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Introduction

- Ring-Tailed lemurs (*Lemur catta*) are kept in animal collections worldwide (WAZA, n.d), however despite this there is minimal research into methods of environmental enrichment.
- Environmental enrichment via olfactory stimulation has been found to have positive behavioural effects in a range of captive species (Wells, 2009).
- For example, Lavender enhanced resting and decreased barking in kennel housed dogs (Graham et al, 2005), peppermint increased activity in captive lions (Powell, 1995), coconut increased exploratory behaviours in wombats (Hogan et al, 2010), and prey odour increased exploration and decreased pacing in cheetahs (Quirke & O’Riordan 2011) and increased activity in black-footed cats (Wells & Egli 2004).
- Ring-tailed lemurs use olfactory cues extensively in their natural habitat (Jolly, 1996; Kappeler, 1998; Drea & Scordato, 2008), however the effects of olfactory stimulation on lemur behaviour has been little studied to date.
- This study investigated the effects of olfactory stimulation on the behaviour of captive Ring-Tailed lemurs.

Methodology

- Eight captive-bred Ring-Tailed lemurs were observed at Birmingham Wildlife Conservation Park (Birmingham, UK) over a six week period (Figure 1).
- Six olfactory conditions were used (novel object control, odour control, lavender, peppermint, coconut, and prey odour, Morio Worms).
- Odours were introduced on eight sterilised 15cm x 15cm square cotton-based cloths which were randomly scattered in the lemurs’ enclosure (Figure 2). Fresh scented cloths were provided daily.
- In the novel object control condition, no cloth or odour was provided, whilst in the odour control condition an unscented cloth was utilised.
- For the odour conditions, the cloths were impregnated with the lavender, peppermint or coconut odours 60 minutes before being placed within the lemurs’ enclosure. Twenty ml of each essential oil treatment was used with a 1:2 dilution of water. For the prey odour condition, the cloths were placed in the Morio Worms’ enclosure for 60 minutes prior to being placed into the lemurs enclosure.
- The Ring-Tailed lemurs were exposed to each condition for three days (4 hours a day) with a 4 day interval between olfactory conditions to allow time for the previous odours to disperse.
- The lemurs’ behavioural responses were recorded using an ethogram adapted from previous work (Ellwanger, 2002; Shire, 2012). Behaviours were recorded every 5 minutes using instantaneous scan sampling, providing 48 observations of each lemur’s behaviour per day.
- Data were analysed using Friedman ANOVAs with post hoc Bonferroni-corrected Wilcoxon Signed-Rank Tests (SPSS version 23.0, SPSS Inc. 2016).



Figure 1: Lemurs observed during study

Results

- Friedman ANOVA analysis found significant effects of olfactory condition on resting behaviour ($\chi^2(5) = 30.986, P < 0.001$), locomotive behaviour ($\chi^2(5) = 30.735, P < 0.001$), sitting behaviour ($\chi^2(5) = 16.884, P = 0.005$), foraging behaviour ($\chi^2(5) = 23.590, P < 0.001$), drinking behaviour ($\chi^2(5) = 11.295, P = 0.046$), mutual grooming behaviour ($\chi^2(5) = 24.114, P < 0.001$), sitting in contact behaviour ($\chi^2(5) = 19.119, P = 0.002$), chasing behaviour ($\chi^2(5) = 18.345, P = 0.003$), scent marking behaviour ($\chi^2(5) = 16.094, P = 0.007$), self-grooming behaviour ($\chi^2(5) = 29.797, P < 0.001$), vocalisation behaviour ($\chi^2(5) = 26.752, P < 0.001$) and vigilance behaviour ($\chi^2(5) = 31.843, P < 0.001$).
- However *Post-Hoc* analysis with Bonferroni-corrected pairwise comparisons found no significant differences between the olfactory conditions.

Discussion

- The findings from this study suggest that olfactory stimulation does not have a marked influence upon the behaviour of captive Ring-Tailed lemurs.
- The findings are somewhat surprising considering Ring-Tailed Lemurs’ extensive use of olfactory cues in the wild (Jolly, 1996; Kappeler, 1998; Drea & Scordato, 2008).
- However, olfactory stimulation, whilst shown to have beneficial effects in a number of species (e.g. Wells & Egli, 2004; Hogan et al, 2010; Rafacz & Santymire, 2014) has not been found to be beneficial for all captive species (e.g. Wells et al, 2007; Myles & Montrose, 2015).
- In addition, many of the odours that were used in the study were biologically meaningless to the lemurs. More biologically relevant odours, such as urine or faeces, from conspecifics or heterospecifics may be of more value.
- Consideration of the method of odour presentation may also be needed, as odour scented cloths may not provide sufficient coverage of the enclosure. Dispersed scent presentation (e.g. Struthers & Campbell, 1996), may be a more effective method of odour presentation for the lemurs.
- Overall, our findings suggest that olfactory stimulation in the form of odour-scented cloths does not greatly influence the behaviour of captive Ring-Tailed lemurs. However, further investigation using a larger sample size and odours of more biological relevance should be considered.



Figure 2: The inside enclosure of the lemurs

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