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RESEARCH ARTICLE

Tongue Twisters: Feeding Enrichment to Reduce Oral Stereotypy in Giraffe

Loraine Tarou Fernandez,[1,2] Meredith J. Bashaw,[1,2]* Richard L. Sartor,[1] Nichole R. Bouwens,[1] and Todd S. Maki[1]

[1]*Zoo Atlanta, Atlanta, Georgia*
[2]*Center for Conservation and Behavior, School of Psychology, Georgia Institute of Technology, Atlanta, Georgia*

Stereotypic behavior has been well-studied and documented in a variety of animals including primates, carnivores, and domesticated ungulates. However, very little information is known about stereotypic behavior of captive exotic ungulates. Giraffe have been found to perform a wide range of stereotypic behaviors. According to a survey of zoological institutions, oral stereotypies, specifically the licking of nonfood objects are the most prevalent stereotypic behaviors observed in giraffe. Their performance appears to be related to feeding and rumination and may be a result of the inability of a highly motivated feeding behavior pattern, tongue manipulation, to be successfully completed. To test this hypothesis, the indoor and outdoor feeders for three giraffe housed at Zoo Atlanta were modified to require the giraffe to perform more naturalistic and complex foraging behaviors. Data were collected using instantaneous scan sampling in both exhibit and holding areas. Our results showed that, for the giraffe that engaged in the highest rates of oral stereotypic behavior in the baseline, more complex feeders that required tongue use to access grain or alfalfa had the greatest effect on behavior. For the giraffe that performed low baseline rates of oral stereotypic behavior, adding slatted tops to the alfalfa feeders indoors virtually eliminated the behavior. Although some changes in ruminating and feeding behavior were observed, the decreases in stereotypic behavior were not associated with the changes in ruminating or feeding behavior. These results provide evidence for the hypothesis that oral stereotypy in herbivores can be reduced by encouraging giraffe to engage in more naturalistic foraging behavior. Zoo Biol 27:200–212, 2008. © 2008 Wiley-Liss, Inc.

Keywords: stereotypic behavior; oral behavior; housing; welfare; giraffe

*Correspondence to: Meredith Bashaw, Department of Psychology, Franklin & Marshall College, PO Box 3003, Lancaster, PA 17604. E-mail: mbashaw@alumni.duke.edu

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INTRODUCTION

Stereotypic behaviors have been defined as unvarying repetitive behavior patterns that have no obvious goal or function in the context in which they are performed [Fox, 1965; Mason, 1993]. They are behaviors that are either not performed in the wild at all or occur naturally but are performed at inappropriate rates in captivity. The presence of stereotypic behavior is often used as an indicator of poor animal welfare [e.g. Broom, 1991; Carlstead, 1998, but see Mason and Latham, 2004] because it is associated with physiological changes indicative of stress [as reviewed by Mason, 1991] and tends to occur at higher rates in sub-optimal environments [Hediger, 1950]. It has been suggested that the performance of stereotypic behavior reflects an inability of the individual to properly mobilize psychological resources to defend against or cope with stressors [Zayan, 1991].

Oral stereotypic behaviors have been extensively studied in domestic ungulates [e.g. Redbo, 1990; Terlouw et al., 1991]. Lawrence and Terlouw [1993] have suggested that these behaviors are partly caused by the motivation to feed during circumstances in which food intake is restricted, the nutritional value of food is restricted, or the processing of food is of shorter duration than it would be in natural conditions. For example, heifers fed a greater portion of roughage and allowed to feed for a longer duration exhibit less oral stereotypy than heifers fed a standard diet [Redbo and Nordblad, 1997]. Increasing the frequency of meals [Cooper et al., 2005] and overall time spent feeding [Ramonet et al., 1999; Lindström and Redbo, 2000] decreases oral stereotypy even when nutritional value is constant. These results suggest restrictions on feeding behavior are related to the development and persistence of oral stereotypy.

Exotic animals in captivity are rarely, if ever, fed a diet that approximates what they would experience in the wild [Young, 1997]. Therefore, oral stereotypic behavior is often a problem in zoo environments. A survey of 257 zoo-housed giraffe and okapi found that a large percentage of individuals perform locomotor and/or appetitive stereotypic behavior [Bashaw et al., 2001]. Almost 80% were reported to perform at least one type of stereotypy, with licking of nonfood objects (72.4%) and pacing (29.2%) being the most common. Among the predictors of stereotypic licking were feeding frequency, method of feeding, and type of food provided. Therefore, the authors concluded that feeding motivation may be related to oral stereotypies in giraffe and okapi, as in domestic ungulates.

In the wild, giraffe spend over half of their time feeding [Pellew, 1984] and feed during every hour of the day [Dagg and Foster, 1976]. Six species of Acacia or Grewia plants comprise 87.2% of the diet of giraffe in the Seronera woodlands of the Serengeti [Pellew, 1984]. These plants have very small leaves and thorns and sometimes house stinging ants so giraffe must remove leaves with their tongues while avoiding ants and thorns [Dagg and Foster, 1976]. In zoos, giraffe are usually fed alfalfa and manufactured concentrated feeds, with occasional browse [Bashaw et al., 2001]. None of these foods are difficult to process. Furthermore, they are often provided in open feeders, making them relatively easy to access and quick to consume. Lawrence and Terlouw [1993] hypothesized that using foraging devices designed to increase the complexity of feeding behavior would "allow for more varied and species-typical expression of strong motivations" and "reduce stereotypies" (p 2823). In support of this hypothesis, foraging devices such as the Equiball or Edinburgh Foodball (United Kingdom) have been shown to increase foraging time [Winskill et al., 1996] and decrease stereotypic behavior [Henderson and Warant, 2001] in horses. In our study, we manipulated the giraffe feeders at Zoo Atlanta and designed new feeders in an attempt to increase the amount of tongue manipulation required by the giraffe to obtain their food. We hypothesized that increasing the complexity of the feeders would increase time spent foraging and decrease the amount of time giraffe spent performing oral stereotypic behavior.

METHOD

Subjects

Observations were made on one male (Aaron) and two female (Betunia and Kamili) Masai giraffe (*Giraffa camelopardalis tippelskirchi*) at Zoo Atlanta. The giraffe were housed in a 1.5 acre mixed species outdoor yard from 09:30 to 17:30 hr each day with zebra, Thomson's gazelle, secretary birds, comb ducks, cape teals, crowned cranes, an African white-faced whistler, and an ostrich. While in the exhibit, all giraffe had access to one or two outdoor feeders containing ad libitum alfalfa, which was refreshed each morning at approximately 0900 and as needed during the day. These feeders were approximately 3 m above the exhibit floor out of reach of the other species. The remainder of the day was spent in individual stalls in an indoor barn, in which all giraffe had full visual, olfactory, and auditory access to each other but limited tactile access. Indoors, each giraffe was provided an individual ration of 10 lb of grain at 1630 and access to ad libitum alfalfa. Grain rations were placed in a feeder where only one giraffe could reach, whereas two giraffe could usually reach alfalfa feeders. At the start of this study, all three giraffe had been documented to engage in stereotypic licking of nonfood objects and substrates both outdoors and indoors [Tarou et al., unpublished data].

Data Collection

Giraffe were observed between September and December, 2000 in their outdoor public exhibit from a slightly raised research platform. This position elicited minimal attention from the giraffe, while allowing the observer a view of the entire exhibit. Data were collected in 1 hr sessions between 14:30 and 16:30 hr using an instantaneous scan sampling technique with 30-sec intervals [Altmann, 1974]. Two observation sessions were sometimes conducted in succession. The afternoon observation time was selected to maximize observed oral stereotypy, as our previous studies showed a peak in nonfood object licking by these giraffe between 14:30 and 16:30 hr [e.g. Tarou et al., 2000]. We recorded feeding (picking up, chewing, or swallowing an edible item), ruminating (bringing up, chewing, or swallowing a bolus of already consumed food), and repetitive nonfood object licking (repeated, lengthy use of the tongue on a nonfood surface, usually of fences but occasionally of rock surfaces) by each of the giraffe.

Experimental Design and Procedure

The study was divided into one initial baseline period during which data were collected earlier to any environmental manipulation and nine conditions in which the complexity of the feeders was manipulated. During baseline, the feeders used to provide alfalfa were slatted, wire baskets with open tops. The giraffe could insert their lips and tongue between the slats to access food from the bottom and sides of the feeder but could freely access the food with very little tongue manipulation from the top. Following baseline, we added new feeders in each subsequent experimental condition that were designed to require more tongue manipulation by the giraffe, returning to the wire basket feeders after every two experimental phases. Even though giraffe were not observed indoors, changes were made to both indoor and outdoor feeders because tongue manipulation required for daily feeding would include eating performed in both places and because grain was not provided outdoors so manipulations to grain feeders could only be performed indoors. The feeders used in each phase are listed in Table 1. Giraffe were given 7 to 10 days after each change in feeders to acclimate to the new feeders before data collection began. Data collection for each of the 10 phases lasted 1 week. Six hours of data were collected in the initial baseline, and 10 hr of data were collected during each subsequent phase, for a total of 96 hr of data on each animal. There were no changes in diet over the course of this study; the giraffe were fed the same portion of grain

TABLE 1. Summary of experimental conditions

Experimental phase	Indoor grain fed in:	Indoor alfalfa fed in:	Outdoor alfalfa fed in:
Baseline	Open-topped bins	Open-topped baskets	Two open-topped baskets
Capped feeders	Open-topped bins	Slatted-top baskets	Two open-topped baskets
Haybag	Open-topped bins	Slatted-top baskets and haybag about 0.67 m above giraffe height	One hay bag, about 0.67 m above giraffe height
Capped feeders 2	Open-topped bins	Slatted-top baskets	Two open-topped baskets
Stationary buckets	Water bottle feeders (3 in diameter holes) lashed to fencing	Slatted-top baskets	Two bucket feeders (3 in diameter holes) lashed to posts
Mobile buckets	Water bottle feeders (3 in diameter holes) hanging overhead, about 0.67 m above giraffe height	Slatted-top baskets	Two bucket feeders (3 in diameter holes) hanging from posts
Capped feeders 3	Open-topped bins	Slatted-top baskets	Two open-topped baskets
Stationary mesh	Water bottle feeders (3 in diameter holes) lashed to fencing	Slatted-top baskets	Two mesh basket feeders (2 in metal mesh) lashed to posts
Mobile mesh	Water bottle feeders (3 in diameter holes) hanging overhead, about 0.67 m above giraffe height	Slatted-top baskets	Two mesh basket feeders (2 in metal mesh) hanging from posts
Capped feeders 4	Open-topped bins	Slatted-top baskets	Two open-topped baskets

All feeders were presented approximately 3 m above the exhibit or barn floor unless another height is specified.

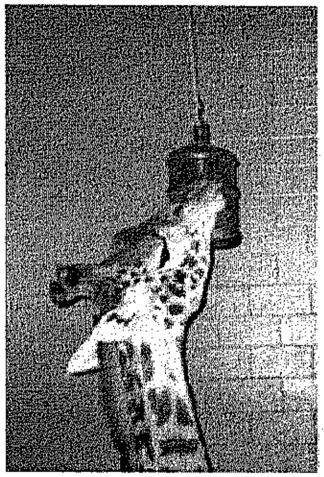
and received alfalfa ad libitum. Keepers reported no change in the amount of alfalfa provided to or consumed by the giraffe.

Materials

Feeders used in the experimental phases were constructed as follows. Slatted-top wire baskets were created by adding a welded cap composed of metal slats to the tops of the original feeders so that the slats matched those on the sides of the feeder (see Fig. 1). The top was hinged so that keepers could raise it when food was provided and secure it with two spring clips during use by the giraffe. Because the hinges were welded on, the feeders remained capped for the remainder of the study, and the capped feeder condition was repeated every third condition. As a result, only the capped feeders phase was comparable to baseline conditions, and all other feeders were examined to see if they caused a change in behavior relative to the capped feeder phase.

Haybags were commercially manufactured mesh bags with 3 in openings for accessing the alfalfa when the bags were full. Haybags were always hung above the heads of the giraffe but within reach (the bottom of the net approximately 0.67 m above the giraffe's head) to avoid entangling their necks. Water bottle grain feeders (see Fig. 2) were made by drilling several holes approximately 3 in in diameter into a 5-gallon water cooler bottle, with the bottom of each hole between 2 and 6 in above the base of the bottle. Three-inch diameter holes are too narrow to allow a giraffe's muzzle to enter the feeders so giraffe could only access the grain in the bottles by inserting their tongues into the holes. Bucket feeders (see Fig. 2) were 5-gallon buckets drilled in the same way, except that the bottom of the holes were between 2 and 12 in from the bottom of the bucket and one hole was placed in the center of the lid. Bucket lids were closed during presentation to the giraffe, but could be opened for easy refilling of the feeders. Again, giraffe could only access food (in this case alfalfa) by inserting their tongues through the holes. Both water bottles and buckets

Fig. 1. Capped feeders, created by hinging a welded cap composed of metal slats onto the tops of the original feeders so that the slats matched those on the sides of the feeder.



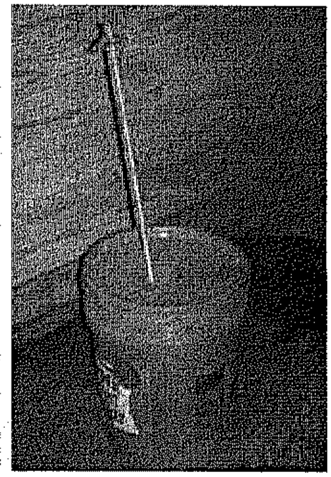


Fig. 2. Water bottle grain feeders (a), made from 5-gallon bottles typically placed atop water cooler stands, and bucket feeders (b) created from 5-gallon buckets with lids.

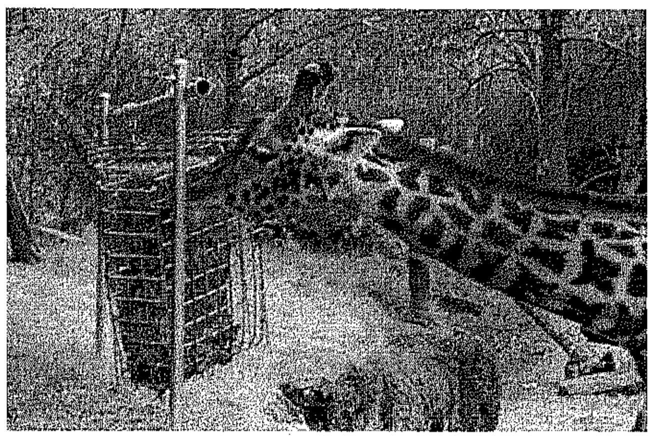


Fig. 3. Mesh feeders created by welding 2 in metal mesh into large rectangular baskets. Inside the baskets, we placed PVC and bolt "jacks" to create artificial "thorns" as might be seen on acacia trees in the wild.

were presented first as stationary feeders (by running a rope through two of the holes and tying it around a segment of the indoor fence or the posts supporting the outdoor feeders) and then as mobile feeders (by suspending the water bottles from a bolt drilled through the mouth of the bottle or the buckets from a pole drilled through the bottom of the bucket and extending through the hole in the lid). Again, all suspended feeders were hung high enough so that the giraffe could not tangle their necks.

Finally, we created mesh feeders (see Fig. 3) by welding 2 in woven metal mesh into large rectangular baskets with lids that were the size of two flakes of alfalfa. The lids were clipped closed with double-ended spring clips. Inside the baskets, we interspersed PVC and bolt "jacks" into the alfalfa to create artificial "thorns" as might be seen on acacia trees in the wild. The jacks were not attached to the feeders, but were large enough that they could only be removed through the open feeder lid. They were created by cutting a piece of 1 in diameter PVC to about 6 in long, smoothing the ends, and adding six 5 in long, 1/2 in diameter bolts that radiated through the pipe in all different directions. Nuts were added to the bolts on either side of the PVC pipe, and lock-tite was used to ensure the nuts and bolts could not be unscrewed and ingested by the giraffe. We sunk two posts into the ground and bolted a third post across the top to form a U-shaped apparatus to which the baskets were clipped. Like the water bottle and bucket feeders, the mesh feeders were first presented as stationary feeders (secured to both the top and side posts) and later as mobile feeders (secured only to the top post and allowed to swing freely under it).

Data Analysis

Because only three individuals were studied, the requirements for most statistical tests were not met. Three dependent variables were analyzed for each individual giraffe using randomization tests: the percent of scans spent licking, feeding, and ruminating. These tests compare a statistic computed on the data obtained in a study with the same statistic computed on 2,000 randomized pseudo-samples created by reshuffling the same obtained values without regard to their original categories [Colegrave et al., 2006]. The probability of obtaining a result greater than the observed value by chance is calculated by counting the number of results greater than the observed value from the pseudo-samples and dividing by the total number of pseudo-samples (i.e. if 20 pseudo-samples out of 2,000 resulted in a mean difference greater than the observed, P of the observed value is 20/2,000, or $P = 0.01$). For each individual, we used a randomization statistical procedure equivalent to an analysis of variance approach (analyzing the sum of the absolute difference among means) to determine the overall effect of our manipulations on each of the three dependent variables across all conditions (3 giraffe $\times$ 3 measures = 9 tests).

We then conducted four subsequent analyses on the absolute value of the difference between means for two conditions. First, to determine whether the simplest feeder change was effective, we compared the percent of time spent in the significant behavior during baseline with when the feeders were capped (averaged across all four capped feeder conditions). Second, to determine if any of the feeders caused a greater change than the simplest manipulation, we performed pairwise comparisons of the percent of time spent performing that behavior when the feeders were capped to each of the other types of feeders individually (i.e. capped feeders to haybag feeders, capped feeders to bucket feeders, and capped feeders to mesh feeders). Third, to determine whether any one of the complex feeders was superior to the others we compared haybag feeders, bucket feeders, and mesh feeders. Finally, we compared stationary vs. mobile feeders by combining data across the bucket and mesh feeders presented in each way. Although we considered them, we decided against using Bonferroni corrections, which would have unnecessarily increased the chance of a Type II error [Nakagawa, 2004].

RESULTS

All three giraffe performed oral stereotypic behavior, specifically licking of the fences or walls in the exhibit, in the baseline condition (see Table 2 for the individual

TABLE 2. Average percent of scans spent performing each behavior during observation sessions when that feeder was used

Behavior	Giraffe	Baseline (%)	Capped feeders (%)	Haybags (%)	Bucket feeders (%)	Mesh feeders (%)
Licking						
∴	Betunia	33.1	16.3*	19.3	12.1	4.0**
∴	Kamili	2.8	4.6	1.8	2.2	2.3
∴	Aaron	3.1	0.4*	0.5**	0.4	0.1
Feeding						
	Betunia	17.4	24.0	25.7	37.8**	23.9
∴	Kamili	25.1	21.6	33.5	28.0	12.1**
	Aaron	32.1	31.2	34.5	46.3**	24.4
Ruminating						
∴	Betunia	30.1	39.5	32.9	25.6**	46.9
∴	Kamili	41.1	42.8	35.3	40.7	62.2**
	Aaron	35.7	41.3	27.8**	29.8**	47.2
Total oral manipulation						
	Betunia	80.6	79.8	77.9	75.5	74.8
	Kamili	69.0	69.0	70.6	70.9	74.8
	Aaron	70.9	72.9	62.8	76.5	71.7

When a feeder was used more than once, data points for all phases in which that feeder was used are averaged. The total oral manipulation values are the sum of licking, feeding, and ruminating for each animal using each feeder. *P*-values are presented in the text. A ∴ in the first column indicates an overall effect across all conditions, a *indicates time spent in the indicated behavior by the indicated animal when feeders were capped was significantly different from baseline, and **Indicates a significant difference between the capped feeder phase and a more complex feeder.

mean rates of behavior). One of the females, Betunia, spent a large amount of time engaged in oral stereotypic behavior and less time feeding or ruminating than the other two giraffe. No other form of stereotypic behavior was either observed or recorded for any of the three giraffe during the study. Figure 4 presents the combined mean rates of oral stereotypic behavior for all three giraffe in each condition. There was an overall significant main effect of the experimental interventions on licking behavior for Betunia ($P = 0.001$), Kamili ($P = 0.024$), and Aaron ($P = 0.032$). There was also an overall significant main effect of these changes on the mean time of Betunia ($P = 0.003$) and Kamili ($P = 0.033$) spent ruminating, but only a trend toward a significant effect for Aaron ($P = 0.071$). Our manipulations only significantly changed Kamili's mean time spent feeding during sessions ($P = 0.009$).

Post hoc analyses revealed that capping the feeders significantly decreased Betunia's licking behavior ($P = 0.024$) and virtually eliminated licking behavior in Aaron ($P = 0.008$). In fact after the initial capping of the feeders, the mean time Aaron spent engaged in stereotypic licking was never higher than 0.7% per condition. Capping the feeders did not significantly change Kamili's stereotypic licking behavior when the data were averaged across all capped feeder conditions ($P = 0.684$); however, her stereotypic licking did decrease significantly from a mean of 2.8% of her time during baseline to 0.42% during the first week during which the feeders were capped ($P = 0.043$). Because levels of licking were so low for Aaron and

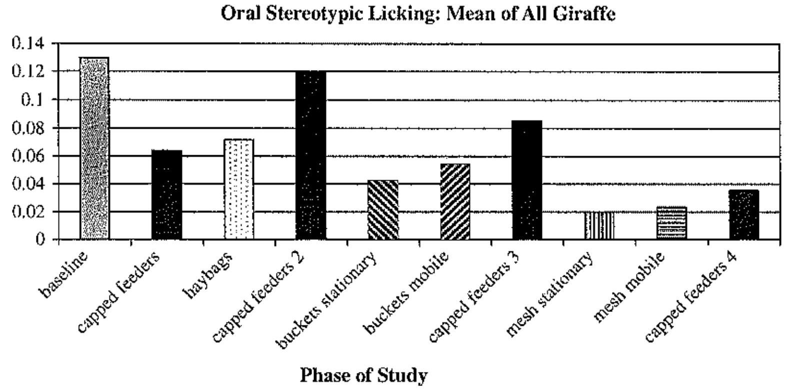


Fig. 4. The mean proportion of oral stereotypic licking behavior across all three giraffe in each condition.

Kamili after the feeders were capped, the mean licking presented in Figure 4 for the subsequent conditions primarily reflects changes in Betunia's licking behavior. Capping the feeders did not significantly affect the mean time spent feeding or ruminating for any of the giraffe.

After capping the feeders we added additional feeders, each designed to require increasingly more work from the giraffe to obtain food. Because the capped feeders could not be removed, these conditions are compared with the capped feeders condition rather than our initial baseline. For Aaron, the haybags actually increased the mean time he engaged in stereotypic licking compared with the capped feeders alone ($P = 0.001$), although this behavior was still rare. His mean time spent ruminating also decreased when the haybag feeders were used ($P = 0.048$). Betunia and Kamili showed no change in behavior when haybags were used. Bucket feeders significantly decreased mean time spent ruminating for both Betunia ($P = 0.006$) and Aaron ($P = 0.045$). They also significantly increased mean time spent feeding for both Betunia ($P = 0.004$) and Aaron ($P = 0.012$). Bucket feeders had no effect on licking in any giraffe, and no effect on Kamili's behavior beyond that seen in the capped feeder condition.

The mesh feeder condition significantly decreased the mean time spent engaged in licking behavior for Betunia ($P = 0.001$), but not for Aaron or Kamili. However, the mesh feeders significantly increased Kamili's time spent ruminating ($P = 0.002$) and decreased her time spent feeding ($P = 0.014$). The mesh feeders had no significant effect on any of Aaron's behaviors compared with the capped feeder conditions.

For Betunia, the female that spent the most time performing stereotypic licking during the baseline, each increasingly complex feeder decreased licking significantly more than the previous manipulation ($P = 0.002$). Neither Aaron's ($P = 0.438$) nor Kamili's ($P = 0.894$) stereotypic licking behavior differed significantly among the three complex feeders. All three giraffe spent the most time ruminating in the mesh feeder condition. For all three giraffe, the mesh feeder was associated with significantly more time spent ruminating than either the haybag or bucket feeders

(Betunia, $P = 0.024$; Kamili, $P = 0.003$; Aaron, $P = 0.012$). For Aaron ($P = 0.03$) and Kamili ($P = 0.002$), the mean rate of feeding decreased when the manipulation increased the mean rate of ruminating.

Making the bucket and mesh feeders mobile (as opposed to stationary) did not significantly alter behavior for Betunia, but significantly increased the mean rate of stereotypic licking behavior in Kamili (stationary = 1%, mobile = 3%, $P = 0.031$), without changing either feeding or ruminating. When feeders were mobile, Aaron ruminated for less time (stationary = 49%, mobile = 29%, $P = 0.003$) and fed for more time (stationary = 25%, mobile = 45%, $P = 0.01$), but showed no significant change in licking.

DISCUSSION

We hypothesized that altering the giraffe feeders to increase the amount of tongue manipulation required by the giraffe to obtain food would increase time spent feeding and decrease the performance of nonfood object licking, an oral stereotypy, by giraffe. Our results showed that feeding behavior changed for only one of the three giraffe following changes to the feeders. However, there was an overall reduction in licking behavior for all three giraffe. In the first phase, in which metal slats were added onto the tops of the original open-topped feeders, all three giraffe decreased nonfood object licking without significantly changing their ruminating or feeding behavior. These results provide further evidence for the hypothesis that oral stereotypy in herbivores can be changed by altering the amount of work required to obtain food.

Betunia, the giraffe that spent the most time licking, licked less as the feeders became more complex. The most complex feeders, the hanging baskets welded from 2 in mesh, significantly decreased the time Betunia spent engaged in stereotypic licking behavior even beyond the decrease produced by the capped feeders. The haybag, bucket, and mesh feeders did not significantly decrease the rate of stereotypic licking in either Aaron or Kamili beyond the change produced by the capping of feeders. The initial capping of the feeders reduced their behavior to almost zero (0.83% for Aaron and 0.42% for Kamili in the first capped feeder phase) leaving little room for improvement with further manipulations. Similarly, a survey by Bashaw et al. [2001] found that the use of closed-top feeders predicted the absence of oral stereotypy in giraffe. Placing slatted caps over current open-top feeders may be sufficient to reduce oral stereotypy in giraffe with low initial rates of oral stereotypic behavior. More complex feeders may be effective if capping alfalfa feeders does not reduce oral stereotypy to acceptable levels.

Captive animals typically eat a different diet than their counterparts in the wild, with a greater proportion of their intake made up of concentrated foods such as grains and commercially available "leaf-eater biscuits." Diets containing a high proportion of calories in concentrated feeds produce excess acid in the gut [Mason and Latham, 2004] and have been linked to oral stereotypy in other ungulates [Redbo et al., 1998; Waters et al., 2002]. Mason and Latham [2004] suggest oral stereotypies may persist because they increase saliva production and therefore buffer gut acidity [although Hemmings et al., 2007 suggest a different proximate mechanism). Altering gut pH may maintain oral stereotypy in giraffe as anecdotal observation suggests nonfood object licking is associated with extensive salivation. If nonfood object licking is a coping mechanism for reducing gut acidity to normal levels, then providing a more appropriate outlet for oral behavior would be expected to reduce licking even without a nutritional change, as observed in this study.

Baxter and Plowman [2001] found that increasing the amount of fiber in the diet of giraffe increased time spent ruminating and decreased licking behavior, but caused no change in time spent feeding. As a result, they concluded that captive diets provided insufficient opportunity to ruminate, which lead to oral stereotypy. In this study, our manipulations caused an overall significant change in the time that the two female giraffe spent ruminating, but licking behavior was not necessarily lowest when levels of ruminating were highest. Furthermore, significant changes in ruminating co-occurred with changes in licking for only one of the giraffe in one of the conditions and significant changes in feeding never co-occurred with changes in licking. The changes in oral stereotypy in the absence of changes in feeding or ruminating observed in this study do not seem consistent with the idea that nonfood object licking is linked to frustrated motivation to feed [e.g. Tarou et al., 2003] or ruminate [e.g. Baxter and Plowman, 2001]. Rather, our data suggest that oral effort exerted during feeding is inversely related to licking in giraffe. Given the cattle and horse data discussed above suggesting that stereotypy is maintained in an effort to balance gut pH, it could be that any increase in oral activity, either rumination or feeding, would increase salivation and therefore reduce the need for oral stereotypy. The consistency of total oral behavior (feeding, ruminating, and licking, see Table 2) across the phases of the study provides some support for this explanation, which would explain why increasing either feeding or rumination is associated with decreased licking.

Unfortunately, the frustrated feeding and ruminating hypotheses cannot be refuted by our data alone. We selected the observation time for this study to maximize the opportunity to observe stereotypic licking by the giraffe. In doing so, we selected a time period when wild giraffe spend less time feeding [Pellew, 1984]. It is possible that the feeders effectively increased the duration of feeding, but that this change occurred in the morning (when wild giraffe feed more and when our giraffe were first given access to the feeders each day) and was therefore not detected in our data. Future studies of this type should include data collection at peak times for each of the three behaviors of interest.

What is perhaps the most interesting about the effectiveness of capping alfalfa feeders is that in this study only the feeders in the indoor holding facility were capped, whereas the outdoor alfalfa feeders were unchanged. Therefore, the effect of increasing oral manipulation indoors generalized beyond the time when the feeders were available to the animals, as some other studies have shown [Bashaw et al., 2003; Shepherdson et al., 1993]. The decrease in nonfood object licking outside when changes were made to feeders inside suggests that the giraffe's motivation to lick may have been affected by changes in feeding strategy, and supports our assumption that tongue manipulation required for daily feeding includes eating performed both indoors and outdoors.

Though we did significantly reduce the overall rates of nonfood object licking in the giraffe in our study, we did not eliminate the behavior entirely. Unfortunately, the reduction but not elimination of abnormal behavior is a common outcome of enrichment studies [Mason et al., 2007]. Though nonfood object licking in giraffe may initially develop in response to the feeding circumstances experienced by the animals, it has been hypothesized that stereotypic behaviors can become a coping mechanism performed in response to stress and may indicate the presence of other environmental stressors [Groothius, 1989, Ridley and Baker, 1982].

Oral stereotypic behavior such as nonfood object licking rarely, if ever, is reported in giraffe in the wild. It is important for zoos and other wildlife parks to acknowledge and address oral stereotypic behavior in their captive ungulates. Though research has not evaluated the long-term effects of diet regimen in captive ungulates, studies conducted on horses indicate that the way ungulates are fed can have serious and perhaps unexpected consequences. For example, diets containing a high percentage of calories in concentrated form such as those fed to captive ungulates are associated with crib-biting, an oral stereotypy, in adult horses [Redbo et al., 1998] and have resulted in the development of crib-biting in foals [Waters et al., 2002]. Furthermore, periods of time when food is not available (e.g. when feeding in discrete meals rather than across the day) can cause stereotypic behavior, increase gastric acidity, and increase the likelihood that horses will develop gastric ulcers [Murray and Eichorn, 1996]. The diet regimen reported by zoos to be the most commonly provided to captive giraffe and okapi [Bashaw et al., 2001] may be compromising both physiological and psychological well-being and should be the subject of further study. We have shown that even fairly simple changes to existing feeders, such as adding slatted tops to open-topped feeders, can have a beneficial effect on behavior.

CONCLUSION

We reduced giraffe nonfood object licking, an undesirable stereotypic behavior, by changing the amount of oral manipulation required to obtain feed without changing the type or amount of feed provided. Creating an opportunity for giraffe to perform manipulative feeding behavior appears to reduce the motivation for licking.

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REFERENCES

Altmann J. 1974. Observational study of behaviour: sampling methods. Behaviour 48:227–265.

Bashaw MJ, Bloomsmith MA, Marr MJ, Maple TL. 2003. To hunt or not to hunt? A feeding enrichment experiment with captive lions and tigers. Zoo Biol 22:189–198.

Bashaw MJ, Tarou LR, Maki TS, Maple TL. 2001. A survey assessment of variables related to stereotypy in giraffe and okapi. Appl Anim Behav Sci 73:233–245.

Baxter E, Plowman AB. 2001. The effect of increasing dietary fibre on feeding, rumination and oral stereotypies in captive giraffe (*Giraffa camelopardalis*). Anim Welf 10:281–290.

Broom DM. 1991. Assessing welfare and suffering. Behav Proc 25:117–123.

Carlstead K. 1998. Determining the causes of stereotypic behaviors in zoo carnivores: toward appropriate enrichment strategies. In: Shepherdson DJ, Mellen JD, Hutchins M, editors. Second nature: environmental enrichment for captive animals. Washington, DC: Smithsonian Institution Press. p 172–183.

Colegrave N, Engel J, Plowman AB. 2006. Randomisation tests. In: Plowman AB, editor. Zoo research guidelines: statistics for typical zoo datasets. London: BIAZA. p. 7–16.

Cooper JJ, McCall N, Johnson S, Davidson HPB. 2005. The short-term effects of increasing meal frequency on stereotypic behavior of stabled horses. Appl Anim Behav Sci 90:351–364.

Dagg AI, Foster JB. 1976. The giraffe: its biology, behaviour, and ecology. New York: Van Nostrand Reinhold Co.

Fox MW. 1965. Environmental factors influencing stereotyped and allelomimetic behaviour in animals. Lab Anim Care 15:363–370.

Groothius T.1989. On the ontogeny of display behaviour in the black-headed gull II: causal links between the development of aggression, fear and display behaviour: emancipation reconsidered. Behaviour 110:161–204.

Hediger H. 1950. Wild animals in captivity. London: Butterworths Scientific Publications.

Hemmings A, McBride SD, Hale CE.2007. Perseverative responding and the aetiology of equine oral stereotypy. Appl Anim Behav Sci 104:143–150.

Henderson JV, Warant NK. 2001. Reducing equine stereotypies using an Equiball™. Anim Welf 10:73–80.

Lawrence AB, Terlouw EM. 1993. A review of behavioral factors involved in the development and continued performance of stereotypic behavior in pigs. J Anim Sci 71:2815–2825.

Lindström T, Redbo I. 2000. Effect of feeding duration and rumen fill on behaviour in dairy cows. Appl Anim Behav Sci 70:83–97.

Mason GJ. 1991. Stereotypies: a critical review. Anim Behav 41:1015–1037.

Mason GJ. 1993. Forms of stereotypic behaviour. In: Lawrence AB, Rushen J, editors. Stereotypic animal behaviour: fundamentals and applications to welfare. Wallingford, Oxon,UK: CAB International. p. 8–40.

Mason G, Clubb R, Latham N, Vickery S. 2007. Why and how should we use environmental enrichment to tackle stereotypic behaviour? Appl Anim Behav Sci 102:163–188.

Mason GJ, Latham NR. 2004. Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? Anim Welf 13:557–569.

Murray MJ, Eichorn ES. 1996. Effects of intermittent feed deprivation, intermittent feed deprivation with ranitidine administration, and stall confinement with ad libitum access to hay on gastric ulceration in horses. Am J Vet Res 57:1599–1603.

Nakagawa S. 2004. A farewell to Bonferroni: the problems of low statistical power and publication bias. Behav Ecol 15:1044–1045.

Pellew RA. 1984. The feeding ecology of a selective browser, the giraffe (*Giraffa camelopardalis tippelskirchi*). J Zool Soc Lond 202:57–81.

Ramonet Y, Meunier-Salaun MC, Dourmad JY.1999. High fiber diets in pregnant sows: digestive utilization and effects on the behavior of animals. J Anim Sci 77:591–599.

Redbo I. 1990. Changes in duration and frequency of stereotypies and their adjoining behaviours in heifers, before, during, and after the grazing period. Appl Anim Behav Sci 26:57–67.

Redbo I, Norblad A. 1997. Stereotypies in heifers are affected by feeding regime. Appl Anim Behav Sci 53:193–202.

Redbo I, Redbo-Tortensson P, Odberg FO, Hedendahll A, Holm J. 1998. Factors affecting behavioural disturbances in race-horses. Anim Sci 66:475–481.

Ridley RM, Baker HF. 1982. Stereotypy in monkeys and humans. Psych Med 12:61–72.

Shepherdson DJ, Carlstead K, Mellen JD, Seidensticker J. 1993. The influence of food presentation on the behavior of small cats in confined environments. Zoo Biol 12:203–216.

Tarou LR, Bashaw MJ, Maple TL. 2000. Social attachment in giraffe: response to social separation. Zoo Biol 19:41–51.

Tarou LR, Bashaw MJ, Maple TL 2003. The failure of a chemical spray to significantly reduce stereotypic licking in captive giraffe (*Giraffa camelopardalis tippelskirchi*). Zoo Biol 22: 601–607.

Terlouw EMC, Lawrence AB, Illius AW. 1991. Influences of feeding level and physical restriction on development of stereotypies in sows. Anim Behav 42:981–991.

Waters AJ, Nicol CJ, French NP. 2002. The development of stereotypic and redirected behaviors in young horses: the findings of a four-year prospective epidemiological study. Eq Vet J. 34:572–579.

Winskill LC, Waran NK, Young RJ. 1996. The effect of a foraging device (a modified "Edinburgh Foodball") on the behaviour of the stabled horse. Appl Anim Behav Sci 48:25–35.

Young RJ.1997. The importance of food presentation for animal welfare and conservation. Proc Nutr Soc 56:1095–1104.

Zayan R. 1991. Summary and perspectives: individual patterns of stress responses. Behav Proc 25:205–209.