



Article

Investigating the Effect of Enrichment on the Behavior of Zoo-Housed Southern Ground Hornbills

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Abstract: Enrichment is essential for the welfare of many zoo-housed animals, yet the value of enrichment is not well understood for all taxa. As an intelligent, long-lived species, the southern ground hornbill (*Bucorvus leadbeateri*) is a good model for enrichment research. A pair of southern ground hornbills, housed at Beale Wildlife Park and Gardens, were observed during study periods in 2014, 2018, and 2019. Three types of enrichment were provided for the birds; these enrichment types were developed based on information on the habits of the species as found in natural history papers. The enrichment types consisted of a pile of twigs, small animal carcasses, and plastic mirrors. Overall, the carcass feeds and the mirrors resulted in the greatest changes in behavior, with hornbills engaging in long periods of food manipulation with carcasses. For the mirror condition, hornbills spent time stalking around and pecking at mirrors, similar to the 'window smashing' behavior seen in wild hornbills. Overall, the research suggests that not only can enrichment modify the behavior of southern ground hornbills, but non-nutritional enrichment may be equally valuable to the animals. Natural history papers may have some value in inspiring novel enrichment items for zoo-housed animals.

Keywords: *Bucorvus leadbeateri*; *Bucerotidae*; mirror; carcass feeding; spread of participation index



Citation: Brereton, J.E.; Myhill, M.N.G.; Shora, J.A. Investigating the Effect of Enrichment on the Behavior of Zoo-Housed Southern Ground Hornbills. *J. Zool. Bot. Gard.* **2021**, *2*, 600–609. <https://doi.org/10.3390/jzbg2040043>

Academic Editors: Kris Descovich, Caralyn Kemp and Jessica Rendle

Received: 6 September 2021

Accepted: 8 November 2021

Published: 13 November 2021

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1. Introduction

Enrichment is fundamentally important for the welfare of many animals in zoos, yet there remain gaps in the knowledge of provision of enrichment for some taxa [1]. Many enrichment studies have been conducted for some taxonomic groups, such as the mammalian families, Felidae and Elephantidae [2]. The availability of studies allows researchers to evaluate and compare enrichment strategies, and therefore put in place the most effective plans. For some taxonomic groups, however, information on enrichment is more limited. This reduces the information available to practitioners to help improve the welfare of their animals.

Enrichment is particularly important for highly cognitive species that may otherwise become bored with a predictable or unstimulating environment. Many avian families are particularly susceptible, expressing unnatural behaviors, such as stereotypy, if enrichment is insufficient. Parrots (family Psittacidae) are a good example; birds in this family are typically intelligent, capable problem-solvers who live long lives. Where enrichment or social groups are not provided, feather-plucking and stereotyped behavior commonly occur [3]. Fortunately, enrichment has been well studied for the Psittacidae, and as a result, animal keepers have several effective strategies available to reduce the prevalence of stereotypy [1–3].

However, other intelligent, long-lived bird taxa are kept in zoos, some of which have received less focus in terms of enrichment research. One example is the hornbills (Order Bucerotiformes). Hornbills can be found throughout Africa and Asia, and are well-known

for their unusual nesting habits, in which females often seal themselves into a tree cavity to incubate their chicks. Hornbills have been shown to be capable problem-solvers [4] and are also sensitive to both visitors and keepers when housed in zoos [5]. With a diverse range of hornbill species held in captivity, each representing different habitats, dietary niches and breeding strategies, there is a need to further investigate enrichment for this group of species.

The southern ground hornbill (*Bucorvus leadbeateri*) is one of the two largest extant hornbill species, reaching weights of up to 4 kg [6]. In recent years, the species has received some conservation attention in the wild, on account of decreasing population numbers [7–11]. In many parts of its historic range, the species has been persecuted because it is viewed as a bad omen [12]. The southern ground hornbill has a cooperative breeding strategy and a slow reproductive rate, leaving it vulnerable to extinction. As a result, zoo populations for this species are important, potentially providing a ‘safety net’. A July 2021 search of Species360’s [13] database revealed that at least 151 institutions globally keep this species, with an overall population size of over 390 birds. While these numbers are not excessively high in comparison to other zoo-housed birds [14–17], there is a need to further develop enrichment strategies for this species.

In the wild, southern ground hornbills typically forage on the ground, walking across the savannah [10]. The birds are entirely carnivorous, and feed on a range of foods including carrion, and invertebrates, reptiles, birds, and small mammals that are captured and killed [6]. The birds are particularly intelligent and social communication is advanced for this species, with small groups or ‘mobs’ developing, that work cooperatively to support female birds during incubation.

The purpose of this study was twofold. First, we aimed to develop an activity budget for zoo-housed southern ground hornbills. Second, we aimed to identify which enrichment types were most effective in encouraging exploratory behavior for the pair of birds.

2. Materials and Methods

2.1. Study Site and Subjects

The study was conducted according to the guidelines of the Association for the Study of Animal Behaviour and approved by the ethics committee of Beale Wildlife Park (A17, 19 January 2014). Following ethical approval from Beale Wildlife Park, the study commenced at Beale Wildlife Park and Gardens in Reading, United Kingdom. Three periods of data collection were undertaken: these were from 27 March 2014 to 30 June 2014, 15 January 2018 to 16 July 2018, and 1 November 2019 to 23 December 2019. Animals were observed during three observation periods: these were 08:00–10:00, 10:30–12:30, 13:00–15:00, and 15:30–17:30. Birds were observed based on the availability of the authors.

The study focused on two (1.1) parent-reared southern ground hornbills who were kept in a large single-species aviary in the ‘Owl Walk’ (Table 1, Figure 1). The exhibit consisted of several elevated perches, and one large barrel (for breeding purposes). The exhibit substrate was a mixture of leaf litter and soil. The birds were not flight restrained, but the exhibit was covered with nylon mesh to prevent escapes.

Table 1. Study subjects.

Sex	Date of Birth	Studbook Number	GAN	Movement into Collection
Male	20 May 2000	EAZA/73	MIG12-28772165	12 November 2010
Female	11 May 2001	EAZA/74	MIG12-28772164	12 November 2010



Figure 1. Hornbill enclosure, with male hornbill resting on log.

2.2. Enrichment Types

Enrichment was provided on a randomized schedule. Three enrichment types were provided for the animals; the enrichment types were inspired by the natural history documentation for the species. The first enrichment type consisted of a large pile of twigs and branches, into which several morio worms (*Zophobas morio*) were presented; this enrichment style was developed to encourage hornbills to forage using their talons and beak. The second enrichment type consisted of an entire rabbit carcass, as the species regularly feeds on large carcasses, and can hunt large prey in the wild [6,18,19]. The final enrichment style consisted of two large, non-shatter mirrors. Mirrors were used because they are frequently applied in bird husbandry to mimic the presence of conspecifics. There is also some evidence to suggest that wild hornbills interact with reflective surfaces such as on water, or in windows, in their native range.

The behavior of the birds was also observed during 'control' periods, when food was not present, and during normal feeding hours. Control periods were matched for time of day to the experimental treatments. The normal feed for the hornbills was provided at 16:00 and consisted of either day-old chicks or chunks of rabbit or quail, chopped into small pieces. When enrichment feeds were provided, they were deducted from the normal dietary provision.

2.3. Behavioral Recording

Behavior was recorded using instantaneous focal sampling of both birds simultaneously. One-hour observations were conducted, with the observer recording state behaviors at one-minute intervals. An ethogram was developed, containing behaviors which were adapted from Kemp & Kemp [6] (Table 2).

Table 2. Hornbill ethogram. Inspired by Kemp & Kemp [6].

Behavior	Description
Allopreening	The bird engages in preening of a conspecific.
Enrichment interaction	The bird uses its beak or feet to poke at or scratch an enrichment item.
Feeding	The bird takes food items from the exhibit and swallows them.
Flying	The bird lifts off the ground by raising and lowering its wings rapidly.
Object in beak	The bird is standing or walking with an item (e.g., food or nest material) in its beak.
Preening	The bird wipes its bill across its feathers in a repeated fashion.
Resting	The bird is motionless. The eyes may be either open or closed. Includes both standing and perching.
Sunbathing	The bird extends its wings in a fan and angles them toward the sun. The bird remains motionless.
Walking	The bird moves around the exhibit using its feet.

During observations, the observers partially concealed themselves behind a large oak tree at the front of the exhibit. Data were compiled onto paper observation sheets. In addition to behavioral data, observers also recorded the temperature and humidity (using BBC weather information for Pangbourne), weather conditions (e.g., rain, cloud), and the number of visitors that walked past the exhibit during the hour observation period.

2.4. Enclosure Use

In addition to hornbill behavior, the enclosure use of the two birds was recorded. The location of each bird was recorded using instantaneous focal sampling at one-minute intervals. The enclosure was separated into seven different zones, based on their biological value to the animals. The size of each useable surface per zone was measured using a tape measure (Table 3).

Table 3. Enclosure zones for the Southern ground hornbills.

Zone	Description	Size (m ²)
Elevated perches (left)	Large logs for perching, 2–2.5 m from ground.	12.5
Elevated perches (right)	Logs for perching, roughly 1.8–2.4 m from ground.	14.1
Central log	Long tree trunk, extending between left and right elevated perches, 0.8–1.5 m from ground.	15.6
Water	Small water pool and surrounding concrete.	3.5
Barrel	Barrel used by female during nesting.	2.1
Tree stump	Large tree stump turned upside down, with roots available for perching.	7.8
Ground	Substrate of enclosure, consisting of soil and leaf litter.	151.2
Total		206.8

Overall hornbill enclosure use was assessed for each bird using a modified spread of participation index (mSPI) [15]. The equation for mSPI is:

$$\frac{\sum |fo - fe|}{2(N - \text{femin})}$$

Here, N refers to the number of observations; fo and fe refer to the number of observed and expected observations in a given zone, respectively; femin refers to the expected observation in the smallest zone [15]. For mSPI, the maximum value of 1 indicates uneven enclosure use (the animal is using only the smallest zone and avoiding all other zones) whereas the minimum value of 0 indicates that animals are using all zones equally (in proportion to their size) [15].

2.5. Data Analysis

Data were compiled onto a Microsoft Excel™ 2010, Albuquerque, USA spreadsheet and then uploaded to Minitab version 21 for analysis. Analysis was conducted on the effect of the three enrichment types and the control condition on hornbill behavior. For analysis, behavioral data were tested for normality. Where data were normally distributed, one-way ANOVAs with Tukey post hoc tests were used to investigate the impact of enrichment. For non-normally distributed data, Friedman’s ANOVAs with pairwise Wilcoxon tests were used [20].

3. Results

3.1. Behavior

A comparative activity budget was developed to demonstrate the effects of enrichment for the male and female hornbills (Figure 2). As data were non-parametric, Friedman’s ANOVAs were run to determine the effect of enrichment on behavior (Table 4). Two behaviors, enrichment interaction and feeding, were significantly affected by enrichment type.

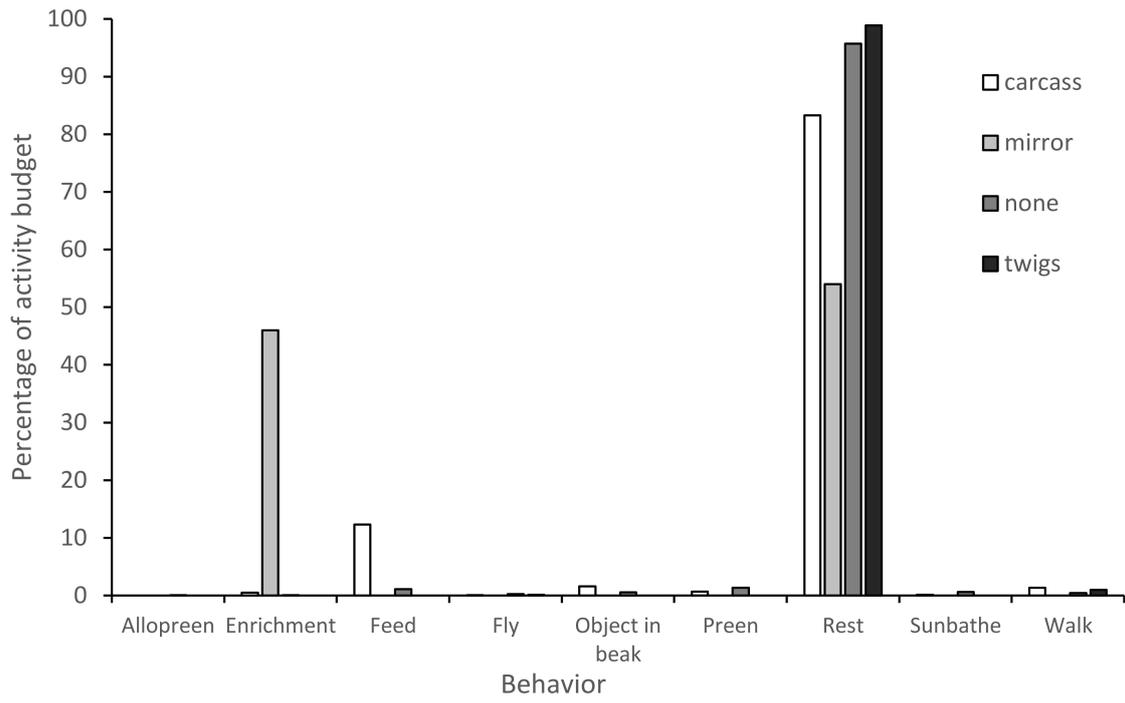
Table 4. Output of Friedman’s ANOVAs on the effect of enrichment on hornbill behavior.

Behaviour	Test Statistic	p	Significant Post Hoc Tests
Allopreening	$X^2_{(3)} = 2.31$	0.412	
Enrichment interaction	$X^2_{(3)} = 99.62$	<0.001 *	Mirror-None, Mirror-Carcass, Mirror-Twigs
Feeding	$X^2_{(3)} = 75.16$	<0.001 *	Carcass-Mirror, Carcass-Twigs, Carcass-None
Flying	$X^2_{(3)} = 6.26$	0.096	
Object in beak	$X^2_{(3)} = 0.68$	0.718	
Preening	$X^2_{(3)} = 6.99$	0.099	
Resting	$X^2_{(3)} = 22.14$	0.127	
Sunbathing	$X^2_{(3)} = 4.16$	0.180	
Walking	$X^2_{(3)} = 11.41$	0.416	

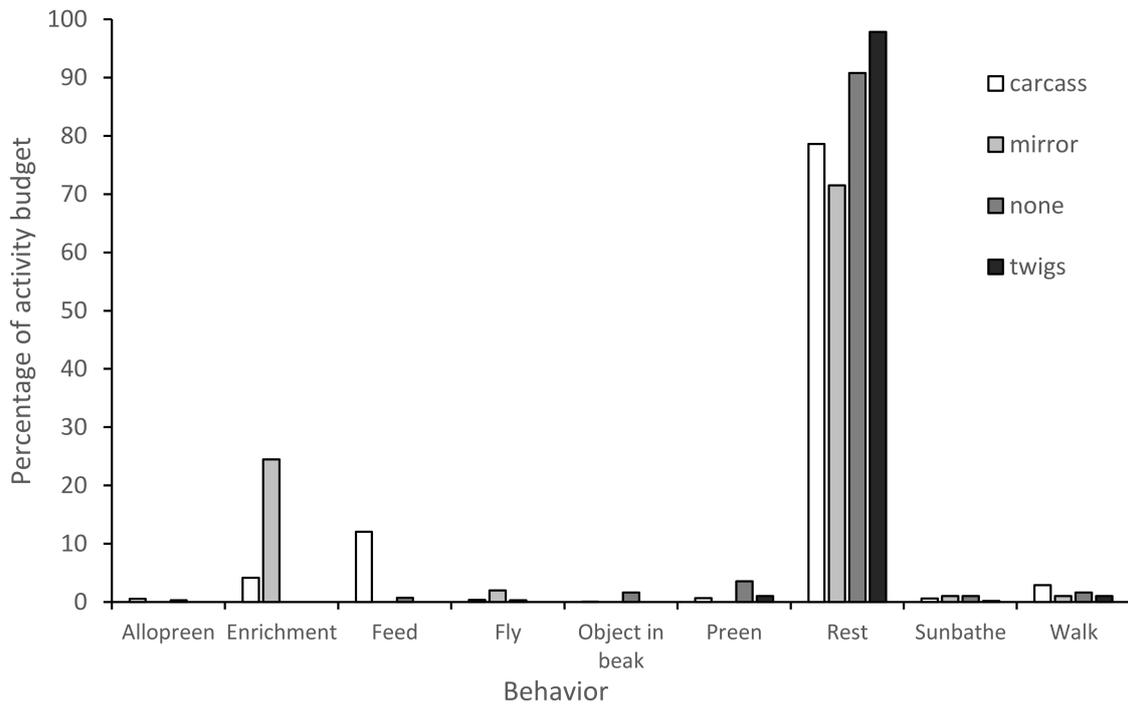
* indicates significant values.

3.2. Enclosure Use

mSPI values were generated for all observations. A bar chart was developed to demonstrate the effect of enrichment on the mSPI values for the male and female hornbill (Figure 3). Whilst average mSPI scores differed slightly between enrichment types, the difference was not significant ($X^2_{(3)} = 6.06, p = 0.195$).



(a)



(b)

Figure 2. Activity budget for (a) female and (b) male hornbill.

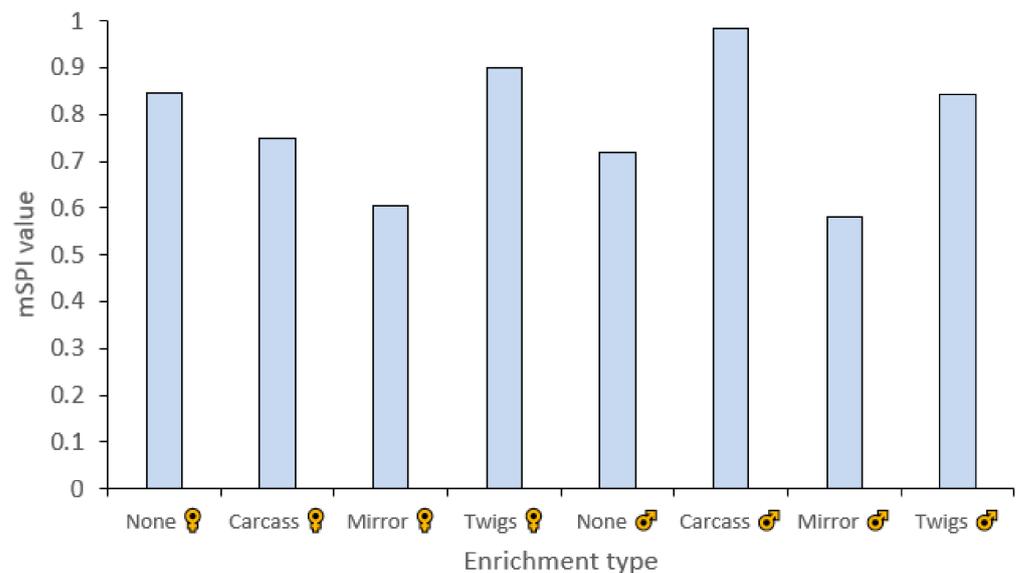


Figure 3. mSPI values for different enrichment types.

4. Discussion

Overall, the introduction of enrichment into the hornbill enclosures resulted in significant changes in feeding and enrichment interaction. Carcass provision resulted in hornbills spending much longer periods of time engaged in feeding and food manipulation, and mirrors were highly effective at engaging hornbills. No other significant changes in behavior occurred. While hornbills did appear to use their enclosure more evenly when enrichment was provided, this was not significant.

4.1. Carcass Enrichment

Significant differences in levels of food manipulation were noted when carcass enrichment was provided. Hornbills engaged in movements including stabbing and shaking of the carcass in order to remove pieces of meat. In the normal feed, typically consisting of chopped meat or day-old chicks, little food manipulation was observed. In the wild, southern ground hornbills may feed on large carcasses, and are also known to hunt animals such as hares and medium-sized snakes [6,9,20]. Occasional carcass feeds may therefore allow the birds to express a greater range of feeding-related behaviors. This could be used in tandem with small food items such as live invertebrates, which could be used to simulate hunting. Providing birds with the opportunity to express more natural behaviors is part of the five welfare domains [16].

Whilst some visitors may support this more natural feeding experience, there may also be a negative response from the public to these feeding techniques [17]. Carcass feeds may sometimes be met with disapproval from key visitor demographics, such as families with small children [17]. Whilst there is an educational value to the provision of carcass feeds, visitors may need to be made aware that carcass feeding is taking place.

Feeding whole foods could also reduce aggression between subjects [18] provided all animals are given access to food items simultaneously. In the current study, no aggression was observed between individuals, though this may pose a challenge if hornbills are kept in groups that simulate their wild social grouping [6,7,20]. Providing whole carcasses can save keepers food preparation time, but larger diet items may require significantly more storage, which could be more difficult for smaller collections. Consideration should also be given to exhibit cleaning once a large food item has been offered.

4.2. Mirror Enrichment

It is sometimes challenging to find non-food-related enrichment types for zoo-housed animals. Food-related enrichment may have drawbacks in that it must be deducted

from the animal's normal rations [21]. Non-food-related enrichment, by contrast, can be used for long periods of time without reducing an animal's appetite or resulting in an imbalanced diet.

Mirrors are a common strategy employed by bird keepers for use as enrichment. The hornbill pair spent significantly longer interacting with mirrors than with any other enrichment type. This significant increase in interactions with mirrors could be considered beneficial, as levels of resting decreased while activity levels increased. The two birds in the study were typically inactive during visitor open hours, so an increase in activity may have a positive impact on physical fitness.

In the wild, hornbills have been noted to interact with reflective objects such as mirrors and windows, and even parts of cars [10]. The hornbill has been persecuted as a result of this behavior. The underlying purpose of the behavior is still not fully understood; the behavior may be related to curiosity or interaction with another hornbill [10]. Whilst the hornbills could in fact be aware that their reflection is harmless, this behavior could also be based around territorial displays, with the hornbills assuming they have another hornbill to defend against or compete with. This could indicate that the birds consider the mirror reflection to be a rival. While this condition could therefore be considered stressful to the birds, it does allow the birds to demonstrate natural behavior and potentially could improve pair bonding. Therefore, mirrors could play a similar role to the playback calls used in zoos for primate species, such as gibbons [21].

4.3. Enclosure Use

There was no significant difference in enclosure use for the southern ground hornbills as a result of enrichment type. Whilst the mSPI scores appeared lower for the enrichment and carcass feeds, this was not significant. This may be due to variability in mSPI scores as a result of other extraneous variables. For example, it is possible that visitor presence influenced the enclosure use of the birds. Other zoo-housed hornbills have been shown to respond to visitor presence [5]. Anecdotally, the southern ground hornbills appeared to favor elevated perches during time periods when visitor numbers were higher. Future studies could consider visitor presence and its influence on behavior.

Enrichment items encouraged the hornbills to use more of the ground substrate, walking around the exhibit. In the wild, southern ground hornbills spend much of their time walking, rather than flying, around grassland and savannah in search of prey [6,11,22,23]. The use of a greater range of zones, rather than primarily the elevated perches, could be beneficial in terms of physical movement for these birds.

4.4. Future Directions

Generally, birds seem to be a neglected taxa for enrichment, despite their prevalence in zoological collections [14]. Finding any objects that have significant impacts on activity is positive for keepers. Many enrichment items create animal interaction, but not for significant periods of time. Hornbills were observed interacting with mirrors for over 40 min, which is an extended period of activity for the animals. The public perception of birds in captivity can often be more negative than other taxa, as many captive birds lack the large amounts of space the public, with little knowledge of husbandry guidelines, believe they need for optimum health. Enrichment can improve public perception of welfare, especially considering birds are viewed much less emotively than other taxa, such as primates.

Future studies should consider use of tests that reduce issues with pseudoreplication, such as G-tests. These studies could also utilize the extensive historical records of natural history, in order to identify novel enrichment practices. For example, early records of sightings of animals in their natural habitats, or interactions with other species, may help practitioners to identify novel husbandry practices to trial. In turn, the use of natural history documents may help zoos to provide more informed, evidence-based management for the animals that they keep.

5. Conclusions

Overall, provision of enrichment influenced some, but not all aspects of captive hornbill behavior. Interaction with enrichment varied between items, with the twigs pile receiving little attention and the carcasses resulting in considerable feeding activity. Mirrors were very well utilized by the birds, linking to the behavior of wild southern ground hornbills and their interest in reflective windows. Information on natural history may be useful in developing novel enrichment devices, especially enrichment types that do not involve food. Further inspiration for enrichment practices may be found in natural history books or papers that could, with controlled testing, be used to advance the state of current enrichment practice.

Author Contributions: Conceptualization, J.E.B.; methodology, J.E.B. and M.N.G.M.; software, J.E.B.; validation, J.A.S., J.E.B. and M.N.G.M.; formal analysis, J.E.B.; investigation, J.A.S. and J.E.B.; data curation, J.A.S.; writing—original draft preparation, J.A.S., J.E.B. and M.N.G.M.; writing—review and editing, J.A.S., J.E.B. and M.N.G.M.; visualization, J.A.S., J.E.B. and M.N.G.M.; supervision, J.E.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the ethics committee of Beale Wildlife Park (A17, 19 January 2014).

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy of zoo records.

Acknowledgments: The authors would like to thank staff at Beale Wildlife Park for their support during the project.

Conflicts of Interest: The authors declare no conflict of interest.

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