

Infant development and behaviour in the Fossa *Cryptoprocta ferox*

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Abstract

The Fossa *Cryptoprocta ferox* is a solitary carnivore native to Madagascar, endangered in the wild and boasting only a small captive population. Preservation of the Fossa would benefit from further knowledge of the species's biology and behaviour, including an understanding of parturition and infant development. This topic has yet to be researched in the wild, whilst captive accounts are limited and anecdotal. We present a quantitative analysis of the early behavioural and physical development of two mother-reared and two hand-reared Fossas. All kits were easily sexed at an early age using visible differences in male and female genitalia. The development of the hand-reared kits paralleled what could be visually concluded from the mother-reared kits and what has been reported by other captive institutions, implying that the methods employed were successful. Behavioural data revealed that the mother-reared kits were more active than the adult female, with increased time spent locomoting and engaged in solitary and social play. They were first seen scent marking at 12 weeks of age, suggesting that behaviours necessary as adults may begin while sexually immature. Agonistic behaviour is common among juvenile carnivores but was not seen in the Fossa, possibly reflecting the small litter size and lack of resource competition. Our results provide the first quantitative look at captive Fossa infant development and hand-rearing techniques, further clarifying the biological and behavioural maturation of this enigmatic species. Studies such as this are necessary to manage captive individuals successfully, and they improve knowledge of a species difficult to study in the wild.

Keywords: captivity, hand-rear, nest box, scent marking

Faminitinana

Ny fosa, izay antsoina amin'ny teny ara-tsiansa hoe *Cryptoprocta ferox* dia biby mpihinan-kena mandeha irery, ary tsy fahita afa-tsy eto Madagasikara. Efa sokajiana ho an-dalam-paharinganana ny fosa hita eny amin'ny natiora ary ankoatra izay dia mbola tena vitsy dia vitsy ny isany any amin'ireo toeram-pihazonana biby eran-tany. Ny fahafantarana ny momba ny fiain-pianany sy ny toetrany, anisan'izany ny fahalalàna bebe kokoa momba ny fiterahany sy ny fitomboany nanomboka tamin'ny fahakeliny dia mitondra voka-tsoa lehibe amin'ny fiarovana azy. Mbola betsaka tokoa ny fikarohana tokony hatao momba izany fahalalàna momba ny fosa izany raha ny any amin'ny natiora no jerena, ary ny zavatra fantatra momba ireo fosa izay hita any amin'ny toeram-pihazonana biby aza hatramin'izao dia mbola azo lazaina ho voafetra tokoa sady mionona amin'ny fitantaràna ankapobeny ihany. Eto isika dia haneho ny vokam-pikarohana iray izay misy antontan'isa mazava mampiseho indrindra ny fitomboana ara-toetoetra sy ara-batan'ny fosa roa izay nobeazin'ny reniny sy fosa roa nobeazin'olona narahina hatramin'ny fahakeliny. Tamin'ireo biby rehetra ireo dia mora tokoa ny namantatra ny lahy sy ny vavy hatramin'ny fahakeliny tamin'ny alalàn'ny fandinihina ny fahasamihafana miavaka eo amin'ny fitaovam-panananahany. Ny fitomboan'ireo nobeazin'olona dia tsy mifanalavitra akory amin'ny fitombon'ireo nobeazin'ny reniny sy izay volazan'ireo toeram-pihazonana fosa hafa ihany koa ka mahatonga haminavina fa mahomby ny fomba fanalehibiazana nampiasaina. Ireo fahalalàna azo momba ny toetrany indray dia naneho fa ireo fosa nobeazin-dreniny dia mavitrika kokoa nohon'ny fosa vavy efa lehibe, ka mampitombo kokoa ny fotoana laniny amin'ny fandehanana ary mavitrika kokoa amin'ny filalaovana irery na miaraka. Tazana namela mari-pofona voalohany izy ireo tamin'ny faha-12 herinandrony ka eritreretina fa mety efa miseho ny toetoetra maha-lehibe na dia mbola tsy maoty aza ny vatana. Ny toetra mitaraindraina dia fahita matetika amin'ireo biby mihinan-kena amin'ny fahakeliny nefa tsy mba fahita amin'ny fosa, ka izany angamba dia vokatry ny fahavitsian'ny zana-posa miaraka ateraky ny reniny ary koa ny tsy fisian'ny fifaninana eo amin'ny fitadiavana sakafo. Ny vokatry ny fikarohana etoana dia nanome ny antontan'isa voalohany mikasika ny fitomboan'ny zana-posa nobeazin'olona sy ny tekinka fiompiana mahomby ka nitondra fanazavana bebe kokoa momba ny fiain-piainana sy ny toetra maha-maoty ity biby sarom-pantarina ity. Ny fikarohana toy izao dia ilaina tokoa mba hitsinjovana ireo biby hazonina sady mampitombo ny fahalalàna momba ireo biby izay sarotra ianarana eny amin'ny natiora.

Introduction

The Fossa (Fosa) *Cryptoprocta ferox* is an endangered carnivore of the family Eupleridae (often previously placed in the Viverridae), endemic to Madagascar. It is the largest carnivore on Madagascar; adults reach up to 12 kg and 80 cm, with a tail of approximately the same length (Parker 1990). It has a beige to reddish-brown coat, with occasional melanistic individuals being reported in Eastern rainforest areas (Garbutt 1999). The gait is distinctive, using plantigrade-like locomotion when arboreal and digitigrade-like movement when terrestrial (Parker 1990). The ease of movement on both the ground and in the trees allows hunting of a wide

variety of prey species. It is an opportunistic hunter, known for predated lemurs, but also taking other mammals, birds, reptiles, and insects (Dollar 1999).

Fossas are generally solitary, but populations still need a mechanism of intraspecific communication to create and maintain social organisation. Individuals have multiple scent glands for this purpose in the anal, genital, neck, and chest regions (Parker 1990). They scent mark throughout the year (Hornsey 1999). Many environmental and social factors affect marking behaviour (Moran & Sorensen 1986), and although the specific motivations behind Fossa scent marking are not known, it is probably used for territory association, individual identification, and mate attraction.

Breeding occurs in the spring and females seek out secluded sites such as hollow trees or termite mounds for parturition (Köhncke & Leonhardt 1986). Litters of 1–6 kits are born after a 90-day gestation (Sunquist 1998, Garbutt 1999). Kits typically weigh 50–150 g at birth, and although toothless and blind, they are born fully furred (Garbutt 1999). They do not reach adult weight or sexual maturity until 3–4 years of age and may stay with the mother for this entire period (Winkler 1996). This slow development correlates with estimated longevity of up to 20 years in captivity (Köhncke & Leonhardt 1986).

Current literature related to Fossa infants and maternal care is restricted to qualitative captive reports and brief care guidelines within the International Studbook/Husbandry Manual; there is no literature related to hand-rearing (Winkler 1996). Infancy is a significant time for behavioural development, as adult behaviour of an individual is partly determined by the environmental and social interactions experienced during early life (Carlstead 1996). If the physical and/or social environment of captivity varies from that of the wild, the behavioural development of the infant may be affected. Given that the early rearing of Fossa has never been documented in the wild, it is imperative that these events be examined in captivity to begin understanding the species's behavioural development.

Cleveland Metroparks Zoo (CMZ) has housed an adult male and female Fossa since 2002. The pair bred in 2004, providing opportunity to research the behavioural development of the infants and maternal care of the adult female as she raised her first litter. The study's objectives were to: (1) provide husbandry information for hand-rearing Fossa kits; (2) describe early development of kits; (3) determine how often Fossas use the nest box; (4) determine how behaviour differs between kits and mother; (5) approximate the onset of developmentally significant behaviours including weaning, scent marking and aggression; and (6) compare the adult female's pre- and post-partum levels of stereotypy.

This study is the first quantitative analysis of infant behaviour in this species and provides information related to behaviour, development, maternal care and hand-rearing. The results are applicable to captive management of the Fossa and may also contribute to understanding Fossa behavioural development in a natural setting.

Methods

Subjects

Subjects included one adult female and her four kits, two female and two male. The adult female has been housed at CMZ since July 2002 and was approximately five years of age at the onset of the study. She was fed daily either Dallas Crowne or chunk horse-meat with $\frac{1}{4}$ teaspoon of Osteo-Form (Vet-A-Mix®) calcium-phosphorus powder supplement. Two kits were mother-reared (MR; see Fig. 1) and were included in the behavioural study. Two kits were hand-reared (HR; see Fig. 2) and data pertaining to their growth and early development are included.

Housing and Husbandry

The adult female and MR (mother reared) kits were housed at CMZ Primate, Cat and Aquatics building in Cleveland, OH, USA. The exhibit consisted of two indoor enclosures (E1 and E2) connected via a 0.76 x 0.36 m opening and lit with skylights and high pressure sodium lamps. Each enclosure was approximately 50 m³



Fig. 1. Male and female mother-reared Fossa kits at approximately five months of age.



Fig. 2. Male and female hand-reared Fossa kits at approximately six weeks of age.

with a cement substrate and side walls and front glass viewing window. The rear walls consisted of welded wire above 1.5 m cement ledges. Each enclosure contained one or two rockwork ledges 1–1.5 m high and natural logs a minimum of 0.15 m diameter affixed both vertically and horizontally. Two wooden nest boxes (0.76 x 0.41 x 0.5 m) were located either on the ground or atop a rock ledge within each enclosure; these are suggested sites for female parturition (Winkler 1996). The boxes were bedded with straw and straw was also placed around the bottom edge of the ledges to protect the kits during a fall.

Plywood was placed over the exhibit glass following the birth of the kits to prevent zoo visitors from viewing the animals. This covering had a small window that could be opened for observers

to collect data. The plywood was removed on 8 September 2004, but visitors were kept approximately 3 m from the exhibit glass using rope barriers for the remainder of the study. The kits initially reacted by investigating the glass and seemingly reacting to the movement on the public side; by the following day these reactions were not seen, and overall the removal of the plywood caused no observed differences in behaviour of the kits or the adult.

Data collection

To minimise disruption, behavioural data collection did not begin until the kits were six weeks old. Early developmental information was gathered via routine daily keeper observations. Quantitative behavioural data were then collected on the adult and MR kits from August to October 2004 for a total of 10 hours. The ethogram consisted of 13 solitary and seven social behaviours and was adapted from McCarthy *et al.* (2003). Data were collected using continuous 15-minute focal-animal observations, all taken between 10h00 and 17h00. Data were recorded using a Psion Walkabout® handheld computer equipped with a protocol written in The Observer® 4.1. Due to the small sample size, data are presented using summary statistics.

Results

Parturition

The kits were born in the nest box of enclosure E1 on 14 June 2004 and were first seen nursing on 16 June. On 17 June each was heard vocalising and seen locomoting within the nest box; they were estimated to be approximately 12–15 cm in length, had their eyes closed, and were a greyish colour. For the first two weeks the kits vocalised daily. The female spent most of the time inside the nest box, exiting only to feed, when she generally consumed all food outside.

On 30 June 2004 two kits were separately carried to the second nest box by the female and abandoned. Animal keepers removed the kits after each had been left for approximately one hour and they were subsequently hand-reared (HR). The kits were started on a diet of KMR® (PetAg®) formula (Table 1) and until 37 days old were kept in an incubator at 26²/₃–28¹/₃ °C. The kits were sexed at 14 days as a male and female due to the presence of a prepuce and penis on the ventral abdomen of the male. Based upon this observation, the MR kits were visually sexed as a male and female.

Early development

The female HR kit opened her eyes at 18 days; the male opened one eye at 21 days and the other at 23 days. By 15 July they could walk short distances, and on 21 July they began to run and wrestle. By late July, at six weeks of age, the kits increased their locomotion and social interaction with climbing, running, more active wrestling, and were stalking each other to incite play bouts. At this age the kits also began grooming each other and cleaning themselves. Their teeth began erupting on 25 July (Table 2) and at two months of age they were first given lean ground beef with Vionate® (Rich Health®) vitamin/mineral powder and Herpcare™ (Mardel®) calcium carbonate powder in addition to the KMR. The kits at first only ate the meat when it was placed into their mouth, but after about one week they began to eat it on their own. On 23 September the kits also began to drink water. The diet of formula and meat was continued until the kits were six months old,

Table 1. Formula regimen for hand-reared Fossa kits.

Date	Age	Amount (tbsp)	Frequency
1 Jul	2 weeks	1	Every 4 hours
21 Jul	5 weeks	1¼–1½	5x/day
2 Aug	6½ weeks	1¼–2	5x/day
14 Aug	8 weeks	1½–2*	5x/day
30 Dec	6½ months	n/a**	n/a

tbsp = tablespoon; *started on small amounts ground beef; **taken off KMR

Table 2. Early tooth development in the captive Fossas.

Date	Age	Event
25 Jul	5½ weeks	Upper/lower incisors erupt
7 Aug	7 weeks	Lower premolars can be felt
31 Aug	10 weeks	First upper molar erupts
13 Sep	12 weeks	Second upper molar erupts

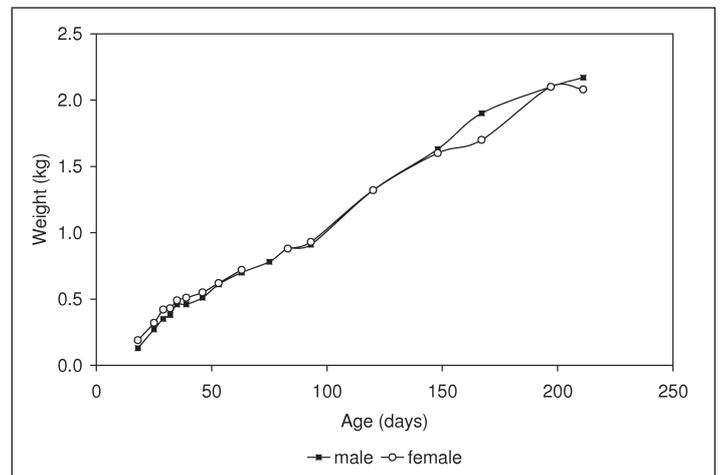


Fig. 3. Weight gain of hand-reared Fossa kits, July–December 2004.

at which time they were gradually weaned off the formula and fed meat twice per day. Weights were taken throughout the kits’ development to track growth; the male and female kit developed at similar rates (Fig. 3).

The MR kits were first seen with their eyes open at 23 days of age. They were heard wrestling and vocalising within the nest box in mid July. At the same time, the female routinely removed the kits from the nest box for brief periods of time, during which they locomoted and played with each other. By the first week of August, at approximately seven weeks of age, they ventured out of the nest box on their own and were able to climb up and down the logs and rocks within the enclosure. The kits displayed bouts of playing behaviour and active investigation of the exhibit out of proximity of the adult female, but paused often to turn their heads briefly towards her. The kits typically remained close to each other. The mother seemed more willing to leave the kits as they became increasingly mobile, including spending time in the other enclosure and focusing her attention on the presence of food or a keeper. She visibly checked on them, however, every 1–2 minutes and continued to carry them back to the nest box before she slept.

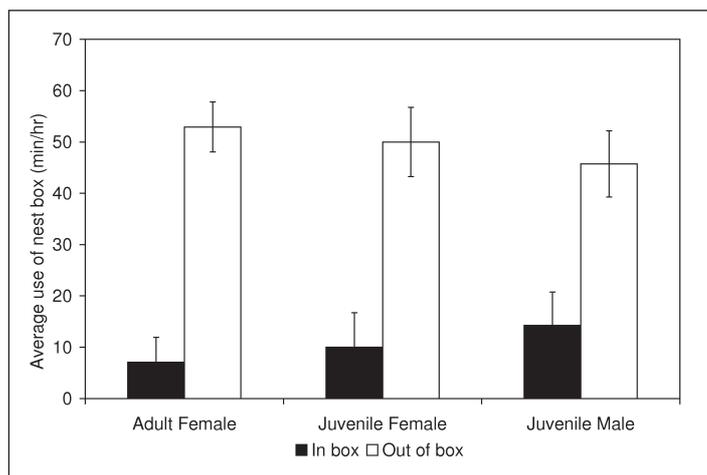


Fig. 4. Average use of the nest boxes by captive Fossas. Location determined by placement of subject's head and anterior limbs; includes nest box use in both enclosures.

Nest box usage

Nest boxes were used throughout the study. Each individual remained out of the boxes more than 75% of the time with no apparent differences between the three (Fig. 4).

Solitary behaviour

More than half the adult female's activity budget (Fig. 5a) was inactive behaviour (60.4%), including sleeping and resting. The majority of her active solitary behaviours consisted of self-grooming (5.9%) and locomotion (8.5%). The kits, however, showed more active behaviours and less inactivity. The juvenile female (Fig. 5b) spent larger amounts of time locomoting (12.6%) and investigating (1.5%) than the adult. The male's (Fig. 5c) investigatory behaviour was similar to that of the adult (0.7%), but his locomotion level was more than twice as high (17.7%). Additionally, only the kits displayed solitary play (male: 0.4%, female: 2.4%). The two females were not visible similar amounts of time (adult: 15.6%, juvenile: 13.6%), typically through being inside the nest box. The male, however, was out of view nearly three times as often as the females (40%). This probably related to his greater level of locomotion, as he often moved behind rocks and logs, so remaining out of view for various amounts of time.

Marking behaviour

Marking behaviour in the adult female was limited to two bouts of head/chin marking seen on two separate days: one lasted for 27.8 s, the other 4.0 s. Both kits were first seen marking on 8 September, at approximately 11 weeks of age. Each displayed two bouts of mount marking, or rubbing the genital region on an upright structure while in a standing posture; the female averaged 4.2 s per bout and the male 11.4 s. The kits were seen marking at later dates as well, though never more than once per observation; all occurrences were mount marks.

Stereotypic behaviour

During July keepers reported two occurrences of pacing in the adult female, and over the course of the study she was only seen pacing during one observation. She displayed 11 short bouts over 15 minutes, giving a rate of approximately 0.73/min; the total time pacing was 123.2 s.

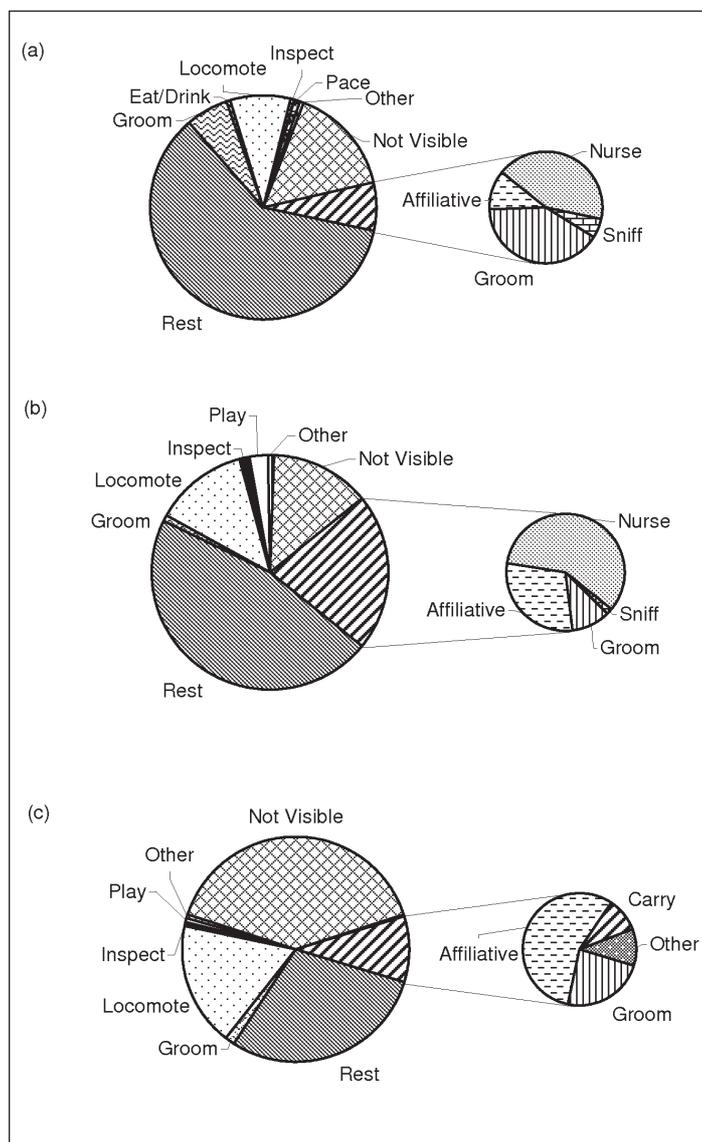


Fig. 5. Activity budgets of the adult female (a), juvenile female (b) and juvenile male (c) captive Fossas. Data are presented as percentages of total time exhibiting each behaviour.

Proximity

Proximate was defined as the subject being within 0.3 m of a conspecific and distant as being greater than 0.3 m from a conspecific. Unknown proximity usually indicated that one or more Fossa was not visible, which occurred most often with the adult female and never in the juvenile female. The adult was distant more often than proximate, though without a significant difference. The kits spent significantly more time proximate than distant (Fig. 6).

Social behaviour

Social behaviour (Fig. 5a) comprised only 6.9% of the adult female's activity budget. Grooming (2.8%) and nursing (3.0%) were the most common, with both sniffing and affiliative behaviour at less than 1%. The majority of these behaviours were initiated by her and directed toward the kits.

The juvenile female (Fig. 5b) showed the greatest amount of social behaviour (21.7%), more than half being nursing (12.7%). The male (Fig. 5c) was never seen nursing and had an overall social behaviour percentage much closer to that of the mother (9.5%).

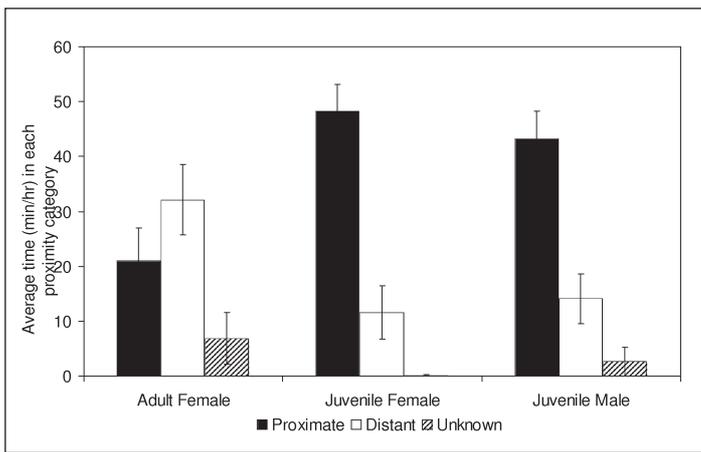


Fig. 6. Average time spent in each proximity category by captive Fossas. Proximate = subject being 0.3 m or less from another individual; Distant = subject being greater than 0.3 m from another individual; Unknown = subject's proximity could not be determined.

Both kits were seen being groomed by the mother and grooming each other, but only the juvenile female was seen grooming the mother, and only for a short period of time (<10 s). The kits also had much greater percentages of affiliative behaviour due to their bouts of social play.

Discussion

Early development

The female gave birth within the nest box, comparable to the secluded locations used in the wild (Hawkins 2003). The kits were smaller than the reported average value of 25 cm (Winkler 1996); this may be the result of our underestimating their size and/or an effect of the large litter size. Litters average 2–4 kits (Parker 1990, Sunquist 1998, Garbutt 1999) and larger litters may result in lowered average sizes of each individual. The kits were born blind, toothless and furred, as expected for this altricial species (Garbutt 1999). Their eyes opened at approximately the same age as that reported by other institutions (Albignac 1975, Köhncke & Leonhardt 1986, Winkler 1996). The coats were much lighter than typical adult coloration, which did not become fully apparent for 5–6 months.

Although adult Fossas rarely vocalise outside the mating season, daily vocalisation is common during the first few weeks of life (Winkler 1996). This is also a time during which the female rarely leaves the nest area, and this female exited solely to feed. After about one month the mother was more willing to leave the nest box and began transferring the kits between boxes. Similar behaviours of removing young from the original nesting area have been shown by captive Fossas and other mammals (Albignac 1975, Carlstead 1996), although the reason is unknown. Having the option to move the kits to a different nest box may have helped to decrease this stress and reiterates the necessity of allowing captive animals some control over their environment, especially when in new situations. It is also possible that the female was motivated by stressors such as ambient noises or keeper presence, as other carnivores will move young in reaction to environmental disturbances (Baker 1994).

Abnormal mothering behaviours such as rejection are not uncommon among captive mammals. Occurrences within the

surrounding environment or even the birthing process itself can induce stress and affect the natural behaviour of the female, and inexperience with infants is associated with abandoning or harming young in multiple species (Carlstead 1996). Albignac (1975: 149) described a Fossa bringing her first litter of week-old kits out of the nest box and leaving them on the enclosure floor, seemingly acting in a 'nervous' way; after creating a partition between the female's exhibit and that of the male she became calmer and kept the kits within the nest box. Kopel (1998) noted that within the first week after birth a female left the nest box twice following a loud noise and proceeded to run and scent mark throughout the enclosure. Female Fossas with litters are clearly sensitive to environmental stressors (Winkler 1996) and their behaviour may also be affected by a lack of prior mothering experience; these factors may have contributed to the female in this study rejecting two of the kits.

Fossa kits are difficult to sex, because females have a penis-like os clitoridis visible when the labia are pulled back (Köhncke & Leonhardt 1986, Winkler 1996). The HR kits proved easy to sex: being a male and female, the anatomical differences could be compared easily (see Hornsey 1999). The male anatomy resembled a puppy's, with the penis enclosed within the prepuce and visible near the rear of the ventral abdomen; no os clitoridis was seen on the female. Hawkins *et al.* (2002) noted a 10-week old captive female lacking an os clitoridis and two female littermates with os clitorides much smaller than average measurements from wild juveniles aged 12–33 months. It is possible that some individuals do not show this feature, or that it is not yet visible in some newborn and young females due to differing rates of development. Female Fossa transient masculinisation is most prominent in individuals from one to two years old and the features diminish with adulthood (Hawkins *et al.* 2002). The difficulty associated with sexing juvenile Fossas may be eliminated if the kits are sexed earlier on.

Nest box usage

The nest box was an integral part of the reproductive husbandry, sheltering the mother and kits as does a nest site in the wild. Healthy development of young needs proper environments for adults (Baker 1994), so natural behaviour of a species should be foremost in designing enclosures for reproduction and parturition. The kits did not leave the nest box on their own until six weeks old. This corresponds to ages reported by Winkler (1996) and Garbutt (1999) for wild Fossas first leaving the den, and accounts of captive breeding have reported ages of 5–8 weeks (Albignac 1975, Winkler 1996, Kopel 1998, Hornsey 1999). Spending more time out of the nest boxes as the kits became increasingly active as they aged was expected, and the female rarely entered the box when the kits were not within. After data collection began at six weeks, the average percentage of time spent inside the box remained at a similar level for each individual, although the adult female's percentage of time inside the box decreased slightly during each month of data collection. This may be because she spent more time sleeping outside the nest box as the kits grew.

Solitary behaviour

Solitary behaviour differed between the kits and the mother. The adult female spent most of her time resting. Wild adult Fossas are generally inactive only 30% of the day, but low activity levels are normal for captive carnivores and previous studies have docu-

mented up to 85% inactivity in captive adult Fossas (McCarthy *et al.* 2003). The kits were much more active, with greater time spent locomoting and both showing some solitary play behaviour. Play and investigatory behaviour by the kits were not observed until the kits were approximately 10 weeks old. These behaviours increased during the third month in both individuals, correlating with their ongoing physical maturity: as they became more adept at walking, climbing and leaping throughout the enclosure, they could more easily explore the space and objects within it. This increased mobility also probably corresponded to the male's large amount of time not visible. He showed a high rate of locomotion and often moved into areas with little visibility, such as into the nest box or behind rocks or logs. Although related to times of high activity, his behaviour when in these areas could not be determined.

An interesting result was that the MR kits were never seen eating solid food, even when it was available. By six weeks of age the incisors of the HR kits had emerged and the molars could be felt through the gums; they began eating meat at two months and were fully weaned by six months. Winkler (1996) and Garbutt (1999) stated that meat is first eaten at 3–4 months of age, with full weaning occurring at 4–6 months. Other captive studies (e.g. Hornsey 1999) corroborated this. At the end of the study the MR kits were over four months old and still only observed nursing; it is likely that if they had not begun eating solid food, this behaviour would soon be evident.

Stereotypic behaviour in the adult female was rarely observed. Adult Fossas are prone to such behaviour, especially when in inadequate enclosures or when exhibit boundaries face exhibits housing other animals (Winkler 1996). The adult female displayed stereotypic behaviour since arrival at CMZ in July 2002, primarily as rapid pacing across the back ledge of the exhibit. From January to June 2004, before the birth of the kits, the female paced for approximately 20% of her overall activity budget (J. Mueller unpublished data). This behaviour ceased at the birth of the kits and was not seen again until the litter was almost one month old. During the duration of the study, the female paced only three times, a radical decrease from her previous rate. It is likely that the increased social interactions necessitated by the kits were a primary factor in this change. Social stimulation is considered the reason that housing compatible adult Fossas in pairs can eliminate stereotypic behaviour (Winkler 1996).

Marking

Marking in the Fossa is likely to have multiple functions, including mate attraction and the creation of territorial boundaries (Garbutt 1999). Both the adult male and female at CMZ marked their enclosures several times daily throughout the year (McCarthy *et al.* 2003, J. Mueller unpublished data), using either a genital rub on a vertical object, an anal rub across a flat substrate, or chin/chest rubbing on an object. During this study, the adult female was seen only chin marking, a common form of marking in viverrids (within which the Fossa was formerly included) and mustelids (Clapperton 1989). Both MR kits were first seen marking at about 12 weeks old. Throughout the remainder of the study they marked multiple times, using only the genital rub. Hornsey (1999) reported genital marking from a captive male kit aged thirteen-and-a-half weeks.

Scent marking when juvenile may reflect continuing behavioural development: young Fossas are unlikely to be motivated by territory or mate attraction, but these are future necessities, so

animals begin to refine marking behaviour at an early age. The similarities between the two kits of different sex are not surprising: other species show similarities in male and female marking behaviour. Adult male and female Ferrets *Mustela 'furo'* use anal drags and body rubbing with the same frequency (Clapperton 1989), and differences in individual Meerkats' *Suricata suricatta* marking behaviour are not sex-related (Moran & Sorensen 1986).

Proximity and social behaviour

The kits were proximate to another individual significantly more often than distant. The adult female averaged more than half her time distant, but this rarely included leaving the kits alone: generally she kept them within viewing distance, and if moving into another area of the enclosure returned every 30–60 seconds to check on them. Fossa kits cannot survive independently for at least six months (Sunquist 1998) and may even remain with their mother and littermates until sexually mature (Winkler 1996). Although adults are solitary in nature the species clearly has social tendencies when juvenile and subadult, so being housed together in captivity for extended periods of time may benefit behavioural development, learning and activity. Winkler (1996) stated that adult Fossas can be housed together if the exhibit is of sufficient size and intraspecific aggression is not displayed.

Social activity varied greatly between subjects, both in total percent of time and the division of specific behaviours. The adult female had the least social activity, of which the majority seen was nursing and grooming of kits. The mother provides vital opportunities to the kits, as her behaviour helps teach the young about sociality and environmental interaction (Carlstead 1996). Nursing, for example, provides not only nutrients but also the chance for the kits to learn that their behaviour (i.e. attempting to nurse) can affect the environment (i.e. cause the mother to allow them to nurse).

The juvenile female had more than twice the social behaviour of the male, largely explained by bouts of nursing lasting up to ten minutes. Her overall time spent being groomed and in social play resembled that of the male. The latter exhibited mostly affiliative behaviour (social play), including non-aggressive wrestling, chasing, pouncing etc., as was also described for Fossa kits by Albignac (1975) and Kopel (1998). As in most mammals, play can dispel energy, refine behaviours needed as adults, and reinforce social bonds (Carlstead 1996).

No aggressive behaviour was seen during the study. Young carnivores may display mild aggression toward littermates when competing for nursing opportunities or solid food, or establishing dominance. Additionally, adult Fossas are solitary and may display intraspecific aggression when housed together in captivity (Winkler 1996). Thus, it was expected that aggression would become more prominent as kits aged and increased their social interactions. The juvenile male and female, however, were never overtly aggressive towards one another. This may be due to the (post-abandonment) small size of the litter, meaning that resources such as food and space would rarely be limited. There was also no aggression seen from the adult female toward the kits, which was expected given that young may stay with their mother until sexually mature.

There are currently fewer than 80 Fossas registered in captivity (ISIS 2007). There were estimated to be fewer than 2500 mature individuals in the wild, hence the species is red-listed as Endangered by IUCN (Dollar 2000). The species has no natu-

ral predators, but the *in situ* population is continuing to decline through habitat loss and overhunting for illegal trade and livestock protection (Köhncke & Leonhardt 1986, Dollar 1999). Relatively little is known about the biology and behaviour of this species, and additional research both in the wild and in captivity could increase the successful propagation of the species. In captivity, encouraging natural behaviours is crucial for the physical and psychological health of the individuals but is difficult without comparative information from the wild (Carlstead 1996). This is the case for the Fossa, as small and fragmented populations along with its secretive behaviour hinder extensive behavioural research. Captivity therefore allows increased knowledge of this species. Long-term management of species relies on providing environments that promote successful reproduction (Kleiman 1994) and for captive Fossas this benefits from objective analyses of maternal care and infant development. Studies such as this can provide a better understanding of the behavioural and physical needs of the mother and infants which can improve husbandry guidelines and provide crucial information for properly housing and hand-rearing Fossas in captivity.

Acknowledgements

The authors thank Vicki Wendt for hand-rearing the Fossa kits and providing developmental data, CMZ Primate & Cat keepers for supplying early developmental data and caring for the Fossas, Poorna Chowdry for assisting with The Observer[®], and Mark Willis for his support and editorial comments.

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