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Studying the Effects of Predatory Presence and Enrichment on *Cryptoprocta ferox* Behavior

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ABSTRACT: The Central Florida Zoo and Botanical Gardens houses two fossa (*Cryptoprocta ferox*), a male and a female. *C. ferox* is an endangered species of Malagasy mongoose from the island of Madagascar. In October of 2018, an amur leopard (*Panthera pardus orientalis*) was moved across from the male and female *C. ferox*. This study was used to identify if the presence of *P. p. orientalis* would affect the stereotypic pacing behavior of the female *C. ferox*. Staff were also curious about the impact of daily-renewed enrichment on the frequency of pacing in the female. Our analysis showed the *P. p. orientalis* did not have a significant impact on pacing or behavior in the female *C. ferox*. The exchange of enrichment every day did not result in a significant difference in the frequency of pacing. Several solutions were presented to the staff to relieve the amount of pacing and to ensure successful breeding.

KEYWORDS: fossa; captivity; *Cryptoproctera ferox*; pacing; stereotypic behaviors

INTRODUCTION

The fossa (*Cryptoprocta ferox*) is the largest extant carnivore native to Madagascar (Veron et al. 2018). Madagascar is adjacent to the continent of Africa on its southwest coast. The island is known for its significant amount of endemic species that contribute to its biodiversity and ecotourism (Robinson et al. 2018). Madagascar has experienced deforestation and introduction of invasive species, including the feral dog (*Canis familiaris*), the feral cat (*Felis catus*), and the Indian Civet (*Viverricula indica*) (Cartagena–Matos et al. 2017). These invasive carnivores threaten *C. ferox* by introducing diseases, such as canine distemper and canine parvovirus (Rasambainarivo et al. 2017). *C. ferox* is also selectively hunted for bushmeat and is considered vermin among the local population (Rasambainarivo et al., 2017). *C. ferox* is a member of the family *Eupleridae*, the Malagasy Mongooses, and have evolved to hunt lemurs and other primates (Dollar et al. 2006). More than fifty percent of their diet is composed of different species of lemur. Their diet also includes species of small mammals, ground birds, and reptiles (Hawkins and Racey, 2008). Their presence on the island allows them to keep prey species numbers under control. The conservation of this species is imperative to maintaining the ecosystem.

C. ferox become sexually mature after four years (A-Z, 2017). The mating behaviors of *C. ferox* are polyandrous; the female will mate with several males (Luehrs and Kappeler, 2014). The female will select a tree to display to other males by vocalizing. The males will then compete at the base of the tree to mate; the larger, older males are usually more successful (Luehrs and Kappeler, 2014). A male will mount the female on a limb of the tree and intercourse will last approximately two hours (Luehrs and Kappeler, 2014). Females will continue to mate, often with the same males. The male *C. ferox* possess a baculum and a barbed penis which assist in securely holding onto the female during mating (Luehrs and Kappeler, 2014). Juvenile female *C. ferox* will possess a large clitoral bone, and it will decrease in size as they mature (Hawkins, 1998). The os clitoris may reduce sexual harassment of juvenile females by older females and males (Hawkins, 1998). *C. ferox* mate from August to December and give birth to one to four pups a year (Vogler et al., 2009). Gestation lasts for approximately 53-60 days (Vogler et al. 2009). The pups are born blind and lacking teeth. After approximately 16 weeks they are weaned, and at two years the pups become completely independent (A-Z, 2017).

This study took place at the Central Florida Zoo and Botanical Gardens in Sanford, Florida. The duration of the study was from August 27, 2018, through November 21, 2018. The subject was a female fossa referred to as "Shelby" by her keepers. Shelby was eight years old and had not been previously bred. Housed to the left of the female was the male *C. ferox*, referred to as Malala. To the right of Shelby's enclosure was the exhibit of two ring-tailed lemurs. Beginning in January of 2019, the staff prepared to breed the two fossas to contribute to conservation efforts. In October of 2018, an amur leopard (*Panthera pardus orientalis*) was introduced into an enclosure on the other side of the guests' path (after the absence of a melanistic leopard, staff moved the previous melanistic leopard due to age and declining health.) This enclosure was approximately 4.5 meters from the female's *C. ferox* enclosure. The staff was curious about Shelby's well-being and if she would be receptive to breeding the following year. *P. p. orientalis* is not a natural predator of *C. ferox*, but the introduction of a new predator to the area was expected to change the behavior of all species nearby. Shelby also expressed stereotypic pacing behavior, including an action called a "head roll" (Central Florida Zoo, Fall 2018). It is described as an anticipation behavior by staff and involves the female going into a corner of the enclosure, rolling her head, and pushing off to run to the other side. An anticipation behavior is used to describe any behavior that occurs consistently before a reinforcing event, such as a changing of enrichment or food. Enrichment was provided daily and has been shown to reduce the amount of pacing in individuals. This study will identify the effects of *P. p. orientalis*'s presence on the female's behavior and the impact of different types of enrichment on stereotypic pacing.

METHODS

For twelve weeks the female was observed for a total of 112.5 hours. The observations took place between 9:00-14:00 on Monday and Wednesday each week. The observer was placed at least 1.5 meters away from the enclosure. During that time the "primary" and "secondary" behavior was recorded every five minutes as well as the location of the female. "Primary" behaviors were determined by which behavior was displayed for much of the five-minute interval. The location levels were categorized based on a previous study including levels 1-4 (UCF Student Study, 2017). The types of behaviors that were observed were: resting/sleeping, pacing, head rolling, observing, interacting, foraging, scent marking, self-grooming, and wandering. Definitions of important

terms are found in Table 1.

Table 1. List and definitions of behaviors

List of Terms	Definitions
Climbing	Locomotion above the ground for a prolonged period.
Enrichment	Enrichment allows animals to demonstrate their species-typical behavior, gives them the opportunity to exercise control or choice over their environment and enhances their well-being. Enrichment was used to decrease stress by providing environment interaction and acclimation to other predators.
Head rolling	Associated with pacing, to climb up a wall and to push off while simultaneously rolling the head
Foraging	Actively drinking or eating. Includes searching through various enrichment items and through mulch for food
Interacting	In contact with an object that is not purely food motivated
Observing	Behaviors where the fossa is sniffing the air or enrichment objects, looking at a stimulus, or focusing in a direction.
Pacing	Includes all repetitive back-and-forth walking motions
Scent Marking	Depositing an odoriferous substance on to an object
Self-grooming	Licking or rubbing to maintain a personal level of hygiene
Resting/Sleeping	Sitting or lying and not actively engaged in an active behavior
Wandering	Locomotion through the exhibit that does not appear to be food or play driven

The changing of enrichment happens every day around 10:00 AM -12:00 PM, which is based on the keepers' schedules. The enrichment was categorized by tactile, visual, olfactory, or keeper engagement and the categories varied each day. The amount of pacing was recorded before and after the enrichment was swapped out. An ANOVA was performed to discover if there was any significant difference between the amount of pacing before and after the swapping out of the enrichment. The incidence of head rolls was also recorded by time and location. The locations were categorized by which corner of the enclosure the head roll took place. The categories are as follows: Left Back Corner (LBC), Left Front Corner (LFC), Right Back Corner (RBC), Right Front Corner (RFC), and Den Entrance (DE). The head rolls were recorded for the day and are an extension of pacing (Dickie and Phil, 2005, Central Florida Zoo, personal communication). An ANOVA test was used to determine the significant difference in behavior before and after *P. p. orientalis* was introduced. August 27th and 29th were excluded from the head roll analysis due to the lack of recording head rolls until the second week of the study. October 1st and 3rd were excluded from both pacing and head roll analysis. (These observations took place during a different time interval than the other observations. The inclusion of these dates had no significant effect on the overall results.)

RESULTS

To determine the impact *P. p. orientalis* had on the female *C. ferox*, her behaviors were tallied and converted to percentages for each day observed (Figure 1).

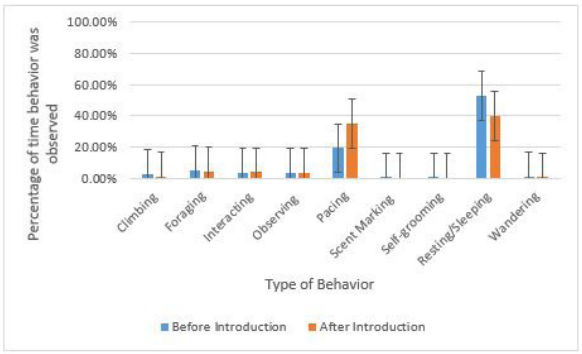

Figure 1. Percentage of behavior presented before and after the introduction of P. p. orientalis

These percentages were then averaged and compared to before and after *P. p. orientalis* was introduced to the area. I completed an ANOVA test to determine the significance of these percentages. The *p* value was approaching one using a two-tail distribution and two samples of unequal variance type, or heteroscedastic. There was little significant difference between behaviors during the two periods.

Enrichment is meant to deter the individual from unwanted behaviors, such as pacing (Nilsson et al. 2014). The amount of pacing was recorded before and after enrichment from the previous day was switched out (Figure 2).

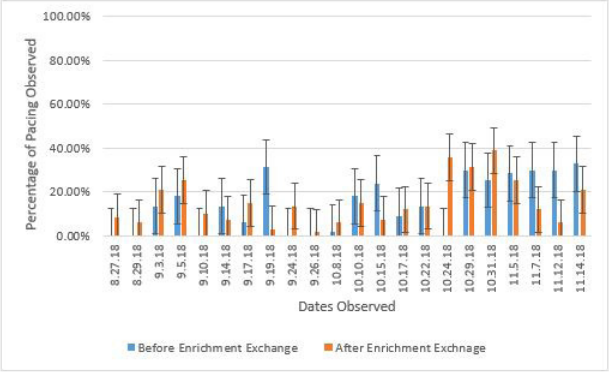

Figure 2. Pacing before and after enrichment was exchanged

An ANOVA was also used to compare the values. The *p* value was 0.89 when using a two-tailed distribution and paired-type. There is no significant difference between the amount of pacing before and after the exchange of enrichment.

The amount of head rolling before and after the exchange of enrichment was also compared using an ANOVA (Figure 3).

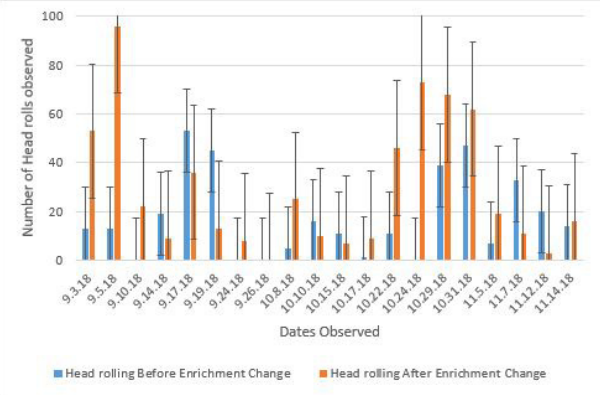

Figure 3. Head rolling before and after enrichment was switched out of the enclosure

The *f* test produced a *p* value (.0011) that was smaller than the alpha level suggesting the use of a homoscedastic type *t* test. The *t* test produced a *p* value (.20). There is no significant difference between the number of head rolls recorded before and after the daily exchange of enrichment.

DISCUSSION

It was hypothesized that *P. p. orientalis* would alter the behavior of the female. *C. ferox*, who was expected to increase pacing and head rolling after *P. p. orientalis* moved to the new enclosure. The null hypothesis was not rejected, meaning *P. p. orientalis* did not affect the female *C. ferox*. Early in the study, the keepers introduced items from *P. p. orientalis*' enclosure to *C. ferox*'s enclosure. The enclosure housing *P. p. orientalis* at the time was in a private area in the back of the zoo. These actions were taken to introduce its scent to *C. ferox* and prevent stress once the individual was introduced nearby. When *P. p. orientalis* was present in the area the female was prepared for the persisting scent of a new predator. It is believed this procedure also reinforces the feeling of security to Shelby because when the scent was introduced, she was not in any immediate danger of being attacked.

Head rolls and pacing were indicators of stress for Shelby (Dickie and Phil, 2005, Central Florida Zoo, personal communication). Enrichment was used to decrease this stress and increase her interactions with her enclosure. According to Figure 2, there was no significant difference between the amount of pacing observed before and after the swapping of enrichment from the previous day. Figure 3 showed there was no significant difference between the number of head rolls before and after this daily event.

The introduction of scents into Shelby's enclosure provided her with the appropriate environment and time to process the new predator's scent. Shelby was also near the clouded leopard (*Neofelis nebulosa*) and was occasionally given items from its enclosure. The keepers continue to reinforce positive reactions to the scents by including them in enrichment. A 2006 study by Clubb and Vickery also suggests providing the female *C. ferox* with more hiding spaces. Hiding spaces are known to decrease stereotypy levels in species near large predators (Clubb and Vickery, 2006) because it provides a sense of security. Hearing and smelling the leopards, which were also suggested by Clubb and Vickery (2006), could decrease pacing in the species near large predators.

The keepers were concerned by the amount of pacing and number of head rolls Shelby was presenting. Enrichment was an obvious solution to decrease both unwanted behaviors due to boredom. Unfortunately, there was no significant change between the two periods of the day. This time also included foraging, meaning the pacing and head rolls may not have been the result of boredom or hunger. In other words, there was another stressor in the environment causing Shelby to display stereotypic pacing far above the expected daily percentage (Dickie and Phil, 2005).

According to the Association of Zoos and Aquariums (AZA, 2011), *C. ferox* individuals should be housed in enclosures of 29 m^2 and their enclosures should have a vertical height of 2.4 meters. Shelby was housed in an enclosure that was approximately 12.6m^2 and 3.6 meters in height (Figure 4).

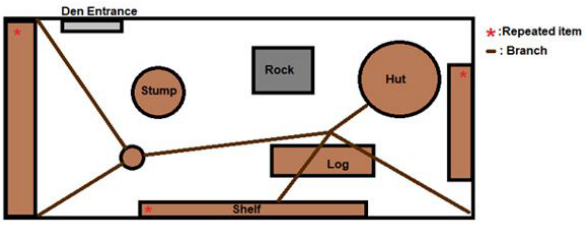

Figure 4. Diagram of Fossa Enclosure

Not having adequate space to patrol could be a possible source of stress. The zoo has plans to remove Malala from his adjacent enclosure and to begin construction to connect the enclosures for breeding, and the zoo were also planning to expand the den area for the female when she is parturient. Supported by the Association of Zoos and Aquariums, this remedial action may decrease the amount of pacing in the female when the enclosure is larger. The enclosures will need to be increased by 25% to account for the introduction of a new *C. ferox* (AZA 2011).

The zoo planned to breed Shelby to Malala. Reproductive success will be increased by decreased levels of stress. The introduction of scents of soon-to-be introduced animals was suggested for assimilation. The zoo had already begun swapping items between the male and female to prepare for breeding. The two *C. ferox* also could visually see each other when at certain heights of the enclosure. The re-introduction of Malala will be necessary after his absence from the enclosure during construction (Association of Zoos and Aquariums et al. 2011). Continued scent swapping will encourage a positive re-introduction.

By way of comparison, study was done at multiple zoos to observe captive behaviors of *C. ferox* (Dickie and Phil, 2005). At Marwell Zoo in Germany, it was found that the female devoted an average of 24% of her active time to pacing. This observation was identical to the amount of time the female devotes to pacing at the Central Florida Zoo. At Zoo Duisburg, "head flicking" was observed as a repetitive behavior in a female *C. ferox* and was like the behavior of Central Florida Zoo's Shelby presented (Dickie and Phil, 2005). Dickie and Phil (2005) suggest more complex enclosures and enrichment to decrease pacing. Shelby was given several types of enrichment including visual, scent, tactile, and keeper engagement. There was not a significant difference in head roll and pacing before and after the exchange of enrichment. A possible solution would be to increase the frequency Shelby is fed or to increase the complexity of enrichment (Clubb and Vickery, 2006).

CONCLUSION

It is suggested that the Central Florida Zoo and Botanical Gardens evaluate the possible solutions in this paper. The benefit is increased welfare for Shelby and the possibility of successful breeding in the future. A note should be taken that some dates were excluded from the analysis.

REFERENCES

1. A-Z Animals. 2017. Retrieved August 23, 2018, from https://a-z-animals.com/animals/fossa/

2. AZA Small Carnivore TAG. 2011. Mongoose, Meerkat, & Fossa (Herpestidae/Eupleridae) Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. 103.

3. Cartagena–Matos, B., Gregório, I., Morais, M., and E. Ferreira. 2017. Trends in the extinction of carnivores in Madagascar. *Animal Biodiversity And Conservation*. 40:103-114.

4. Central Florida Zoo. Fossa. (n.d.). Retrieved August 18, 2018, from http://www.centralfloridazoo.org/animals/fossa/

5. Clubb, R and Vickery, S. 2006. Locomotory stereotypies in carnivores: does pacing stem from hunting, ranging, or frustrated escape. In Stereotypic animal behavior: fundamentals and applications to welfare. Center of Agriculture and Bioscience International. 2:58-79.

6. Dickie, L. A., and M. Phil. 2005. The behavior and reproductive physiology of the fossa (*Cryptoprocta ferox*) in captivity. Thesis. University of London, London, England, UK.

7. Dollar, L., Ganzhorn J.U., and S. M. Goodman. 2006. Primates and other prey item in the seasonal diet of *Cryptoprocta ferox* in Ankarafantsika national park, Madagascar. *Primatology*. 27:90-91.

8. Hawkins, C. E., and P. A. Racey. 2008. Food habits of an endangered carnivore, *Cryptoprocta ferox*, in the dry deciduous forests of western Madagascar. *Mammalogy*. 89(1):64–74.

9. Hawkins, C. E. 1998. Behaviour and ecology of the fossa, *Cryptoprocta ferox* (Carnivora: Viverridae) in a dry deciduous forest, western Madagascar.

10. Nilsson, S., J. Sjoberg, M. Amundin, C. Hartmann, A. Buettner, and M. Laska. 2014. Behavioral responses to mammalian blood odor and blood odor component in four species of large carnivores. PLoS ONE. 9: e112694.

11. Luehrs, M., and P. M. Kappeler. 2014. Polyandrous mating in treetops: how male competition and female choice interact to determine an unusual carnivore mating system. *Behavioral Ecology And Sociobiology*. 68:879-889.

12. Rasambainarivo, F., Farris, Z. J., Andrianalizah, H., and P. G. Parker. 2017. Interactions Between Carnivores in Madagascar and the Risk of Disease Transmission. *Ecohealth*. 14:691-704.

13. Robinson, J. E., Griffiths, R. A., Fraiser, I. M., Raharimalala, J., Roberts, D. L., and F. A. V. St. John. 2018. Supplying the wildlife trade as a livelihood strategy in a biodiversity hotspot. *Ecology And Society*. 23:13.

14. UCF Student Study. Spring 2017. *Cryptoprocta ferox* Behavioral Study at Central Florida Zoo.

14. Veron, G., Duprè, D., Lührs M., Kappeler, P.M., Dollar, L., Pomerantz, J., and S. M. Goodman. 2018. Genetic polymorphism and structure of wild and zoo populations of fosa (Eupleridae, Carnivora), the largest living carnivoran of Madagascar. *Mammalian Biology*. 92:68-77.

15. Vogler, B. R., Blevins, B., Goeritz, F., Hildebrandt, T. B., and M. Dehnhard. 2009. Gonadal Activity in Male and Female Captive Fossas (*Cryptoprocta ferox*) During the Mating Season. *Reproduction In Domestic Animals.* 44:98-102.