The influence of food-based enrichment on the behaviour of captive red pandas *Ailurus fulgens fulgens*

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Abstract

Developing simple and creative ways to feed captive animals, especially those kept for captive breeding programs is important because food-based enrichment has a beneficial effect on animal welfare. The red panda, subject of this study, is threatened with extinction and needs support in developing a successful captive breeding program. The Indian captive population of red pandas exhibit stereotypic behaviour, which could impact negatively on species health and hamper captive breeding success. Therefore, to combat stress, zoos must design effective enrichment programs, such as food-based enrichments which are key to optimum animal welfare. I investigated the effect of bamboo dispersal, i.e., bamboo distributed spatially in the enclosure (mimicking the red panda's natural habitat), compared to bamboo served on a feeding platform and how it affected red panda behaviours such as pacing, aggression, foraging and behavioural diversity. Results revealed that dispersing the bamboo (known as food-based enrichment) increased the level of behavioural diversity significantly by 1.6 times ($p < 0.05$), whereas foraging by 3.6 times although insignificant. Similarly, pacing decreased by 5.8 times and aggression by almost three times in the subjects ($p < 0.05$). Individual analysis suggests that behavioural diversity in the male doubled when food dispersed around the enclosure ($p < 0.05$). This suggests that spatially distributing bamboo stimulates foraging behaviour and limits stereotypical behaviour, such as pacing, in captive red pandas. This study showed that planning simple yet innovative food-based enrichments in captivity promotes natural behaviours and reduces abnormal behaviours supporting species conservation.

Key words Captive breeding; food-enrichment; foraging; red panda; stereotypy

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Introduction

Zoos around the world are working towards animal welfare through collaborative research, conservation, and education (Fernandez & Timberlake, 2008; Ralls & Ballou, 2013). One way to facilitate animal welfare is to develop, evaluate and promote different environmental enrichment practices in captivity. A simple definition of enrichment is “a modification in an environment for animals to behave naturally" (D. Shepherdson & Carlstead, 1994). Enriching captive spaces provide a more complex environment and mimic wild conditions enabling individuals to exhibit natural behaviours more freely thereby reducing stress. These measures can promote natural behaviours and address stereotypical behaviour in captive animals. Stereotypies are defined as repetitive behaviours exhibited by captive animals induced by stressors or frustration associated with sub-optimal environments (Mason, 1991). A reduction in stressors through improvements in captivity (e.g., enrichment) can reduce stereotypy (Shepherdson *et al.,* 1998), and augment more species-typical or appropriate natural behaviour. Food-based enrichment is one of the most common forms of environmental enrichment; practices such as distributing food widely in the enclosure have proven effective in reducing stereotypy and increasing the frequency of natural behaviours (Fernandez & Timberlake, 2019; Ryan *et al.*, 2012).

Research on enrichment and stereotypy is lacking in most zoo species, with most of the literatures focusing on large and flagship species while ignoring small yet enigmatic mammals such as red panda, despite its endangered status (Choudhury, 2001; Choudhury, 2001; Glatston *et al.,* 2015) are poorly documented (Karki *et al.,* 2021). The red pandas are declining in the wild (Glatston *et al.,* 2015), therefore, improving welfare in captive populations is imperative for species conservation through captive breeding. Captive red pandas are reported to show stereotypy (Jule, 2009; Khan *et al.,* 2022; Khan *et al.,* 2023), hence addressing these issues could improve their welfare and, potentially, captive breeding which indeed support the global captive breeding program of the red pandas. Indian zoos typically provide bamboo leaves, a staple food for red pandas, in the enclosure at a particular time and place. Animals kept in confinement with a predictable food delivery and monotonous food type are not stimulated to forage, leading to individuals demonstrating stereotypical behaviour (Mellen & Macphee, 2001; Mellen & Macphee, 2001). Previous studies, for example, in captive small Neotropical felids showed a significant reduction in abnormal behaviour when animals presented with a surprise package

(consist of raw beef hidden in the middle of alfalfa) as a feeding enrichment (Resende *et al.,* 2009). Another study on red fox suggests that feeding enrichment with temporal and spatial unpredictability in the food presentation increased behavioural diversity and other active behaviours (Kistler *et al.,* 2009). Therefore food-based enrichment is likely to change behaviours in captive red pandas.

This study compares the effects of dispersing bamboo versus the zoo's daily feeding regime, which involves providing bamboo at a fixed platform, on the natural behaviour (such as foraging) and stereotypic behaviour (such as pacing) of captive red pandas. I hypothesized that dispersing bamboo around the enclosure would result in increased foraging behaviour and a potential reduction in stereotypy.

Study area

The study was conducted at Padmaja Naidu Himalayan Zoological Park (aka Darjeeling Zoo), Darjeeling, (27°3'N & 88°18'E and at an altitude of 2150 m), north-eastern India. The study was conducted in an enclosure that housed a breeding pair of red pandas. The enclosure was fairly square in shape, measuring 400 m^2, and surrounded by brick walls approximately 6 feet tall on all sides. One side featured a visitor's gallery, two sides were aligned with other red panda enclosures, and the back side was attached to the management area. All the sides, a depression immediately separates the wall, preventing individuals from reaching out and escaping. The enclosure was enriched with dead wooden logs, medium-sized trees, two artificial wooden nest boxes, and a wooden platform for serving bamboo to the inhabitants.

Methods

Behavioural study and food-based enrichment

I used focal sampling (Altmann, 1974) on a pair of red pandas (one male, one female) managed in one enclosure of 400 m^2. Through observation, I quantified time spent foraging, resting, moving, pacing, and other activities while aggression was recorded in frequencies. Pacing is stereotypic behaviour defined as repeated movement between two fixed points without any specific goal (Mason, 1991). The first eight days of observation were under 'clumped' food condition i.e., bamboo supplied at a feeding platform (the way practiced by the Darjeeling zoo routinely). The next eight days of observation took place under 'dispersed' condition i.e.,

bamboo spatially distributed in multiple sites within the enclosure. I gave two days for subjects to acclimatise to enriched conditions before testing them. In total, sampling for 16 days, 96 h of observations were made on the two individuals, 48 h for each of the clumped and dispersed feed conditions (24 h each on male and female). The behavioural observations conducted between 06:00 and 18:00 h, at 15-min intervals with 10-min observation and 5-min break. On a given day, one individual (either male or female) was observed for a maximum of 6-h, from 06:00 till 12:00 h and on the next day from 12:00 till 18:00 h, as described previously (Khan *et al.,* 2022). One replicate consisted of a set of twelve daylight hours (across two days) of observation for an individual. During the observation, various behaviours exhibited by the focal individual were recorded to the nearest second. Behavioural diversity calculated using Shannon-Wiener diversity index H (Collins *et al.,* 2016; Khan *et al.,* 2022; Kistler *et al.,* 2009). Pacing excluded while calculating behavioural diversity. Major behaviours recorded and analysed during the study given in Table 1.

Statistical analysis

The time spent on foraging and pacing, frequency of aggression and behavioural diversity analysed for clumped and dispersed feed conditions. These behaviours compiled on an hourly basis using each 10 min observation separately for each individual in both the conditions, this makes 40 min of observation at any given hour considered as hourly observation. The hourly data so obtained in minutes was converted into a percentage (Khan *et al.,* 2022). The hourly average, as a percentage, used for further analysis. I analysed the combined data for the two individuals as well as separately for each sex. Observed differences between clumped and dispersed conditions in time spent on foraging and pacing, frequency aggression and behavioural diversity were assessed for statistical significance using the Mann-Whitney U test as our data were neither normally distributed nor could be transformed to normal using any of four transformations. Statistical analysis was conducted using the *R 3.4.1* version (R Core Team 2018).

Table 1: Ethogram of red panda

Behaviour	Description
Foraging	searching for bamboo and feeding on it
Moving	walking on trees, climbing up and down the tree
Exploring	exploratory/territorial investigation of the enclosure can involve sniffing, digging, interaction with furnishings within the enclosure
Grooming	cleaning their body by licking
Sleeping	resting gesture either curling the body or spread out on a tree
Vigilant	continuous sensory tracking of the environment or events
Scratching	scratching body with paws
Aggression	grunts call, chasing and attacking gesture towards counterpart
Pacing*	Repetitive movement between two fixed points or on a fixed path

*Pacing behaviour was excluded from the behavioural diversity calculations and only natural behaviour were considered.

Results

Major behaviours showed significant difference between clumped and dispersed conditions (Table 2). Behavioural diversity increased significantly ($p < 0.05$) under the dispersed condition as compared to the clumped condition, while pacing and aggression were reduced significantly ($p < 0.05$; Figure 1). Foraging behaviour was increased in subjects during dispersed condition as compared to clumped condition but there was no significant difference in percent change ($p > 0.05$). Individually, foraging, and behavioural diversity were increased in male and female although only behavioural diversity was significant ($p < 0.05$) in male, (Table 3).

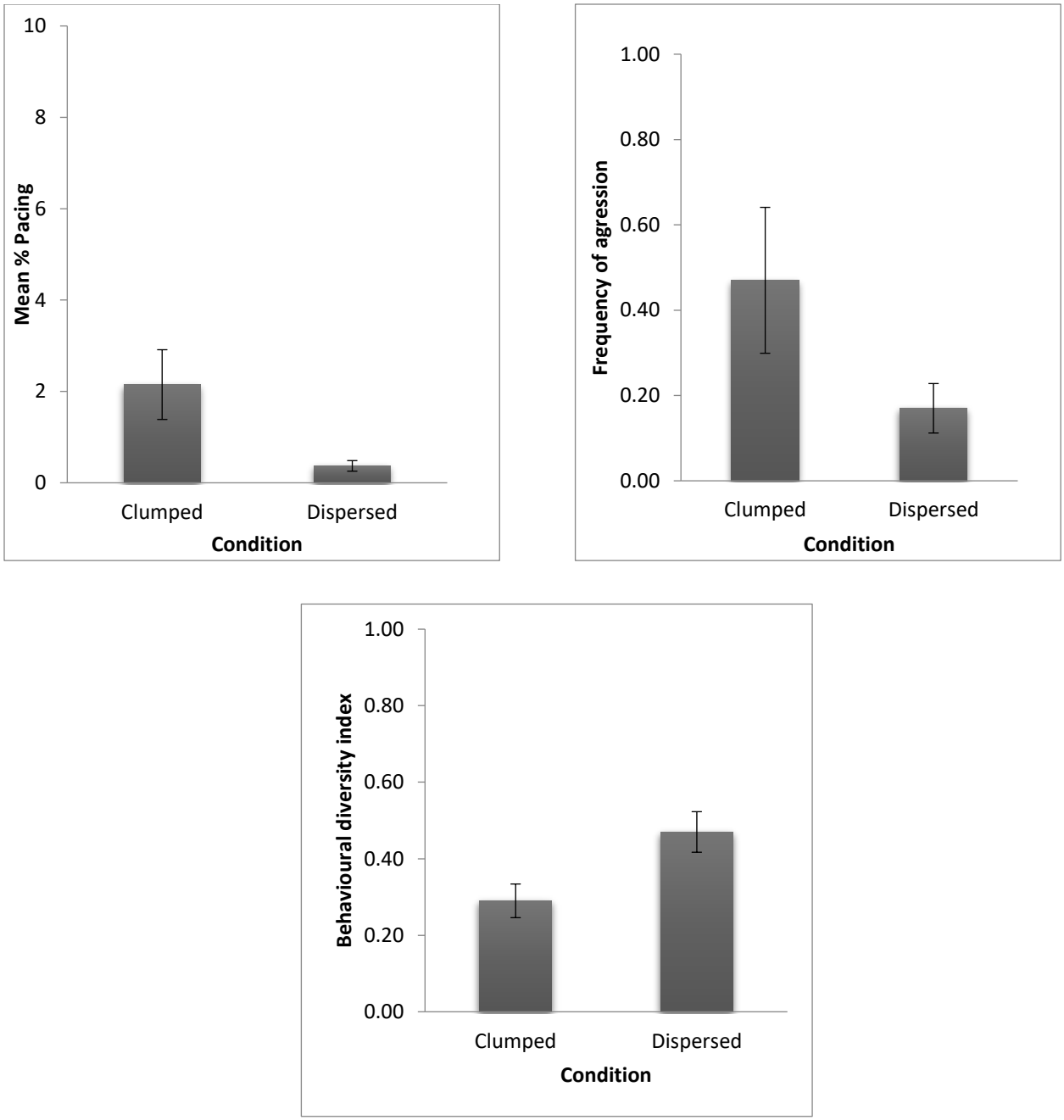

Figure 1: Effect of food-based enrichment on captive red panda behaviours per hour (a) % time spent pacing, (b) frequency of aggression, (c) behavioural diversity index

Table 2: Significance test between the duration of behaviour across the clumped and dispersed condition (n = 48 for each condition)

Behaviour	Bamboo food provision		*Mann Whitney U-test (p)*
	Clumped Mean±SE	Dispersed Mean±SE	
% Foraging	2.45 ± 1.165	8.75 ± 3.335	1139 (0.899)
% Pacing	2.15 ± 0.763	0.37 ± 0.116	1375 (**0.045**)
Frequency of aggression	0.47 ± 0.171	0.08 ± 0.058	1300 (**0.041**)
Behavioural diversity index	0.29±0.044	0.47±0.053	841 (**0.022**)

Table 3: Significance tests between the duration of behaviour across the clumped and dispersed conditions for each sex. U-value indicates the Mann Whitney U test. (n = 24 for each condition)

Behaviour	Male		Female	
	Clumped condition Mean ± SE	Dispersed condition Mean ± SE	Clumped condition Mean ± SE	Dispersed condition Mean ± SE
% Foraging	1.48 ± 1.251	11.54 ± 5.943	3.42 ± 1.97	5.96 ± 3.073
U-value (p)	268 (0.554)		302 (0.724)	
Behavioural diversity index	0.24 ± 0.062	0.51 ± 0.085	0.36 ± 0.062	0.44 ± 0.064
U-value (p)	196 (**0.049**)		243 (0.358)	
% Pacing	1.22 ± 0.461	0.25 ± 0.122	3.07 ± 1.446	0.48 ± 0.199
U-value (p)	355 (0.079)		334 (0.268)	

Frequency of Aggression	0.50 ± 0.240	0	0.45 ± 0.248	0.17 ± 0.115
U-value (p)	-		316 (0.323)	

Discussion

Consistent with the hypothesis, food-based enrichment, dispersed condition – specifically bamboo spread spatially throughout the enclosure, enhanced foraging and behavioural diversity while reducing pacing and aggression in captive red pandas compared to the clumped condition, the conventional method of providing food on a feeding platform in the enclosure. While most of the behaviours were not significant between the sex they have increased comparatively in dispersed conditions. However, behavioural diversity was significantly increased in the male.

Previous research found that captive bears, elephants, and chimpanzees all improved feeding performance, meaning increase in feeding time, when subjected to spatially and temporally varied feed dispersal (Morimura & Ueno, 1999. Fur seals showed varied foraging behaviours and overall diversity in behaviours when subjected to foraging-based enrichment (Hocking et al., 2015. Similarly, when captive walruses were provided with variable opportunities to forage and feed using enrichment devices, foraging behaviour increased and stereotypical behaviour decreased (Fernandez & Timberlake, 2019)(. This study showed that captive red pandas also positively respond to food-based enrichment with increased foraging, behavioural diversity, and reduced pacing and aggression.

Clumped food sources in close proximity could be one of the reasons for aggression in housed animals (Nieuwenhuijsen & de Waal, 1982), and it can be reduced by dispersing food throughout the enclosure (Little & Sommer, 2002). For example, captive langurs spent 64% of their time close to counterparts in the small and less complex enclosure but increased the distance significantly by 46% in the new big and enriched enclosure, which led to lesser aggression (Little & Sommer, 2002). Supporting previous findings, our study reports a significant decrease in aggression among captive red pandas when food is dispersed, which also allows them to move around in the enclosure to feed and forage. Food given in the dispersed form within the enclosure

facilitates foraging behaviours and reduces pacing significantly in captive red pandas. Food dispersal maximizes the use of the enclosure area, which reduced aggression significantly.

This study indicates that simple food-based enrichment experiments such as bamboo dispersal are a positive and practical approach to reduce stereotypy while stimulating foraging behaviours in captive red pandas. However, certain limitations exist. Sample size can be increased and observation time could be extended for longer period to deeply understand the effect of food-based enrichment on the behaviours of captive red pandas. Bamboo should be dispersed spatially and temporally in the enclosures. Subjects must also have a combination of multiple males and females to explore sex-based differences. Nevertheless, this study has shown that, through food-based enrichment, improvements to animal welfare can be achieved thus supporting the long-term conservation of red pandas. The outcomes of this study have encouraged the Darjeeling Zoo management to incorporate food dispersal i.e., temporal and spatial distribution of bamboo and other supplementary food as a tool to induce foraging behaviour in captive red pandas selected for a release programme at Singalila National Park as a part of the red panda reintroduction programme (2019-2023) implemented by the government of India (I was personally involved in the designing the enrichment experiments).

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Conflict of interest

The author declares no competing interests.

Ethical statement

The Zoo director has granted the necessary permission to set up the feeding experiments. The study employed a non-invasive method, which involved behavioural observation from a distance, ensuring no stress for the animals.

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