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Research article

Should zoo foods be coati chopped?

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Abstract

The process of chopping food for zoo animals is common in many zoos, but few studies have evaluated the benefits. While the perceived benefits of chopped diets include reduced food aggression, it is acknowledged that chopping food is time consuming for keepers and increases the risk of desiccation and contamination. Given the potential disadvantages of chopped diets, there is a need to evaluate food presentation in a range of zoo-housed species. To investigate the possible effects on ring-tailed coati (*Nasua nasua*) behaviour, meals were provided as either chopped or whole for a group housed at Beale Wildlife Park, UK. Effects of food presentation were monitored, with particular attention paid to aggression, allo-grooming, food manipulation and activity levels. Surprisingly, analysis revealed a significant decrease in aggression ($P=0.046$) and a significant increase in food manipulation behaviours ($P<0.001$) when whole foods were given. Levels of inactivity were not significantly affected by food presentation technique. These results suggest that chopped food may not provide the presumed behavioural benefits in coatis, and that whole food diets may in fact provide greater opportunities to express natural food manipulation behaviours. Whole food may also decrease aggression levels observed during mealtimes. Chopped versus whole food studies are recommended in other zoo taxa to evaluate the behavioural effects of food presentation.

Introduction

Zoo nutrition has become an advanced science, covering topics ranging from digestive physiology to microbiology (Clark et al. 2016). While some research is available, the subject of food presentation would benefit from a greater research focus (Britt 1998; Plowman et al. 2009). It is common practice in many mammal, bird and reptile collections to provide chopped diets; it is presumed that this avoids aggressive competition for large food items, and that it increases time spent foraging (Smith et al. 1989). However, the disadvantages of chopped foods include an increased rate of desiccation and contamination (Rico et al. 2007), and an increased food preparation time for keepers (Plowman et al. 2009). Given these potential disadvantages, there is a need to evaluate the behavioural benefits of chopping food for a range of taxa.

Young (1997) suggests that zoo diets should be fed in a format that encourages species-specific natural behaviours, in addition to being nutritionally relevant. Previous investigations into food presentation have helped to devise evidence-based husbandry practices for a range of species. Studies on lemurs (*Varecia variegata*) have indicated that arboreal feeding practices are more successful in encouraging natural foraging behaviours (Britt 1998). Further studies of feed enrichment for two lemur species demonstrated an increased rate of food manipulation and grooming and a reduction in inactivity (Maloney et al. 2006).

Food for wild animals is unlikely to be presented in bitesize chunks (Mathy and Isbell 2001), and many species possess specific food handling behaviours. Previous studies on whole food compared to chopped food presentation have been conducted in tapirs (*Tapirus terrestris*) and macaques (*Macaca nigra*) (Plowman et al. 2009) and reveal no significant change in the amount of food eaten per individual, nor in number of bouts of aggression. A study on macaques (*M. silenus*) reinforced these findings, revealing that animals ate significantly more when presented with whole food items, and spent longer engaged in feeding behaviours (Smith et al.

1989). As a husbandry modification, leaving food whole will not require additional financial investment, and may be time-effective for keepers.

Several food presentation studies have been conducted on primates (Dalton and Buchanan-Smith 2005; Britt 1998; Smith et al. 1989), but few are available for other mammal groups. Given the differences in behaviour and biology between taxa, studies on food presentation are required in a wide range of zoo animals. Species of the Order Carnivora are well represented in zoos, with all 286 species held in captive collections (Kroshko et al. 2016). Previous studies on carcass feeding (McPhee 2002) and food enrichment (Ruskell et al. 2015) have yielded valuable findings for zoo husbandry. Acknowledging their wide representation, studies on carnivore food presentation may have powerful implications for husbandry practices and welfare (Melfi 2009).

The ring-tailed coati (*Nasua nasua*) is an omnivorous procyonid originating from South America (Alves-Costa et al. 2004; Di Blanco and Hirsch 2006). The status of the species in the wild is categorised as Least Concern on the IUCN red list, though it is believed that populations are declining due to habitat loss (Emmons and Helgen 2016). At the time of writing, there are at least 1,277 coatis housed in captivity, of which 936 are housed in Europe (ZIMS 2017).

Ring-tailed coatis naturally inhabit a range of habitats, including cerrado, rainforests and scrub (Aguiar et al. 2011). Coati females are known to forage in groups in the wild, whereas adult males (known as coatimundi) may forage alone (Booth-Binczik et al. 2004). Wild ring-tailed coatis are primarily frugivore-insectivores and their diets are known to consist of plants, millipedes, spiders, fruits, eggs and gastropods (Alves-Costa et al. 2004); there is also evidence to suggest they occasionally feed on vertebrate prey (Hass and Valenzuela 2002). Prior to consumption, many of these foods require capture, deshelling or manipulation (Aguiar et al. 2011) and wild coatis are known to use their paws to dig out foods or remove inedible components (McToldridge 1969).

The aim of this study was to investigate the behavioural effects of providing food in either chopped or whole format for a group of coatis at Beale Wildlife Park, UK. Behavioural indicators of welfare, including social interactions, grooming and aggression, were used to determine the effects of food presentation.

Table 1: Ethogram used to record the behaviour of three female coatis at Beale Park, adapted from Hirsch (2011).

State behaviours	Description
Locomotion	Animal moves across ground, platforms or ropes by running, walking or climbing.
Inactive	Animal remains stationary in one position, and may be sitting, resting or sleeping.
Feeding	Consumption of food items. Also includes drinking water.
Foraging	Subject is stationary or walking, using snout and/or paws to find food within substrate or plants.
Food manipulation	Subject uses paws or teeth to carry or break open food items.
Auto-grooming	Subject uses paws and/or mouth to clean own body.
Allo-grooming	Subject uses paws and/or mouth to clean the body of a conspecific.
Event behaviours	Description
Vocalisation	Subject creates an audible sound, such as a squeak or grunt.
Biting	Subject uses mouth and teeth to close on the body of another animal.
Chasing	Subject pursues another individual at speed.
Scratching	Subject uses limbs to scratch body.
Allo-grooming bouts	Subject uses paws and/or mouth to clean the body of a conspecific.
Intra-conflict	Subject directs aggression at a conspecific.
Inter-conflict	Subject directs aggression at an individual of another species (raccoon).

Methods

Subjects, husbandry and housing

Research was carried out from July to August 2016 at Beale Wildlife Park & Gardens, Reading, UK, on three female coatis, all aged eight at the time of the study. As part of a mixed species 'Americas' exhibit, the coatis shared the enclosure with a single female racoon (*Procyon lotor*). Throughout the study, animals were housed within their normal enclosures, and followed their normal husbandry routine.

The open-top coati enclosure included artificial platforms and hose-pipes, with areas of cover including barrels, open shelters and enclosed wooden boxes filled with straw. The enclosure substrate consisted of long grass. Enclosure barriers were comprised of metal sloped walls with a surrounding dry-moat, topped with an electric fence.

Feed presentation

Throughout the study, the coatis and raccoon were fed communally twice per day, at 0800 and 1600. The morning feed consisted of 300 g of James Wellbeloved complete dog biscuits and 300 g of fruit and vegetables. Fruit and vegetables varied daily, and included carrots, apples, pears, plums, grapes and parsnips. The afternoon feed consisted of 300 g dog biscuits and two-day old chicks per animal. Prior to the study, fruit and vegetables were cut into 2 × 2 cm cubes. During all observed feeds, the diet was scattered throughout the enclosure to encourage foraging behaviours.

Food presentation was modified for the purpose of the study, with all fruit, vegetables and day-old chicks chopped into 2 × 2 cm cubes in the first condition, and left whole in the second condition. Chopped or whole meals were presented on a randomised schedule. Scattering and quantity of food remained consistent throughout the study.

Behavioural data collection and analysis

Behavioural observations were carried out between 0800–1000 and 1600–1800 on study days throughout the study period, resulting in 80 hours of data collection. Instantaneous scan samples were carried out on the coati group at 60-sec intervals. An ethogram, adapted from Hirsch (2011), was used to define and record behaviours. Twelve state behaviours were recorded during data collection, and these were condensed into seven generic behaviours for analysis (see Table 1). Observation time of each state behaviour was converted to a percentage of overall observation time for analysis. To identify potential causes of variation in behaviour, weather conditions, temperature and humidity variables were recorded from 'the Weather Channel' (2016).

Event behaviours, including intra- and inter-specific aggression and bouts of allo-grooming (see Table 1), were recorded

continuously for the whole group throughout each study period. While event behaviours were not recorded individually, individual animals could be identified based on physical features, and some anecdotal information was recorded regarding aggression and affiliative behaviour for each animal.

Results

Effects on behaviour

Significantly more time was spent manipulating food when it was provided whole ($Z=-3.89$, $P<0.001$; Figure 1). No other significant differences were determined between the two food presentation methods.

Effects on social behaviour

There were significantly fewer intra-specific conflict events when food was provided whole ($Z=-1.886$, $P=0.046$) (Figure 2). A weak, non-significant positive correlation was identified between allo-grooming and bouts of aggression ($r_s=0.133$, $P=0.126$). There were no other significant changes in event behaviour frequency between the chopped and whole conditions.

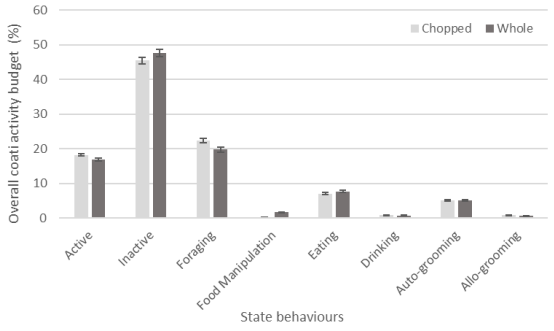

Figure 1: Proportion of time (+/- standard error) spent engaged in behaviours when provided with chopped food (light bar) or whole food (dark bar).

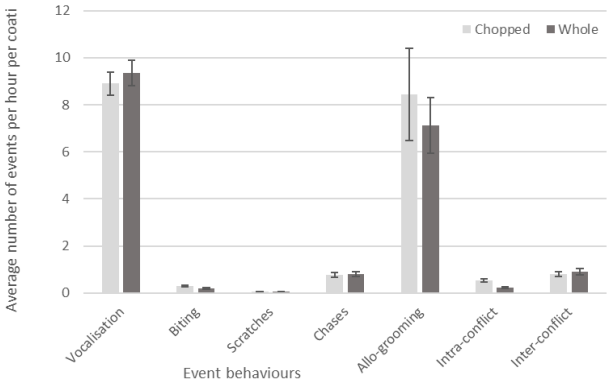

Figure 2: Average number of event behaviours per hour per coati (+/- standard error) when provided with chopped food (light bar) or whole food (dark bar).

Discussion

Effects on state behaviours

Feeding of whole foods resulted in no significant change in the proportion of time spent feeding by coatis. This finding supports previous research suggesting that tapirs (Plowman et al. 2009) and macaques (Smith et al. 1989) ate similar quantities of food and spent similar periods of time eating whether provided with chopped or whole food. Within the study, all animals were still able to access significant portions of food; the feeds were not monopolised by any individual.

Whole food provision resulted in a significant increase in rate of food manipulation among coatis. It was observed that foods were carried to platforms before eating, and were handled using paws to remove skins. These behaviours were rarely seen within the coati group when chopped food was provided. Potentially, whole foods may provide coatis with greater opportunities to express wild behaviours, as the wild diet of invertebrates, fruit, plants and vertebrates would require such processing before consumption (Aguiar et al. 2011; Alves-Costa et al. 2004). Gnawing behaviours were expressed when food was left whole, potentially encouraging oral maniplatory behaviour and better maintenance of coati dentition (Aguiar et al. 2011).

The proportion of active behaviours was not affected by food presentation type. Coatis are known to forage both on the ground and in branches (McClearn 1992); future inclusion of food items on platforms and in branches may further help to encourage locomotion.

There was no significant change in time spent foraging when whole foods were provided to coatis. Coatis, as insectivore-frugivores, do spend considerable periods of times searching for food (McClearn 1992). Foraging accounts for a considerable proportion of wild activity budgets for many omnivorous species, for example, 38% for red-tailed monkeys (*Cercopithecus ascanius*) (Struhsaker 1980) and 13–21% for moustached tamarins (*Saguinus mystax*) (Garber 1993). While foraging accounted for 22% and 20% of chopped and whole feeding times of coatis, respectively, these values do not consider the activity budget for the overall day. Enrichment strategies may be more effective at encouraging active foraging behaviours (Young 1997).

Effects on social behaviour

In contrast to common belief, there was significantly less intra-specific aggressive behaviour when whole food was presented and more when food was provided in chopped format. Aggressive encounters are known to occur between groups of wild coatis around fruiting trees (Gompper 1996). Wild coati groups cooperatively defend foraging resources against lone males, other groups or sympatric species (Burger and Gochfeld 1992; Aureli and Romero 2007). A key social component of female coati relationships is access to high quality food resources (Beisiegel and Mantovani 2006). Given this cooperative feeding strategy within groups, there may be little need to defend resources against other individuals. Further studies evaluating the effects of whole foods in large coati groups are required to investigate these findings (Gompper 1996).

In the current study, changes in interactions between the coatis and the raccoon were not investigated. Mixed species enclosures are relatively commonplace in zoos and aquaria (Dalton and Buchanan-Smith 2005), and it is essential to test the effects on behavioural interactions between species to inform such practices. Future directions for this project should therefore include an assessment of interactions between the two species within their shared exhibit and how these might be influenced by food presentation technique.

Implications

This study investigated a group of three individual coatis. Given the small sample size, replicate studies at further zoological collections would be beneficial. As an initial investigation, this study identified few benefits for providing chopped food for coatis. Contrary to popular belief, providing chopped food did not increase aggression, and valuable behaviours such as food manipulation were significantly increased. Added to the fact that keeper time may be saved by leaving coati diets whole and other disadvantages associated with chopped diets may be avoided, it is suggested that whole food presentation be considered. While the conclusions of one food presentation study cannot be directly extrapolated to other taxa, the results of such chopped food studies may have valuable implications for other species.

Conclusions

1. Contrary to the perception that chopping zoo diets can reduce aggression, the current study identified a significant decrease in intra-specific aggression when food was provided whole.
2. An additional benefit of providing feeds in whole format comprised an increase in food manipulation; a behaviour that was rarely observed in chopped diet observations.
3. Research is recommended for a wide range of zoo-housed species to determine which taxa might benefit from whole food presentation strategies.

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