dominant. Bergeron et al. (2006) suggested three reasons why ruminants perform oral stereotypies: (i) the food does not fully satisfy the need for gut fill, energy or a specific nutrient; (ii) the food is too easily found and acquired, leaving a motivation to forage unfulfilled; and (iii) a diet too low in fibre causes acidosis in the rumen, which can be tempered by the buffering saliva triggered by oral stereotypies.

For giraffes, Baxter and Plowman (2001) showed that it is possible to reduce oral stereotypical behaviour by increasing fibre intake. This finding has been reproduced several times since (Duggan et al. 2016; Gussek et al. 2017; Hummel et al. 2006; Monson et al. 2018). Additionally, it was shown that changing feeding methods so that giraffes are forced to use their tongues to extract feed items from specially designed feeders reduces stereotypies (Fernandez et al. 2008).

Furthermore, Schüßler et al. (2015) reported that a female giraffe tended to show fewer oral stereotypies when raising a calf after she gave birth.

This study further contributes to investigating the effect of feed presentation on the behaviour of zoo-kept giraffes by documenting behaviour during transition to a feeding regime that used slow-feeders. Until 2013, the feeding management of the giraffes consisted of providing an in-house pellet two times per day in open cribs, where the giraffes could put their mouths directly into the pellets, and free access to chopped ensiled grass. In 2014, the silage was replaced with chopped dried lucerne and the amount of pellets was reduced (for a rough description of the diets, see Appendix 1). The pellets were mixed with the chopped lucerne and parts of the diet were placed in slow-feeding barrels that allowed feed intake only by the use of the tongue (Figure 1, Appendix 2). Additionally, the amount of browse provided was increased. From 2015, the proportion of the diet that was offered in the slow-feeding barrels was continuously increased. In the winter of 2016–2017, this process was accompanied by the video evaluation of the present study.

It was expected that the giraffes would have a different activity budget compared to wild giraffes. The older individuals that had lived for a longer time at Kolmården were expected to perform more stereotypical behaviours than the younger individuals due to their history of being fed without slow-feeding barrels for many years, compared to the younger individuals that had grown up always taking a part of their diet from the slow-feeders. When open crib feeding was completely discarded, an increase in feeding time and a decrease in stereotypical behaviour were expected. An additional decrease in stereotypical behaviour was expected in a female giraffe that gave birth and raised her calf.

Materials and methods

Animals and husbandry

According to the information about giraffe holders in Species360 (ZIMS), Kolmården djurpark did hold the most northern living giraffe herd in the world in 2020, except for one lone giraffe that was kept further north in a Russian institution. Keeping giraffes this far north comes with its challenges. During the summertime, Kolmården keeps the giraffe herd outdoors around the clock on a six-hectare savannah enclosure. The giraffes share this enclosure with other ungulates such as blackbuck *Antilope cervicapra*, blue wildebeest *Connochaetes taurinus* and Grevy's zebra *Equus grevyi*. During the winter, Kolmården may keep the giraffes indoors around the clock depending on the weather—usually for a period of three to five months. On ice-free days and warmer days, the giraffes are given the opportunity to choose if they want to be inside or outside, but are closed in during the night if the outside temperature goes below 10 °C.

The data for this study were collected when the giraffes were kept indoors around the clock in December 2016, February 2017 and March 2017. The indoor stable measures 340 m^2 and consists of several individual enclosures. The openings between the enclosures were always open, giving all giraffes free access to the whole stable, except for short periods during the morning and afternoon when the enclosures were cleaned one by one and new food, including browse, was provided. The stable was equipped with two large straw beds as lying areas, four water bowls, seven feeding cribs and four roughage feeding stations. An overview of the stable can be seen in Appendix 3. The group consisted of eight animals, including males that were castrated to facilitate a larger group (Table 1); since then, due to the hybrid status of many animals, breeding has been allowed under a 'breed and cull' concept where culled giraffe are used as food for zoo carnivores.

The giraffes were first studied for five consecutive days (period A). Initially, the keepers followed their usual routine, which resulted in one day with 15% of the feed put in open cribs and the rest in slow feeding barrels. This was followed by 2 days when 30% of the feed was put in the open cribs (period A1). For the last 2 days of period A, no feed was put in the open cribs and instead all of it went in the slow-feeding barrels (period A2).

An evaluation of the videos from these five days formed the basis of a discussion on how to manage feeding. Due to the higher levels of feeding and lower levels of stereotypies in period A2 compared with A1, it was decided that the open cribs would no longer be used at all, and all feed would be presented in the slow-feeding barrels (except for browse). A new data collection period of five days took place two months later (period C).

In between, another five days of data collection (period B) took place to investigate what effect having a calf had on the mother's activity budget. During this period only the mother and a younger female (used as a control animal) were studied. The individual Janis was selected as the control to be compared with the breeding female, as she was an almost full-grown female that had never given birth.

Figure 1. Slow-feeding barrel for giraffes. Access to the feed inside the barrel is possible by inserting the tongue through the openings on the side of the barrel. More examples can be found in Appendix 2.

Data collection and evaluation

Four camera traps (UOVision UV572 Panoramic) were used. They had a viewing angle of 110° (infrared angle 100°) and a range of 12 m, making it possible to see almost the whole enclosure when they were placed up in a corner (3.5–5.5 metres above the ground). Their recording was synchronised to record in 720p at the same time every 5 minutes. They recorded 10 seconds to allow for identification of behaviours. Behaviours were recorded by instantaneous scan sampling (Altmann 1974) at this interval. The only behaviour that was recorded was the behaviour that occurred during the start of the clip; any change in behaviour during the 10 seconds was ignored. The ethogram used with the recorded behaviours was based on that used by Fennessy (2004) to facilitate a direct comparison with data from a natural habitat, with the addition of stereotypies (Table 2).

During the day (when the lights were on, period A 0600–2000, periods B and C 0700–1900), the giraffes were studied at an individual level at the same time. During the night (when the lights were off), they were studied as a group due to difficulties in distinguishing individuals in the infrared-based images. In these images, it was also difficult to discern stereotypical behaviour, which was therefore not assessed at night.

The data were expressed as the proportion of observed time spent in the respective behaviour. The data were mostly explored visually from graphs. In the case of feeding and stereotypic behaviours (including pacing, object licking, tongue rolling and abnormal oral; Table 2), the data were analysed using the Microsoft Excel Analysis ToolPak with a paired t-test. The significance level was set to P=0.05, and results P≤0.07 are reported as trends. The approach is considered exploratory and the results should be interpreted with appropriate caution.

Results

When assessing the individual parts of period A, it was evident that between periods A1 (days 2 and 3) and A2 (days 4 and 5), feeding time numerically increased and stereotypies decreased during the daytime. A typical example is given in Figure 2. This first assessment led to a general change in feeding management.

Averaged across all individuals, there was a clear difference in the distribution of daytime behaviours between period A (feed partly in open cribs) and period C (feed only in slow-feeder barrels) (Figure 3). Numerically, feeding increased by 24% compared to the baseline, whereas stereotypies reduced by 68%.

Comparing the proportion of feeding and stereotypy time between period A1 and period C, the numerical increase in feeding and decrease in stereotypies are evident in all animals (Figure 4). The increase in feeding time was significant in all animals (P<0.05) except the two adult females (Marionette and Marylin) and the adult male (tendency, P=0.07). The reduction in stereotypy was significant in all animals except Marionette and the youngest animal Manyara (Figure 4). When 30% of the feed was put in cribs, most giraffes had a mean feeding time of less than 50%, compared with the period when no feed was put in the cribs (60–70%). The time spent stereotyping was highest in the two older females and appeared to decrease with age in the other animals, with the exception of the older breeding bull who had a relatively low proportion of stereotyping.

For the nighttime observations, there was an evident shift between periods A and C, with an increase in feeding and rumination behaviour and a decrease in the time spent resting without rumination (Figure 5).

Comparing behaviour between the lactating female Marylin and the control female Janis between period A1 and period B (after Marylin had given birth) did not yield significant changes in feeding time in either animal, although numerically, feeding time for Janis increased (Figure 6). By contrast, although feeding time did not increase in Marylin, her stereotyping time decreased distinctively and significantly, whereas the reduction was not significant in Janis (P=0.07; Figure 6).

Discussion

The results of the present study support the observation of Fernandez et al. (2008) that making access to feed more difficult for giraffes leads to a reduction in stereotypies and an increase in

Table 1. Giraffe individuals observed in the present study (2016–2017). *this female gave birth in the study period and was additionally monitored in period B. **this female was used as a control animal during period B

Name	Sex	Year of birth	Subspecies
Garp	Male	2006	*G. c. reticulata*
Zlatan	Male (castrated)	2014	*G. c. reticulata*
Mercurius	Male (castrated)	2015	hybrid
Marionette	Female	2006	hybrid
Marylin*	Female	2006	hybrid
Janis**	Female	2013	*G. c. reticulata*
Marie Antoinette	Female	2015	hybrid
Manyara	Female	2016	hybrid

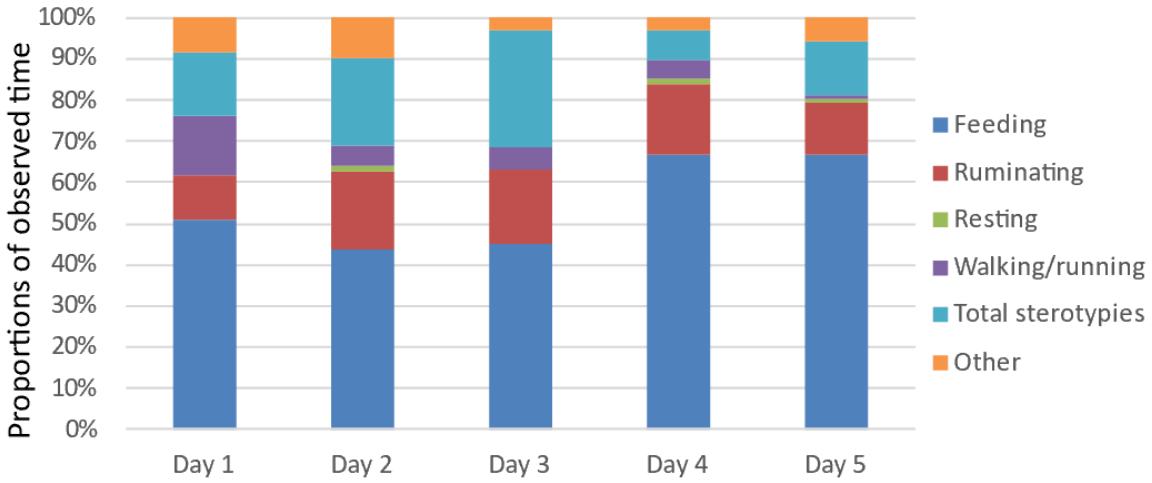

Figure 2. Proportion of observed time (for the four most important behaviour categories and for stereotypies) in the giraffe Marylin during period A. Day 1: approximately 15% of feed was put into open cribs; days 2 and 3 (=period A1): approximately 30% of feed was put into open cribs; days 4 and 5 (=period A2): no feed in open cribs but all in slow-feeder barrels.

feeding time. Additionally, the results support the observation of Schüßler et al. (2015) that caring for a calf can reduce stereotypic behaviour in giraffe mothers.

Evidently, the results of the present study must be considered with caution, due to the generally low number of observations made and the short observation periods. Thus, the results should not be considered as stand-alone evidence, but in relation to the literature. The logistical constraints of the author, who acted as animal caretaker (and nutritionist) at the time of the study, did not allow evaluation over longer periods. Additionally, the camera setup did not allow confident evaluation of stereotypic behaviour at night; typically, stereotypies are more evident at night in zoo-managed giraffes (Duggan et al. 2016; Veasey et al. 1996). However, the present study gives an example of how in-house behavioural

Table 2. Ethogram used for giraffes in the present study

Behaviour	Description
Feeding	The giraffe is observed physically eating; this activity includes the time spent chewing and swallowing.
Resting	The giraffe is standing, lying down or sleeping and is neither ruminating nor showing vigilance.
Ruminating	The giraffe chews its cud while standing, lying or walking.
Walking	The giraffe travels between forage sources or within the study area (not ruminating).
Grooming	The giraffe is observed scratching and rubbing itself.
Sexual behaviour	This activity includes flehmen testing, courtship and mounting attempts. Flehmen testing involves the testing of urine (to detect pheromones) to assess a giraffe's reproductive status.
Excretion	The giraffe is observed defecating or urinating.
Vigilance	The giraffe is focussed on external stimuli such as humans, other animals, machines or other movements and/or sounds.
Interaction	This activity includes neck sparring (necking) and rubbing or chesting another giraffe.
Drinking	The giraffe is observed drinking.
Suckle	This includes both the mother letting a calf drink milk and the calf drinking milk from an adult giraffe.
Pacing	The giraffe is walking steadily and at a constant speed back and forth, covering the same distance repeatedly.
Object licking	The giraffe repetitively licks a non-food object such as the wall or water bowl.
Tongue rolling	The giraffe is swinging with the tongue outside the mouth or repetitively rolling the tongue inside the mouth.
Abnormal oral	The giraffe is chewing or grinding its teeth against the wall or taking an object in and out of the mouth without eating it.
Other	The giraffe is observed performing a behaviour that is not included in the list above.

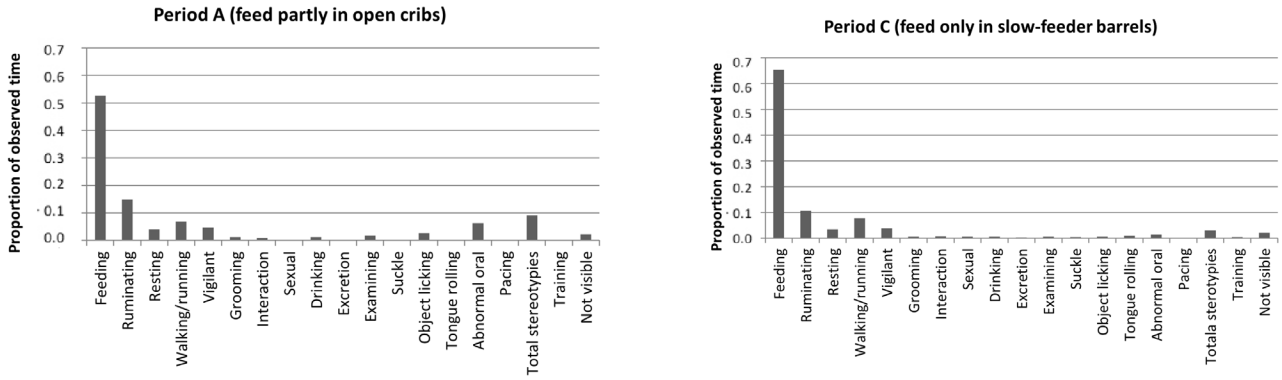

Figure 3. Proportion of behaviours observed in all giraffe individuals between the two feeding periods

observation can be used to guide management decisions. The change in behaviour between periods A1 and A2—which covered only two consecutive days each—was later corroborated by the observations made in period C. Period C served as a control to establish that the new feeding management should be continued. Thus, using in-house protocols for behavioural observations becomes an integral part of husbandry management (and not just a tool for scientific studies).

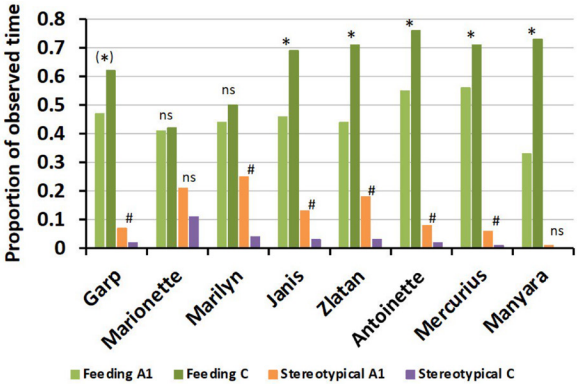

Figure 4. Proportion of feeding and stereotyping behaviour in period A1 and period C in individual giraffes. *denotes a significant difference in the proportion of time spent feeding (P<0.05); # denotes significant difference in the proportion of time spent stereotyping (P<0.05); (*) denotes a P value≤0.07; ns=not significant

The results can be used to add to concepts about zoo giraffes and for comparison with free-ranging animals. A discrepancy in feeding behaviour between free-ranging and zoo giraffes has been noted by Veasey et al. (1996). The recorded proportions of feeding time in the present study during period A1 fall within the range reported for other zoological institutions in that publication. After the change in feeding management, the feeding time recorded for the younger animals was close to the range reported for free-ranging giraffes. Thus, the results lead to the clear recommendation to offer feed to zoo giraffes in ways that force them to use their tongues for feeding, and to avoid any situation where they can dip their snout into any offered feed like lucerne hay, but especially into pellets or concentrates. As a side effect, this would also limit the danger of jaw fractures that occur when giraffes can put their snout between the bars of hayracks (Remport et al. 2022). The baseline condition for the present study—period A1—did not represent traditional zoo feeding management with open snout access to both pelleted feed and hay, but consisted of 70% of the daily ration being offered in slow-feeding barrels. Thus, the present study underlines the importance of not considering slow-feeding devices a form of enrichment to be offered in addition to a classical feeding regime, but that the whole diet should be offered in this way.

With respect to the different scenarios outlined by Bergeron et al. (2006), the reduction in stereotypies that accompanied the increase in feeding time in most animals, even though the diet composition itself was not notably changed, suggests that the oral stereotypies observed in giraffes might be less related to the fermentation processes in their rumen. Rather, the explanation referring to a lack of use of the tongue under conventional feeding regimes appears more likely. It was expected that age should play a role in the development and expression of stereotypic behaviour, as also suggested by Bashaw et al. (2001). The two youngest individuals (Mercurius and Manyara) spent little time stereotyping, whereas this increased in the older individuals with notable exceptions related to reproductive activity.

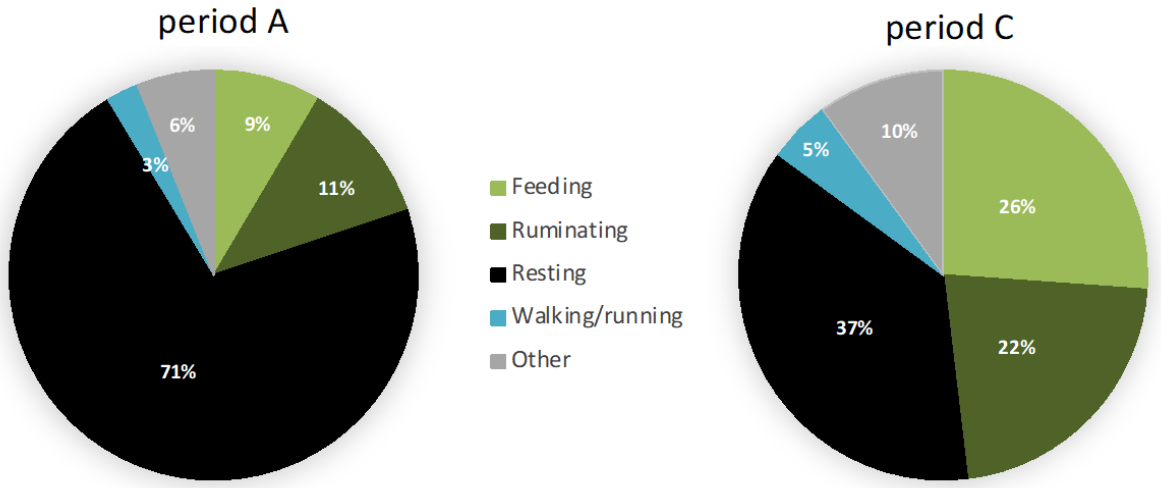

Figure 5. Behaviour of all giraffes during the night (where individuals could not be reliably identified in infrared-based images) for period A (with some feed presented in open cribs) and period C (no feed presented in open cribs)

First, the breeding male Garp spent less time on stereotypical behaviours than the similar-aged females and the younger castrated males. Being reproductively active and perceptive might predispose him to increased types of other activities and less stereotypic activity. Whether this effect can be generalised to male giraffes would have to be tested in a study comprising more than a single zoological institution.

Second, there was a distinct reduction in stereotyping in one of the most stereotyping animals in this giraffe group, the older female Marylin, at a time when she was caring for her new calf. This reduction occurred in parallel with the general reduction in the whole herd due to the new feeding regime, but in Marylin, the reduction between period A1 and period B was of a higher magnitude than that of the control animal, and—in contrast to the overall observation in the whole herd—this was not linked to an increase in feeding activity. Use of a second female as a control confirms that this change is not due to other changes in husbandry. Thus, this study provides an n=1 report that allowing reproductive activity is associated with a decrease in unwanted behaviours. Whether this is interpreted as relevant to welfare may be a philosophical question, as it may not be possible to decide whether stereotyping or caring for a calf actually leads to a more positive affective state in the mother animal. Nevertheless, it matches the concept that if a zoo-managed animal has a task that it is equipped to perform, it will perform fewer 'unnatural' behaviours. This can be considered an indicator of welfare. It is likely that the stereotypy-reducing effect of caring for a calf wears off as the juvenile becomes older and more independent. Therefore this should be further looked into over a longer period and in a larger number of animals.

Allowing giraffes to breed—especially when the animals involved are hybrids as in this case, and thus do not contribute valuable offspring to the population—is generally linked to a 'breed and cull' population management approach. This approach is typically chosen with the explicit aim of facilitating natural breeding and offspring-raising behaviour. For example, Penfold et al. (2014) state: "It is important to acknowledge that culling does allow individuals to express a wider range of natural behaviours (courtship, mating, parental care) than do non-reproducing animals." Similarly, Gray (2017) stated: "Preventing breeding may require ongoing drugs, surgery and isolation. Considering that zoos should strive to allow animals a natural life, the removal of breeding opportunity may diminish the quality of that life". The EAZA's culling statement declares "Limiting the opportunity to breed in species which display nurturing parental behaviour, by

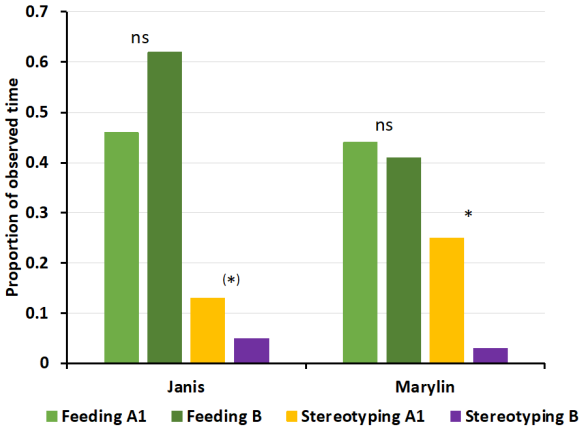

Figure 6. Proportion of feeding and stereotyping behaviour in period A1 and period B in a control female (Janis) and a giraffe taking care of a neonate (Marylin). * denotes a significant difference in the proportion of time spent stereotyping (P<0.05); (*) denotes a P value≤0.07; ns=not significant

definition, reduces an individual animal's opportunity to express one of the most important and complex sets of natural behaviours and can thus lead to a decrease in welfare." (EAZA 2015). Culling is defined by EAZA as "the removal of animals from a population in human care by humane killing carried out by appropriately qualified and experienced staff" (EAZA 2015). 'Breed and cull', from a zoo's point of view, goes hand in hand with its conservation goals of maintaining viable populations and animal welfare. Loss of life itself, as by humane killing, is regarded as neutral from a welfare perspective. The removal of an individual from a herd can be considered a stressful event. But (i) this should be done at an appropriate age like the natural dispersal time, and (ii) it might be considered that loss of juveniles and neonates is frequent in free-ranging giraffes.

Especially after the international reactions to the culling of a giraffe at Copenhagen Zoo in 2014 (Bertelsen 2014), some zoos might fear public reactions to a 'breed and cull' strategy. Considering that, for example, many more than 300 million cows were culled for human consumption in 2020 (FAOSTAT 2022), reluctance to accept the culling of a giraffe for feeding it to zoo carnivores appears inconsistent. A zoo that keeps carnivores will need meat for those animals. By performing 'breed and cull', there is meat that can be used for feeding the carnivores and the zoo can take responsibility for the welfare of animals that become food for the carnivores, rather than buying slaughter products.

Giraffe husbandry appears to have improved over the years, as evident from the subjective impression of a reduced occurrence of malnutrition (Bertelsen 2015) and Europe-wide improvements in giraffe dietary management (Gussek et al. 2017). A next improvement step may be providing all feed in such a way that it is only accessible to giraffes either in the form of browse or in systems that require tongue manipulation during feeding, without any opportunity to 'dip in' their snout to the feed. This will likely lead to behaviours and activity budgets considered beneficial, or at least more similar to behaviours and time budgets in free-ranging animals. Additionally, allowing reproductive activity will have the same qualitative effect, again shifting the behavioural repertoire closer to that in natural habitats.

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