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Gotta Chop 'em All? Investigating the Impact of Food Presentation on Zoo-housed Azara's Agoutis

Muss man alles kleinschneiden? Untersuchung der Auswirkungen der Futterpräsentation auf im Zoo gehaltene Azaras Agoutis

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Abstract

The presentation of zoo animal diets can affect animal behaviour, nutrition, motivation and ultimately, welfare. While the science of zoo food presentation is advancing, there remains a tendency for food to be presented in ways that speed food deterioration and do not reflect the ecology of the species being fed. The current literature on zoo food presentation has tended to focus on specific taxonomic groups, especially Primates and Carnivora, with less research focus on taxa such as Rodentia. To fill a gap in the literature, a study was undertaken at Woburn Safari Park on a group of five Azara's agoutis (*Dasyprocta azarae*) to investigate the effects of chopped or whole diet presentation on behaviour. Animal behaviour was recorded using instantaneous focal sampling at 60 second intervals in one-hour sessions, with continuous sampling of events. Overall, stashing behaviour significantly increased, while feeding and food manipulation behaviour increased and foraging levels decreased during the whole food condition. There was no significant effect on aggression levels. Keeper preparation time significantly reduced during whole foods saving over two minutes of keeper time per meal, and no significant difference in the amount of food eaten was noted. Stashing and food manipulation are natural behaviours in wild agoutis, and as such whole food presentation may allow agoutis to express a wider range of natural behaviours. It should be noted, however, that a decrease in foraging

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behaviour was noted. Further studies into a wider range of zoo-housed species would help to identify taxa that would benefit from whole food, or alternative, food presentation.

Keywords: chopped food, *Dasyprocta azarae,* food preparation, zoo nutrition

Introduction

One of the aims of a zoo nutritionist is to ensure animals are given diets that are both nutritionally appropriate and that encourage species-specific behaviour (Plowman et al., 2006). While the field of zoo nutrition has advanced, the origins of many zoo diets stem from a time when advanced knowledge was not available and as such many diets were developed through trial-and-error or folklore knowledge (Brereton et al, 2021). While many older practices have now been scientifically examined, others, such as timing of foods and food preparation, have not been examined across the broad array of taxa housed in zoos and aquaria.

Food presentation styles vary throughout zoos and aquaria, but the chopping of foods into small, bitesize pieces is a common strategy (Shora et al., 2018). In the wild, animals would not receive their food carefully diced into pieces. Suggested reasons for chopping food into smaller pieces include the suggestion that chopped food could increase foraging (Waasdorp et al., 2021) and reduce aggression (Mathy & Isbell, 2001), though these suggestions have not been systematically investigated. Conversely, in some species, aggression has been shown to reduce when whole foods are provided (Smith et al., 1989; Sandri et al., 2017; Shora et al., 2018; Welsh et al., 2022). It is likely, therefore, that whole food diets may actually be better for some common zoo species.

The preparation of chopped food diets takes a significant amount of keeper time (Griffin & Brereton, 2021) and decreases the nutritional quality of the food provided (Hodges & Toivonen, 2008). For example, the water and vitamin content (e.g. vitamin C) of chopped food rapidly reduces, while ethylene content increases (Watada et al., 1996; Hodges & Toivonen, 2008). For smaller chop sizes and in higher ambient temperatures, this deterioration of food quality occurs more rapidly. The chopping of foods also increases the risk of microbial contamination as moist surfaces are opened to their environment (Brackett, 1987). The chopping of foods should therefore be considered from a cost-benefit standpoint, taking into account animal preference, keeper time (and its financial consequences), food nutritional value and microbial contamination.

While some animal orders, such as Primates, Carnivora and Elephantidae, have been well studied in a zoo environment, other orders have received limited attention (Melfi, 2009). The order Rodentia, for example, is exceptionally well-represented both in terms of species diversity (2,375 recognised species, IUCN, 2023) and in individuals in zoos (over 46,600 individuals: Species360, 2023). Welfare-oriented research in this taxonomic group therefore has the potential to improve the lives of thousands of animals.

Rodentia, with their constantly-growing incisors, have the ability to gnaw through tough materials and as such could be a good model for food presentation research (Whishaw & Tomie, 1989). Food presentation has been well studied in laboratory rodents and has identified some interesting trends associated with particle size (Whishaw & Dringenberg, 1991). In rats (*Rattus* spp.) and house mice (*Mus musculus)*, for example, smaller food items are typically eaten at the food bowl, whereas larger food items are associated with running with food and hoarding (Nakatsuyama & Fujita, 1995). It is possible that this trend, in which animals are more likely to transport large food items to safe places for eating, is conserved across a range of mammalian taxa.

The agouti (*Dasyprocta* spp.) is a genus of large, South American rodents (Henry, 1999). Agoutis possess a generalist feeding strategy and are able to eat a wide range of fruits, seeds

and nuts, though occasionally also meat and eggs (Dubost et al., 2005; Jones et al., 2019; Silva, 2013). The constantly-growing incisors of the agouti enable them to gnaw through the tough shells of even Brazil nuts (*Bertholletia excelsa)*. The 13 species of agouti are reasonably well-represented in zoos globally (693 individuals); of these, Azara's agouti (*Dasyprocta azarae)* makes up the majority of the world zoo population. There is no published research, to the authors' knowledge, on food presentation effects for any agouti. Research on the effects of food presentation on agouti behaviour may therefore have value in evidence-informed husbandry.

Material and methods

Study subjects and location

Data collection was undertaken between January and March 2023 at Woburn Safari Park in the United Kingdom. Prior to data collection, the study was approved through ethical review at University Centre Sparsholt. Behavioural research was undertaken on five female Azara's agoutis, that were housed together in a public exhibit with a large outdoor enclosure combined with a smaller, heated, indoor exhibit (Tab. 1). All individuals originated from Cotswold Wildlife Park, but parentage is uncertain. The agouti shared their exhibit with common marmosets (*Callithrix jacchus*) (Green et al., 2023) but did not share any food nor shelter with them, and all husbandry routines, bar feeding, continued with no changes during data collection. Before the main study began, a one-hour pilot study was completed in December 2022 while the agoutis were shut inside their house. The four researchers involved in data collection (AV, JD, MMH and MH) also completed an interobserver reliability test to ensure the accuracy of the behavioural observations, this was conducted by watching a video observing and recording the behaviour of a related species, the capybara (*Hydrochoerus hydrochaeris*). Approval for data collection was provided once all pairs achieved a Kappa Cohen coefficient above 0.9.

Tab. 1: Study subject details

House name	Studbook number/ID	Birth date	Birth location
Muriel	EAZA/403	23 Feb 2017	Cotswold Wildlife Park
Betsy	EAZA/410	13 Nov 2015	Cotswold Wildlife Park
Ethel	EAZA/418	20 Jul 2015	Cotswold Wildlife Park
Elsie	MM1931	4 Nov 2014	Cotswold Wildlife Park
Doris	EAZA/315	21 May 2014	Cotswold Wildlife Park

Study design

The researchers observed the agoutis from one viewpoint around the enclosure which provided best visibility. Behavioural observations were conducted using instantaneous focal sampling for state behaviours at 60 second intervals for one-hour timeslots, with continuous sampling of event behaviours (Bateson & Martin, 2021). A total of 24 hours of data were collected for each agouti in the study. An ethogram (Tab. 2) was adapted based on the pilot study to define the observed behaviours. Three hours of data were collected at set times; 10:45, 12:15, and 14:00 to coincide with the three feeds given in the day and to avoid issues associated with pseudoreplication. The forecast temperature, humidity, windspeed, current weather conditions and ultraviolet level were recorded at the start of each hour of observation, using World Weather Online (2023). The study was conducted during open and close days of the park, with visitor presence sporadic and unpredictable.

Tab. 2: Ethogram, authors own, adapted from Shora et al. (2018).

Behaviour type	Behaviour	Definition
	Autogrooming	Cleaning or picking at the animal's own fur.
	Feeding	Chewing and swallowing the food. Includes drinking water.
	Food manipulation	Tough or inedible parts of the food are removed using the mouth and teeth.
	Foraging	Using tactile means to look for food, using mouth and paws while looking around.
	Locomotion	Running and walking on land, without food.
	Resting	No locomotion, or sat down, or head down, or lying down, or no attentiveness to its surroundings.
	Stationary	No movement while standing or sitting, usually with the head upright.
	Vigilance	Observing other animals or humans.
Event	Aggression	Using any part of the body, animal jumps towards a conspecific in a vicious manner, usually includes a small vocalisation and results oftentimes with a flee.
	Dropping	The act of dropping food under no pressure from other individuals.
	Flee	A response to a stimulus with an aggressor. Involves moving away from the area.
	Food manipulation	Tough or inedible parts of the food are removed using the mouth and teeth.
	Stashing	Picking up multiple food items at one time without stopping to eat or stash the food.
	Inter-socialising	Interaction with individuals of a different species, not involving locomotion.
	Intra-socialising	Interaction with other individuals of the same species, not involving locomotion.
	Locomotion with food	Running and walking with food in paws or mouth.
	Scent marking	Marking territory by urinating or rubbing anal scent glands over stationary object.
	Sentry	Being alert to its surroundings and standing on the animals' hind legs, as if to look for danger.
	Sniffing	Nostril flaring, head up.
	Startle	A response to a stimulus without an aggressor. Involves moving away from the area.
	Stashing	Digging a small hole and placing food into hole, including retrieval of food.
	Stealing	Food being taken from one individual to another without dropping.
	Stomping	Using back legs to aggressively hit the floor.
	Vocalisations	Squeaks, grunts, and barks.

Food presentation

Food was presented in one of two formats: either chopped or whole. Chopped food items were prepared in approximately 3 cm^3 cubes by animal keepers, whereas whole food items were not chopped (except very large food items such as butternut squash (*Cucurbita moschata)* which were sometimes quartered). Each day, the agoutis had 675 g of fruit and vegetable diet given to them, with the diet not changing throughout the study to prevent variables like food motivation and preference skewing results. The diet consisted of butternut squash, chicory (*Cichorium intybus)*, and beetroot (*Beta vulgaris*), though occasional substitutions were used as part of normal husbandry. The food presentation alternated between chopped and whole each week, to prevent the acclimatisation of the agoutis to one presentation style and to mitigate the effects of extraneous variables such as the season, weather, and visitor presence. When the food was presented, it was scattered over a three metres space on the enclosure floor, to make it easier when collecting left over food and ensure visibility throughout. At the end of each data collection day, the left over food was collected and weighed in to ensure the agoutis were still consuming an appropriate amount of food (weight accurate to the nearest gram). Diet preparation time (including cleaning of equipment) was also timed at the beginning of the day to see if it was quicker to prepare whole foods. In addition to the study diet, a staple diet of guinea pig food was given ad lib in multiple bowls throughout the enclosure as per normal husbandry. Consumption of guinea pig feed was not assessed in this study.

Data analysis

Data were collated using Microsoft Excel™ 2016 and Minitab version 21. Figures were produced using Excel. For statistical analysis, comparisons were made to investigate the impact of food condition (chopped or whole) on selected agouti behaviours. The data for these selected behaviours were tested for normality, and where data were normal, a paired t-test was used. For non-normal data Wilcoxon tests were used. Similarly, comparisons of time taken for food preparation and for food consumption were conducted for chopped versus whole food using Wilcoxon's tests.

Results

State behaviour

An activity budget (Fig. 1) was generated to show the differences in behaviour between the chopped and whole food conditions. For state behaviours, six behaviours (autogroom, dig, locomotion, resting, stationary and vigilance) were not affected by food condition. For the whole condition, time spent feeding was significantly increased ($t_{(59)}$=3.51, P=0.026) and foraging was significantly reduced ($t_{(59)}$=4.67, P<0.001).

Event behaviour

Event behaviours were analysed by looking at the group of animals as a whole, with a focus on behaviours concerning feeding and aggression (Fig. 2). Food condition resulted in no significant difference in dropping food, aggression, fleeing, food manipulation, sniffing or startle. Stashing occurred significantly more often ($W_{(59)}$=6, P<0.001) in the whole food condition, as did locomotion with food ($W_{(59)}$=4, P=0.045).

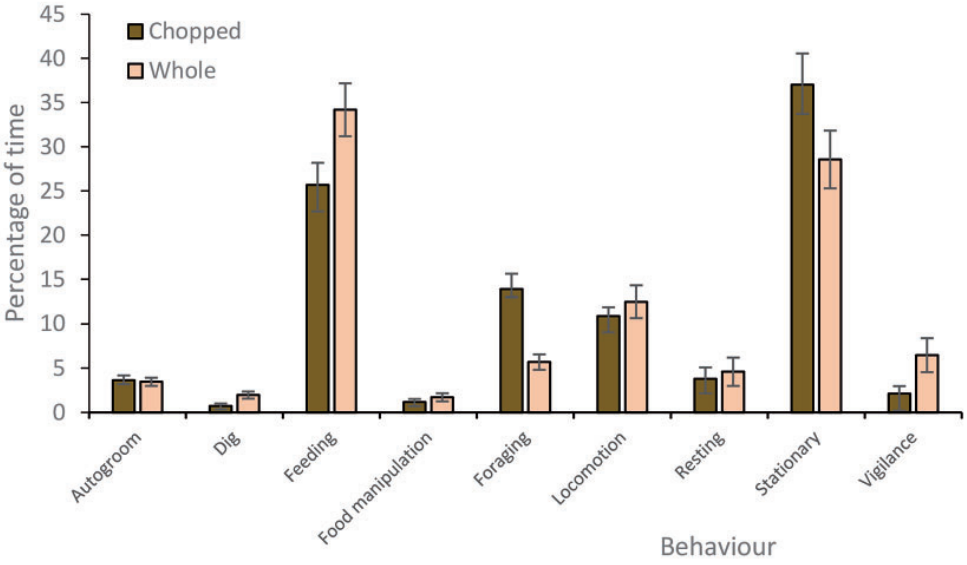

Fig. 1: Difference in state behaviour between chopped and whole conditions (+/- standard error).

Food consumption and keeper preparation time

There was a significant difference between the time it took keepers to prepare the diets for either chopped versus whole (P=0.05), with it taking an average of 395 seconds to prepare chopped food versus an average of 233 seconds for whole food preparation. There was no significant difference in amount of food eaten between conditions.

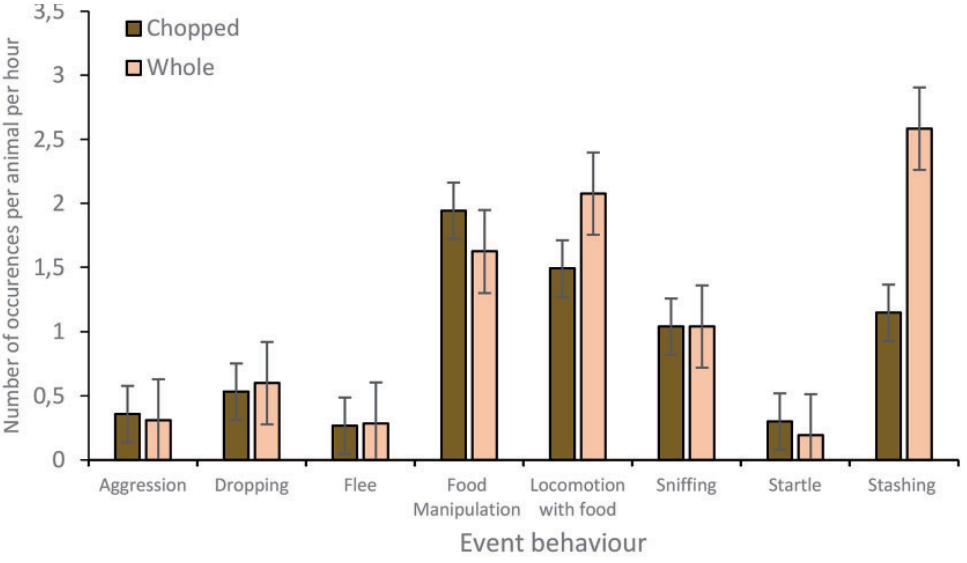

Fig. 2: Event behaviour during chopped and whole food conditions (+/- standard error).

Discussion

Overall, agouti activity budgets remained relatively stable irrespective of food condition. However, several notable changes occurred when whole foods were provided: time spent feeding and occurrences of moving with food and hoarding were increased, while time spent foraging decreased. Keepers saved an average of 162 seconds when preparing whole food diets as opposed to chopped meals. Given the limited changes in animal behaviour and the time saving benefits for keepers, provision of whole food may be a viable option for captive agoutis.

Effect on behaviour

When whole foods were provided, agoutis spent significantly more time engaged in feeding behaviour and considerably (but not significantly) less time spent inactive. This is a promising direction, as it therefore increases activity levels whilst providing the animals with more naturalistic activities (Young, 1997). The increase in time spent feeding, despite no significant difference in the amount of food eaten, is indicative that the food was more challenging to process or that food motivation was higher (meaning that the agoutis were eating the food sooner after it entered the exhibit). This direction is positive, as it demonstrates that agoutis spent longer engaged in naturalistic behaviours, rather than longer periods of stationary resting.

The whole food condition was also associated with a significant decrease in foraging behaviour. This reduction in foraging behaviour may be a direct result of whole food provision, as a) whole foods are easier to spot and therefore can be found rapidly and b) whole food items take longer to process, meaning that the agoutis had less time to search for food items. Foraging is commonly perceived as a beneficial activity for zoo animals (Young, 1997), so the reduction in this behaviour should be noted. The amount of foraging exhibited by wild agoutis has not been systematically studied (Jones et al., 2019), so further research in this field would be valuable.

Stashing or hoarding behaviour also significantly increased when whole foods were provided. Hoarding is a natural behaviour across rodents, carnivorans and birds and allows animals to safely store food for future use (Andersson & Krebs, 1978). Hoarding behaviour has useful application, especially in unstable environments where food may sometimes be scarce (Whishaw & Tomie, 1989). In the agouti, as in many rodent species, hoarding is believed to be a natural behaviour (Jones et al., 2019). While the trigger for hoarding is not known, it appears that in this case larger food items were more attractive for hoarding.

No other significant changes in behaviour occurred in this study. The limited effect on other aspects of agouti behaviour, such as welfare indicator behaviours or social behaviour, suggests that the whole food was not considered to be stressful by the animals. Rodents are often neophobic when introduced to novel environments or enrichment styles, yet the whole food condition did not elicit this response (Barnett, 2018). Given that the whole food item condition took less time for keepers to prepare and is potentially of higher nutrient value, with a lower risk of microbial contamination (Watada et al., 1996), this feeding style could help in moving forward the husbandry for agoutis in general. It should be mentioned that the study feed periods could be spaced out over a longer period of time to provide longer opportunities for feed-related behaviours.

Future directions

This study opens up several avenues for future research from both a pure and applied science standpoint; from a pure science perspective, the association between food particle size and hoarding and locomotion with food warrants further investigation. The results of this study demonstrate that hoarding behaviour increased when larger food items were provided, similar to

the findings in rats and mice (Charron & Cabanac, 2004; Mares & Williams, 1977; Whishaw & Dringenberg, 1991; Whishaw & Tomie, 1989). While it seems logical that animals should select larger food items for stashing, it should also be considered that an animal could also hoard smaller food items by gathering several items and transporting them simultaneously. Given that large food particle size has been identified as a trigger for hoarding in evolutionary different rodent species (rats, agouti), it is possible that food particle size may be motivated by particle size across a much wider range of rodents. Further pure research may aid in testing this hypothesis.

In a related vein, locomotion with food appears to be driven by food particle size (Whishaw & Tomie, 1989). This is a logical extension of the hoarding theory, as animals need to transport their food in order to hoard it. However, a much wider range of species have been seen to selectively transport larger food items: this has been observed in South American coatis (*Nasua nasua)*, whereby group aggression was reduced when whole food was provided, as individuals were more likely to transport large food items to secluded spots to eat (Shora et al., 2018). It is likely that this transporting of large food items has resulted in reduced aggression in other taxa when fed whole food (e.g. Sandri et al., 2017). Future investigations could identify what sizes of food (e.g. very small, medium, large) elicit locomotion with food and could explore the associated impact on group aggression.

From an applied standpoint, future studies could consider the complex relationships between food nutrient value and size and the motivation for feeding and hoarding. For example, Rozek & Millam (2011) demonstrated that orange-winged amazons (*Amazona amazonica)* were highly motivated to gain access to oversized pellets, even when a nutritionally identical small pellet was available in the exhibit. It was beyond the scope of this study to identify food preferences and motivation, though it is likely that higher-calorie items are preferentially eaten or hoarded. Research could be conducted that investigates whether certain items are likely to be eaten first and which items are normally hoarded. There should also be some consideration of the risk of pests in association with hoarded food, which may provide opportunities for pests. Comparative studies that allow the animal to select its preferred size of food would also have merit.

Finally, future studies should consider a wider range of species. Given the presence of a couple of positive changes in behaviour were noted, with only one possible negative change (foraging), it appears that whole foods may improve agouti husbandry regimes. It is likely that a much wider range of rodents, all of whom are equipped with tough teeth for gnawing, would benefit from whole food. Other taxonomic groups that have featured rarely in zoo and aquarium food presentation research include reptiles, passerine birds and fish (for a review, see Brereton, 2020).

Conclusion

The provision of whole food items resulted in increased time spent feeding, hoarding and moving with food and reduced foraging in a group of zoo-housed agoutis. Given that there was a limited change in behaviour as a result of food condition, and that providing food in the whole format saved minutes of keeper time, it is reasonable to suggest that food could be provided to agoutis in larger or in whole form, in zoos globally. The extra processing required for whole foods may be enriching for agoutis and therefore may potentially enrich the daily husbandry for these animals. Further studies across a wide range of species would help to provide an evidence-base for animal food presentation.

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Zusammenfassung

Die Aufbereitung des Futters für Zootiere kann sich auf das Verhalten der Tiere, ihre Ernährung und Motivation auswirken und letztlich das Wohlergehen der Tiere beeinflussen. Obwohl die Wissenschaft der Präsentation von Zoofutter voranschreitet, besteht nach wie vor die Tendenz, das Futter so zu präsentieren, dass es den Verderb des Futters beschleunigt und nicht die Ökologie der Spezies widerspiegelt, die gefüttert wird. Die aktuelle Literatur über die Präsentation von Zoofutter hat sich tendenziell auf bestimmte taxonomische Gruppen konzentriert, insbesondere Primates und Carnivora, und weniger auf Taxa wie Rodentia. Um eine Lücke in der Literatur zu füllen, wurde im Woburn Safari Park eine Studie an einer Gruppe von fünf Azaras Agoutis (*Dasyprocta azarae*) durchgeführt, um die Auswirkungen von kleingeschnittener oder unzerteilter Nahrung auf das Verhalten zu untersuchen. Das Verhalten der Tiere wurde in 60-Sekunden-Intervallen in einstündigen Sitzungen mit kontinuierlicher Erfassung von Ereignissen aufgezeichnet. Insgesamt nahmen das Versteckverhalten, das Fressverhalten und die Futtermanipulation deutlich zu und die Futtersuche nahm unter dieser Bedingung ab. Es gab keine signifikanten Auswirkungen auf das Aggressionsniveau. Die Zubereitungszeit durch den Tierpfleger wurde aber signifikant reduziert. Während der Fütterung unzerteilter Nahrung sparte der Tierpfleger mehr als zwei Minuten pro Mahlzeit und es wurde kein signifikanter Unterschied in der Menge des gefressenen Futters festgestellt. Verstecken und Manipulation der Nahrung sind natürliche Verhaltensweisen wildlebender Agoutis, so dass die Agoutis ein breiteres Spektrum an natürlichen Verhaltensweisen zum Ausdruck bringen. Es ist jedoch anzumerken, dass ein Rückgang des Futtersuchverhaltens festgestellt wurde. Weitere Studien an einer größeren Anzahl von in Zoos untergebrachter Arten würden dazu beitragen, Taxa zu identifizieren, die von ganzer Nahrung oder alternativen Nahrungsangeboten profitieren würden.

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