Weaning process among wild angola black and white colobus monkeys (*Colobus angolensis palliatus*) in Diani Beach, Kenya

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Introduction

Maternal behavior is critical for infant survival in mammals and for this reason has been subject to intense selection throughout evolutionary history (Nicolson, 1991). Primates, relative to other mammals of comparable size, produce fewer young at a time and have both longer intervals between births and a longer period of infant dependence. In most species, females perform the greatest share of infant caretaking.

Harlow et al. (1963) described three stages of the mother-infant relationship, a stage of care and comfort, a stage of ambivalence, and a stage of relative separation. Other studies have been focused on describing how the primate mother-infant dyad changes over time by developing quantitative measures for assessing maternal and infant contributions (Hinde and Atkinson, 1970). The timing of this process depends on a host of factors, including both species and environmental characteristics. Two key concepts are described: lactation period and weaning process. The weaning definition varies according to studies: first intake of solid food, complete termination of suckling or female's resumption of sexual activity (Lee, 1987). These stages differ in length among primate species, for example, in many smaller, seasonally breeding species such as vervet monkeys (*Chlorocebus pygerythrus)* infants are nursed on average for almost one year (Whitten, 1982), whereas chimpanzee (*Pan troglodytes*) infants continue nursing for up to four-five years (Clark, 1977). Even if these processes are gradual and variable, the aim is always to reach the social, locomotion and nutritional independence of the infant.

Compared to other species to the Cercopithecidae family, Colobine monkeys are not well documented on this aspect, especially the Peters' Angolan black-and-white colobus (*Colobus angolensis palliatus*), our study subspecies (listed as "Data Deficient" on the International Union for Conservation of Nature; Anderson, 2007). Arboreal and folivorous, they live in territorial troops of 5 to 10 animals. There is no distinct breeding season and all members of the troop can take care of the infants.

The objectives of this study is to give a infant care protocol to Colobus Conservation, organization based in Diani Beach, Kenya, in order to increase the survival rate of infant black and white colobus. To achieve this, behavioral data on mother-infant relationship and infants are recorded on a wild troop. We want to know (1) how long is the lactation period, (2) what is the ratio between milk and solid food eaten by infants, (3) when does start and end the weaning process according to different infants' ages. Few environmental and social

factors such as quality and quantity of food available, rainfall and global group data are also recorded.

I. Presentation of the host organization

A. Diani Beach: localization, climate, fauna and flora

Diani Beach is located on the South East Coast of Kenya, in the Kwale District. Diani is approximately 35 km south of Mombasa and 50 km before the Tanzanian border (Fig. 16). South coastal Kenya is characterized by two rainy seasons with lighter, infrequent rains in October-December, and heavier, more frequent rains occurring March-June (Mwamachi et al. 1995). Temperature is relatively constant year round, reaching 35°C in dry seasons and falling to 28°C in the rainy seasons (Okanga et al. 2006). This area is exceptionally humid (80-100%) year round (Okanga et al. 2006).

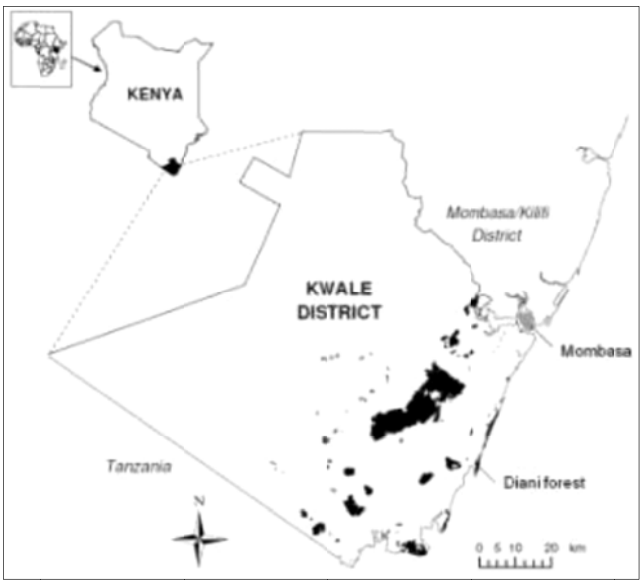

Figure 1: *Map localization Kwale district and Diani Beach according to Kenya*

Kenya's Forest is part of the Zanzibar-Inhambane Floristic Region stretching from Mozambique to Somalia (Dunham, 2013). It is also part of the Coastal Forests of Eastern Africa Global Biodiversity Hotspot, an internationally recognized priority area for conservation activity with numerous endemic flora and fauna (Metcalfe et al., 2009). These forests are extremely rich in biodiversity and very important for both humans and wildlife. They maintain many species of flora and fauna included 1750 plants, 11 birds, more than 50 retiles, 6 amphibians and 11 mammal species. Diani's forest is a particular type of coastal forest called coral rag forest. There are only three remaining patches in the world. The vegetation is sustained by a thin layer of soil which overlays fossilized coral reef.

The Diani area is a location of major infrastructural development with mining and tourist industries presenting major threats to forest and wildlife conservation. Despite its high biodiversity and conservation value, the Diani Forest is not gazetted as a reserve or national park, but divided into numerous private lots. This allows individual property owners to clear areas of forest at their discretion. After decades of anthropogenic disturbance, the Diani Forest now represents a continuum of degradation (Dunham, 2013). Diani is home to a diverse primate community containing six species: Sykes monkeys (*Cercopithecus mitis albogularis*), vervet monkeys (*Chlorocebus pygerythrus*), yellow baboons (*Papio cynocephalus*), Kenya coast galagos (*Galago cocos*), small-eared galagos (*Otolemur garnettii lasiotis*) and black and white colobus monkeys (*Colobus angolensis palliatus*).

B. Colobus conservation

Established in 1997, Colobus conservation is a primate rehabilitation center, focus on habitat conservation and community links as well as human/primate conflict management, welfare, education and research. The organization works in partnership with local communities to promote the conservation of the colobus monkeys, along with other endemic primate species, and the unique coastal forest habitat on which they depend.

Colobus Conservation regularly receives animals that have been orphaned and require hand-rearing in order to survive. Until they are ready to be integrated with other rehabilitation monkeys, these individuals are cared by staff/volunteers. Colobus monkeys in general are exceptionally difficult to hand rear, they have an incredibly delicate digestive system and do not respond well to dietary changes especially because the infant period is not enough understand. According to Colobus Conservation experience, Angola Colobus do not respond well to human baby milk formula or cow milk, diarrhea develops quickly and the infant become weak dehydrated and dies. Autopsies have revealed that these types of milk may cause ulcers to form in the first stomach chamber. Colobus Conservation has successfully hand reared and weaned Angola Black and White Colobus monkeys, using goat's milk with special dilution. In Colobus conservation, once a week for the first 6-8 weeks of age, the infant receives a fecal transplant, made by collection of small sample of feces mixed with milk. Moreover, a number of institutes that hand rear leaf-eating monkeys recommend mixing 'tea' with the milk from a very early age. This aids the infant at weaning making the transfer from milk to solids easier without suffering the side effect of taking tannins. This supplement was not really successful in Colobus Conservation.

I. Material and method

A. Study site and subjects

The study is conducted since the 27th March 2017 on a troop of Angola Black and White Colobus living in Diani Beachalet, a private property nearby to Colobus Conservation (4°20'44.2"S, 39°33'51.8E). This group is observed as long as possible on a 6 hours period per day, morning (6:00 to 12:00) or afternoon (12:00 to 18:00) during 6 days per week. The group contained ten individuals in total; all of them are habituated to the presence of observers, and individually identified by physically characteristics. Data are collected from all individual, two adult males, three adult females, one male juvenile and four infants (three males and one female). The tree family was build according to relationships between mothers and infants.

B. Data collection

Once the troop is located, the instantaneous scan sampling method is used to collect data, during 5 minutes every 20 minutes, on study troop localization and general group members' behaviors to have information on the troop's activity budget (Altmann, 1974). Focal sampling method is used to record data on infants only, during 15 minutes. Behaviors are recorded following an ethogram (Table. 3) with Cybertracker and Prim8 software. A random plan has been established to observe all infants during the entire study period.

Table 2: *Ethograms used during the study period on wild colobus monkeys in Diani, Kenya*

Scan sampling	Focal sampling
Feeding - Tree species - Leafs, seeds, … - Drink - Foraging	**Maternal-infant interaction** - Rejection (turn back, bit, push, hit, move away) - Following - Suckling - Distress vocalization
Resting - Sitting - Lying - Standing	**Proximity indicators** - Ventral-ventral contact - Hanging by - Movement
Moving - Walking - Running - Jumping	**Others** - Eat solid food - Interaction with (play, groom,)
Social interactions - Grooming - Touching - Playing - Mating - Aggression - Voc	

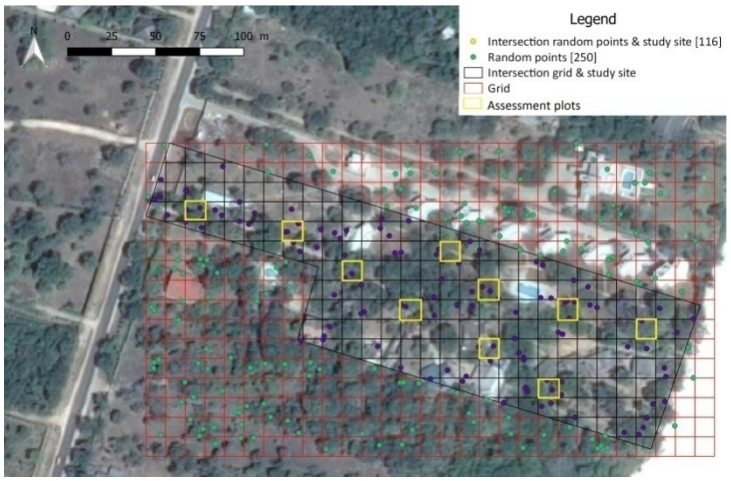

Figure 2: *Map habitat assessment study*

A habitat assessment was made weekly to evaluate the food quantity and quality available during the study period. A map was build with random points after the study site was defined. Random squares (10x10m) were chosen according to point's density (Fig. 16). Only foliar and floral element of trees were assessed because they are directed related to feeding habits of colobus monkeys. In each plot, all tree species, tree height, diameter at breast height (DBH), percentage of young leaves, mature leaves, flower buds, flowers, ripe fruits and unripe fruits were recorded following a scale: 0: 0%, 1: 1-10%, 2: 11-30%, 3: 31-100% according to the canopy cover. The percentage of canopy cover was recorded with a visual estimates guide.