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Research article

The effect of a new enclosure on the behaviour of a large captive group of lion-tailed macaques *Macaca silenus*

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Abstract
The captive environment can significantly impact animal behaviour. Relocating a captive group to a more biologically relevant enclosure can positively impact behaviour and welfare. The aim of this study was to determine the effect of a new enclosure on the behaviour of a captive group of lion-tailed macaques *Macaca silenus* located in Fota Wildlife Park. The macaques were moved in late January/early February 2015 to an enclosure that is larger and more complex but is in closer proximity to visitors. Baseline data were collected from February to October 2014, prior to the move. Data in the new enclosure were collected for the 2 months following the move, prior to additional changes occurring in the group. One year since the relocation, data were collected again, in February and March 2016. The results showed that in the months following the move to the new enclosure the macaques spent more time out of sight and less time engaged in self-directed behaviours. Visitor number had an impact on behaviour of the macaques, but there was no significant difference between the two enclosures in terms of visitor effect. Further monitoring will continue to determine the effect of the new enclosure on behaviour.

Introduction

In general, captive environments are rarely sufficiently stimulating and, in comparison to wild habitats, are unchanging and spatially limited (Swaisgood et al. 2001). Enrichment is often employed to improve the quality of these environments, using foraging devices, sensory stimulation or social groupings (e.g. Bayne et al. 1991; Mallapur et al. 2007; Leonardi et al. 2010; Gronqvist et al. 2013). The relocation of a captive group to a new, more biologically relevant enclosure is considered a form of enrichment as it provides novelty and more stimulation. Clarke et al. (1982) showed that the relocation of chimpanzees to a more naturalistic environment significantly reduced the occurrence of stereotypical behaviours.

Fota Wildlife Park, in Cork, Ireland, is currently undergoing a 27-acre expansion, with the creation of a new section known as the Asian Sanctuary. The new area contains a larger enclosure for the resident group of lion-tailed macaques *Macaca silenus*, which aims to provide more space and stimulation. Fota is of particular importance in relation to this species as it has one of the most successful captive groups of lion-tailed macaques in the European Endangered Species Programme (EEP). In 2014, when this research began, this group was composed of 21 individuals, with 14 successful births since 2007.

As stated by Dufour et al. (2011), there are few studies on how captive primates in particular cope with moving and changes in their environment, even though these zoo animals regularly undergo moves between enclosures and institutions. The objective of this paper was to look at behaviour before and after the move to the new enclosure to identify any changes caused by the relocation of the lion-tailed macaque group in Fota Wildlife Park.

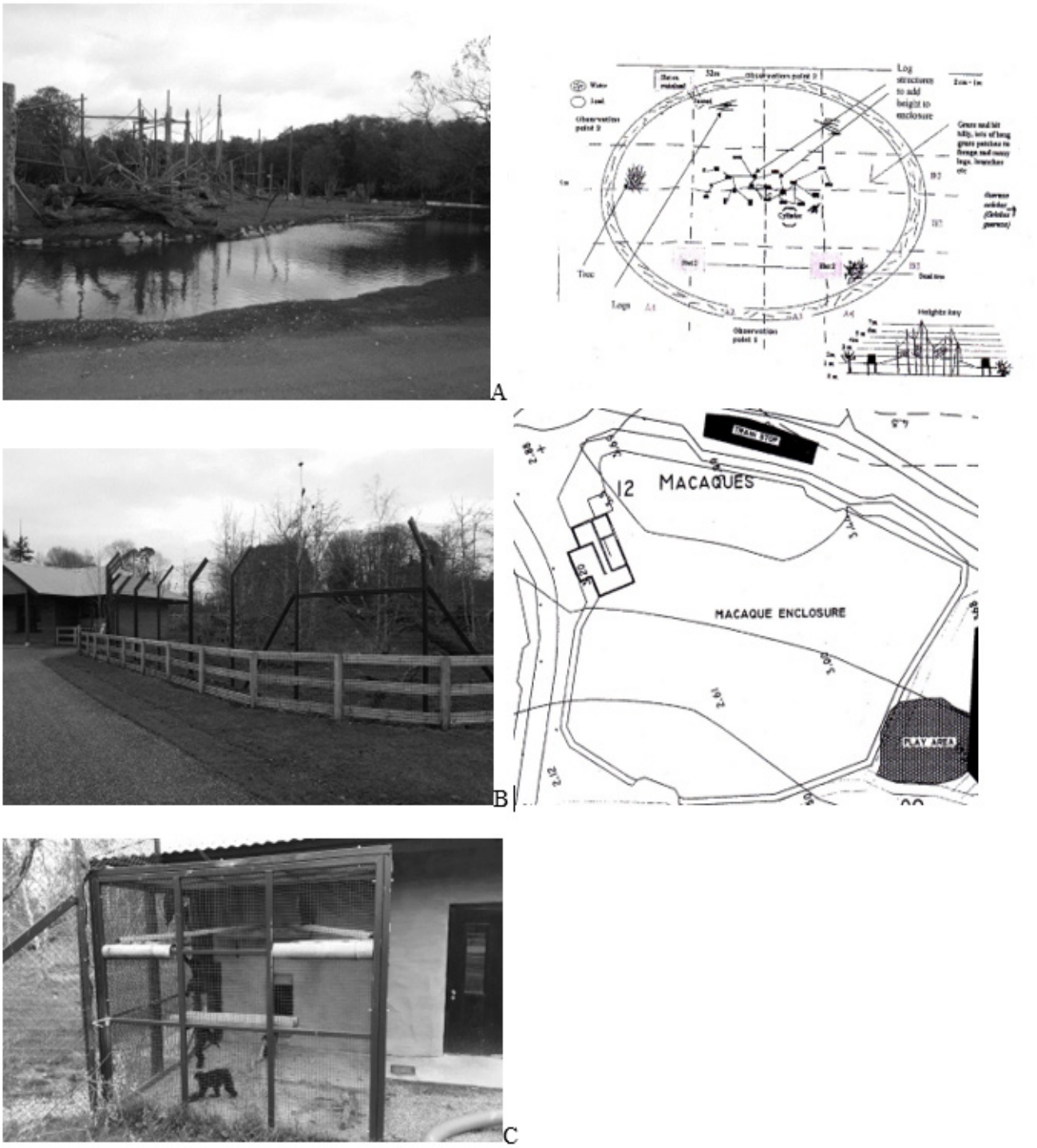

Figure 1. Photographs of the lion-tailed macaque Macaca silenus enclosures at Fota Wildlife Park, Co. Cork. (A) Old enclosure with large water barrier; map from Casey (2007); (B) New enclosure with large indoor house; (C) Small outdoor cage area of new enclosure.

Methods

Study site and group

This study took place in Fota Wildlife Park, Co. Cork, Ireland, over a period of three years (2014 to 2016). The old macaque enclosure (Figure 1A) was a 430 m^2 artificial island (Casey 2007) surrounded by a natural barrier of Cork Harbour water, with visitor trails to the north, south and east of the island. This island was shared by a small population of black-tailed prairie dogs *Cynomys ludovicianus*, with two neighbouring islands housing black howler monkeys *Alouatta caraya* and Siamang gibbons *Hylobates syndactylus*. The island contained various horizontal structures, plastic containers, with swings and raised platforms, as well as two indoor houses, one of which was shared with the black howler monkeys and agile gibbons *Hylobates agilis*.

The new enclosure (Figure 1B) is a 4600 m^2 fenced area (over 10 times larger than the old enclosure) with a large naturalistic outdoor section containing many trees, shrubs and large logs,

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Table 1. An ethogram of the observable behaviours of the lion-tailed macaques Macaca silenus in Fota Wildlife Park, Co. Cork, Ireland during the study period February 2014 to March 2016. [1]Fishing in the surrounding water was also observed but not included as it was only possible in the old enclosure.

Category	Behaviour	Description
Feeding`	Foraging	Searching for food
	Feeding[1]	Eating of food
	Drinking	Drinking of water (often leaning forward and lapping water)
Active	Walking	Slow paced locomotion
	Running	Fast locomotion
	Climbing	Moving from one area to another in a vertical direction
	Swinging	Hanging from an elevated structure
Restful	Sitting	Idly sitting
	Resting	Lying down idle
Affiliative	Sexual Inspection/ Presentation	Lifting of the tail area to inspect or smell genital area/presentation of genital area to another
	Mounting	One individual climbing on another to initiate copulation/dominance display
	Copulation	Sexual intercourse
	Interaction with infant/parent	Contact between infant and mother, either through vocalisation, playing or carrying
	Allogrooming	Individuals grooming or being groomed by another
	Playing	Interaction between individuals through chasing, rolling, swinging or wrestling
	Huddling	Two or more individuals sitting close together with no grooming taking place
Self-directed	Scratching	Individual scratching itself
	Autogrooming	Individual grooming itself
Aggression		Threatening or defensive behaviour including posture, vocalisation, chasing
Out of sight		Individual not visible

and a larger indoor house with a viewing window for visitors. Furthermore, around the fenced perimeter of the enclosure are two large glass viewing windows, allowing visitors to view the outdoor section of the enclosure. In comparison to the old enclosure, this enclosure is in closer proximity to visitors (with no large water barrier) and in an area of greater visitor traffic due to the popularity of the surrounding exhibits. It is located next to the Sumatran tigers *Panthera tigris sumatrae* and another enclosure shared by Visayan warty pigs *Sus cebifrons* and Visayan spotted deer *Rusa alfredi*. During data collection in 2015, all other enclosures surrounding the macaques were empty; by 2016 the remaining exhibits surrounding the macaques were occupied by François langurs *Trachypithecus francoisi* and agile gibbons.

During the baseline study in 2014, while in the old enclosure, the group was composed of 21 individuals, with one adult male, three adult subordinate males, nine adult females and eight juveniles. Following the move to the new enclosure, the three subordinate males and one juvenile male were separated from the group and placed in separate caged area of the indoor house, where they still had visual contact with the rest of the group, both inside and outside the house (Figure 1C). This was in preparation for their move to another zoo, as part of the EEP for this species. Furthermore, as part of the long-term management of this species by the EEP, in 2016, the alpha male and one juvenile male were removed from the group, and three new males were being introduced to the group. Contact between the remaining 15 macaques (females and juveniles) and these three new males was primarily visual. For this part of the study, only the behaviour of the females and remaining juveniles were analysed, the new males were not included.

Data collection and analysis

Data were collected using instantaneous scan sampling to look at the behaviour of the entire group and 15-minute focal sampling (with females and juveniles chosen at random), over two 2-hour periods in the morning and afternoon, with scans samples taken between every focal sample. Baseline behavioural data were collected between February 2014 and October 2014 (Table 1). A total of 258 scan and 259 focal samples were recorded during the baseline study. Visitor numbers around the enclosure area was estimated (low, medium or high visitors) and recorded for every 2-hour period. Cloud cover, precipitation and temperature (max/min) were also noted for each recording period. The macaques were transferred to their new enclosure in late January/early February 2015, and data were collected using the same methods from then until March 2015. A total of 105 scan and 96 focal samples were collected during this period. Data collection stopped at this point as three new males were introduced to the group as part of the EEP.

In February and March 2016, data were collected using the same methods, to record any differences in behaviour one year since their introduction into the new enclosure. A total of 73 scan and 65 focal samples were collected.

Data were analysed using R 3.4.3 (R Core Team, 2017). Each of the behaviours (except for out of sight) were corrected for time in sight and the scan sample data were also corrected for group size. For the scan sample data, collinearity was measured using variance inflation factors (VIF) (Zuur et al. 2009), to determine if any explanatory variable had a strong linear relationship with any other explanatory variable(s) (Field et al. 2012). Month was removed as the VIF value was greater than 10 (Myers 1990) and

Table 2. Estimated parameters and P-values for each explanatory variable. Significant (P<0.001) values indicated in bold.

Variable type	Variable	Active	Affiliative	Feeding	Resting	Self-directed	OOS
Year	2015	-	-	-	-	-1.825 (0.012)	-
	2016	-0.616 (0.002)	-	-	0.491 (0.001)	-	-
Time	Morning	-	-	-	-	-	-0.355 (0.015)
Visitors	Low	-0.898 (0.012)	-	-	-	-	-
	Medium	-	-	-	-	-	-
Precipitation	Nil	-	-	-	-1.169 (0.002)	-	0.769 (0.016)
	Light	-	-	-	-0.985 (0.012)	-	
Cloud cover	Nil	-	-	-0.496 (0.037)	0.498 (0.004)	-	-0.749 (0.0004)
	Partial	-	-0.367 (0.02)	-	-	-	-0.506 (0.005)
Temperature: Visitors	Medium	-0.066 (0.048)	-	-	-	-	-0.059 (0.008)
Time: Visitors	Morn: Low	0.612 (0.028)	-	-	-	-	0.825 (0.00004)
	Morn: Medium		-	-	-	-	0.915 (0.00001)

could bias the model. For each of the grouped behaviours, a generalised linear model (GLM) for proportional data was used. Overdispersion was detected and corrected using a quasi-GLM model where the variance is given by $\emptyset \times \mu$, where μ is the mean and $\emptyset$ is the dispersion parameter (Zuur et al. 2009). The optimal model was found using backwards model selection and validated by plotting residuals against the fitted values and each explanatory variable.

For the focal samples, only the data from the female and juvenile macaques were analysed, as males were removed throughout the study. Each of the behaviours (except for out of sight) were corrected for time in sight. Non-parametric tests were performed as the data were found to deviate significantly from a normal distribution, which was confirmed through the Kolomogorov-Smirnov and Shapiro-Wilk tests, and visual checks. To compare behaviour of females and juveniles across year, Kruskal-Wallis tests were used. Post-hoc analysis was performed using the R package pgirmess (Giraudoux 2018). Variability is described using standard error (±SE).

Results

The estimated parameters and P-values for each explanatory variable can be seen in Table 2. For active and restful behaviours, 2016 was significantly different from 0 at the 1% level when compared to 2014. Self-directed behaviours during 2015 differed significantly from 0 at the 1% level when compared to 2014. Compared with high levels of precipitation, restful behaviours during 'nil' and 'light' precipitation levels differed significantly from 0 and the 1% level. Restful behaviours during 'nil' cloud cover was also found to differ significantly from 0 when compared to 'full' cloud cover. For out of sight, 'nil' and 'partial' cloud cover was found to be significantly different from 0 at the 1% level compared with 'full' cloud cover. Also, for out of sight, the interaction between temperature and medium visitors was found to differ significantly from 0, as was the relationship between morning time and low visitors, and morning time and medium visitors.

The non-parametric tests indicated a significant difference (P<0.001) between the amount of time females spent out of sight between 2014 (19%±2.45) and 2015 (41%±4.46). Juveniles also spent significantly more (P<0.001) time out of sight in 2015 (28.3%±5.44) compared to 2014 (30%±2.69). No other significant differences in behaviour were found.

Discussion

In the months following the relocation to the new enclosure the macaques were observed to spend more time out of sight and less time engaged in self-directed behaviours compared to observations in the old enclosure. The increased time spent out of sight following the relocation is unsurprising given that the new enclosure contains far more dense and tall vegetation, and as there were no outdoor shelters in the new enclosure, the macaques were inclined to spend more time indoors and out of sight when the weather was unfavourable or during feeding times. These out of sight observations could also be associated with exploratory behaviours, due to the new surroundings. Exploration is said to provide information for the animals about the general spatial patterning of resources, to help the animals gauge future resource availability (Shepherdson et al. 1998). Lion-tailed macaques have been found to frequently engage in exploratory behaviour, and object manipulation, which is possibly related to their omnivorous lifestyle (Westergaard and Lindquist 1987).

Novelty can stimulate this exploratory behaviour, but it can also cause fear or stress in an individual (Shepherdson et al. 1998). Self-directed behaviours, such as scratching or autogrooming, are termed as displacement activities which are characterised by their apparent irrelevance to the situation in which they appear (Maestripieri et al. 1992), and when frequently observed in an individual, are often associated with stress, frustration or anxiety, or they can occur following an aggressive encounter with another individual (Aureli et al. 1992; Das et al. 1998; Diezinger and

Anderson 1998; Manson and Perry 2000; Kutsukake and Castles 2001; Troisi 2009). Baker and Aureli (1997) found increased levels of self-directed behaviours associated with anxiety in chimpanzees *Pan troglodytes*. Self-directed behaviours decreased in this lion-tailed macaque group following the move to the new enclosure, which could indicate that this group did not find the relocation or novel surroundings stressful, or the new enclosure was sufficiently enriching to reduce these behaviours. It is important to note that it is likely that this decrease could be related to the higher levels of out of sight, meaning other behaviours were observed less frequently overall.

The new enclosure was not the only novel experience for this group; visitor proximity was also greater in the new enclosure. Several studies have examined the effects that visitors have on captive primate behaviour. Mallapur et al. (2005) found that there was an increase in abnormal behaviours in the presence of visitors in comparison to when visitors were absent in lion-tailed macaques housed in Indian zoos. A study by Wood (1998) showed that larger crowds significantly decreased foraging, playing and grooming among captive chimpanzees. Fernandez et al. (2009) stated that gorillas in Belfast Zoo spent significantly more time engaged in aggressive, abnormal and self-grooming behaviours when large crowds of visitors were present. Visitor presence did have some impact on the behaviour of the macaques in Fota, with the macaques less active during low visitor numbers compared to high visitors, but there were no significant differences found between the two enclosures in terms of visitor effect. Similarly, although the environmental variables measured were found to have an effect on certain behaviours, such as out of sight, there was no interaction found between these variables and the two enclosures.

One year since the relocation to the new enclosure, the macaques were noted to be less active when compared to behaviour in the old enclosure, but no significant changes in behaviour were found since 2015. The decrease in activity could possibly be due to the presence of the new male macaques.

The quality of the environment is just as important as the size; zoos that are unable to move their animals to a new environment can enrich the existing enclosure to improve welfare. Not only is the new enclosure in Fota more than 10 times larger than the previous one, but more importantly it contains much more vegetation, with trees, bushes and long grass providing cover and increased foraging opportunities for the macaques. The high levels of out of sight, while as discussed are not necessarily a negative outcome due to exploratory behaviour, could be an issue when it comes to visitor experience. When designing an enclosure there is generally a trade-off between visitor experience and animal welfare (Hosey 2005; Fernandez et al. 2009). While studies have shown that visitor prefer to see animals in a naturalistic environment (as opposed to barren or concrete enclosures), they have also said that their exhibit preferences are dependent on a combination of how close the visitor is able to get to the animal, how easily it can be seen by the visitor, the animal's activity levels, in addition to the aesthetic elements of the enclosure (Fernandez et al. 2009). The high levels of out of sight therefore could have a negative impact on visitor experience of the macaques. One study by Anderson et al. (2003) found that the length of time a visitor stayed at the Asian small-clawed otter enclosure increased from an average of 82.90 seconds during low animal activity to 360.33 seconds during high animal activity, an increase of over 430%. By encouraging more feeding and activity in the outer sections of the enclosure (with feeders or toys), nearer the fence, this would provide more opportunities for visitors to see the macaques, as well as providing further stimulation and novelty for the group.

Conclusion

The relocation of a captive species to new, better quality surroundings, whether within an institution or between institutions, can be enriching and stimulating, but it is important to consider that it can be a source of stress and anxiety. As these relocations can be a common part of a captive animal's life, it is important to consider the effect that they may have. Further research will be needed before it can be determined if the relocation of this group to a new enclosure encourages more positive or negative behaviours in the long-term.

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