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Comparative reproductive behavior in captive baboon (*Papio anubis*) and red capped mangabey (*Cercocebus torquatus*)

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Abstract

Information on basic reproductive parameters are crucial in understanding of primate ecology, behavior and reproductive strategies. Herein, we report daily observational data on the reproductive traits of female Baboon (*Papio anubis*) and Red-capped mangabey (*Cercocebus torquatus*) at Afolayan Sanctuary, Federal University of Technology, Akure, Nigeria. Our study spans across a period of 120 days covering three consecutive reproductive seasons, documenting reproductive behavior in two females of individual species, giving account of oestrus cycle in relation to their behavior and associated physical changes. Swelling was at its largest within 2-3days of ovulation and maximum swelling were observed in females who had not given birth. One major physical change observed for *P. anubis* and *C. torquatus*, was the discharge of mucus after menstruation and the display of restlessness and aggression during menstruation of *P. anubis*. Information on the precise timing of ovulation was attributed to the swelling size (maximum swelling), changes in swelling coloration and also back counting since the start of deflation. Observations made infers ovulation to be associated with mucus discharge and also period when their swelling reaches its peak. This baseline data is an important addition to further help in the initiation of artificial insemination for captive breeding reproduction.

Keywords: Reproductive parameters, restlessness, aggression, captive breeding

Introduction

The underlying reproductive parameters of non-human primates has allowed researchers to address questions relating to their ecology, social behavior and evolution [1, 2]. Thus, investigating female basic reproductive parameters and visual signs (behavioral pattern) during this period is important for artificial insemination and cross species analyses [3, 4]. In a number of Old World primates, females exhibit a conspicuous and prominent sexual swellings which are hormone-dependent signals that play a key role in understanding the patterns of behavior. The large size and bright coloration associated with sexual swelling of non-human primate species during reproductive cycles, have been an interesting focus of scientific interest and have fascinated primatologists for over a century [5]. Studies therefore commonly use changes in swelling to infer the timing of ovulation, and subsequently to predict both female and male behavior [6]. These reproductive characteristics have been observed in all non-human primate species belonging to genera *Cercocebus*, *Mandrillus*, *Theropithecus*, *Papio* and *Pan* [7]. The Olive baboon (*P. anubis*) and (*C. torquatus*) are non-human primates species with pronounced sexual dimorphism, with adult male being larger than females. Adult female develops large peri-ovulatory genital swellings [8]. Even though the Olive baboon is one of the most thoroughly studied of African primates [9], few studies exist on the ecology of West African Olive baboons [8] and Red-capped mangabey. This could be attributed to the difficulties associated with close intensive studies and collection of data from naturally reproducing wild populations.

The question of whether swelling size variation between cycles of the same female gives information on the quality of cycle i.e. the probability of conception [5] has been an intriguing area of research. However, growing evidences have shown that sexual swelling size variation between cycles is relative to female's probability of conception. Accordingly, when female baboon cycle and conception probability increases, there is also an increase in the sexual swelling size [10, 11, 12]. To examine the extent and how accurate sexual swellings signal

ovulation, we identify the timing of ovulation using the “discharge of mucus”. The different reproductive parameters and life-history traits in *P. anubis* and *C. torquatus* was studied under captive conditions [10, 13], using visual ratings to examine variation in swelling size and identifies the timing of ovulation using physical observational data i.e. a day after the discharge of mucus.

Materials and Methods

Study Area

The T.A Afolayan Wildlife enclosure sanctuary (Figure 1) covers a total area of 89,100 sq meters (8.91 hectares). It is a lowland rainforest with an average rainfall of 1650mm to 1700mm yearly, located on elevation 1200 above sea level [14]. It lies between latitude 50° 4' and 70° 5' N and longitude 40° 2' and 60° 05' E.

Reproductive observation parameters

Four matured females (one of which had given birth) living in single cages exhibited sexual swelling; thus, they were classified as adolescents. Diurnal and nocturnal observation of two adult female olive baboons and two Redcapped mangabey were carried out from 6am - 8pm daily for a period of 120 days from 21st March to 20th July 2017. Higham [10, 17] protocol was followed for data collection, data on the female reproductive state (oestrus cycle, menstruation), behavioural (Aggressiveness) and physical changes (sexual swellings) were recorded. Definition of protocols for data collection are as follows;

Oestrus cycle: the recurring periods of oestrus in adult females of most mammalian species and the correlated physiological uterine, ovarian, and other changes that occur in the reproductive tract from one period to another.

Aggressiveness: Setting an unjustly attack, an act of hostility and offence.

Sexual swellings: when the skin around the vulvar and/or anal region swells and shrinks in response to fluctuations in ovarian hormone levels, peaking in size around the time of ovulation [16].

Menstruation: Period in which the ovum matures, is ovulated, and enters the uterine lumen via the uterine tubes.

This observational data was based primarily on the time, signs and length of oestrus cycle, 1st day of conspicuous sexual swelling (maximum). The size of swelling was visually categorized on a daily basis using the following categories definition;

No swelling: refers to the outer genital structures minimum size i.e when the vulva is appears as a pink mass of less than 2 cm (approximately 1/4 of one Ischia callous) in length and becomes almost invisible (compares to stages 0 and 1 of Dahl and Nadler's [17] scale).

Partial swelling: No swelling and maximum swelling, intermediate stage. The protrusions and vulva lobes becomes smooth and visible.

Maximum swelling: Maximally protrusion of all genital structures implies both maximum size and tumescence. The Vulva dimensions is approximately 3–4 cm (approximately 3/4 of one Ischia callous) in length (compares to stages 4 to 7 of Dahl and Nadler's scale).

Results and Discussion

Papio anubis

The *P. anubis* exhibited maximum swelling of the sex skin (Figure 2) with fluctuations in the color. Color of the sex skin changes frequently from light to dark and back again. This darker shades (medium and dark pink) was associated with low or no swelling while the lighter shades (pale and light pink) with medium/maximum swelling and the average length of days for swelling is 28.3 ± 0.9 (Table 1). *P. anubis* experienced menstruation throughout the three cycles (Figure 2) with an average length of days for menstruation of 4.7 ± 0.5 days (Table 1), after the menstruation there were mucus discharge from its sex skin (Figure 3). The mucus discharge was observed to appear around the 16th to 17th day after the last day of menstruation, this discharge lasted for an average of two days in all the four individuals that was understudied. Restlessness and aggressive behavior was also recorded during the first day of menstruation. The frequency of occurrence for each behavior during each phase of the cycle lasted for the two days of the bleeding periods, animal was observed to roll on the floor of its pen and also aggressive towards the zoo keepers in the early hours of the day between 8am -11:30am.

Cercocebus torquatus

During this study it was observed that *C. torquatus* experienced swelling of the sex skin (Figure 4). Two phases of swelling was recorded during this period; medium and maximum swelling while the fluctuations in the colour of the sex skin colour changes from light to dark and back again. The darker shades (medium and dark pink) were associated with medium swellings; while the lighter shades (pale and light pink) occur with maximum swelling. The swelling was recorded to last all throughout the oestrus cycle. It was also observed that *C. torquatus* experienced menstruation at intervals (Figure 4). Bleeding periods were recorded each for the oestrus cycle with an average length of 5.0 ± 0.8 days (Table 1).

The comparative parameters for *C. torquatus* and *P. anubis* exhibited maximum swelling of their sex skin during their oestrus cycle, confirming the theory of advertising fertility in numerous prosimians [7, 18]. It also explains the function of large sexual swellings, in which most of the hypotheses proposed in the past also treats swelling of the sex skin as honest signals indicating female quality [10-12] or timing of ovulation in order to attract males [19]. Within a menstrual cycle variation in sexual swelling size indicates when ovulation occurs and thus predicts that ovulation will coincide with maximum swelling i.e. when the swelling is largest. Accordingly, previous studies that examined the relationship between swelling size and ovulation observed that, although not always for every cycle, during peak swelling ovulation tends to occur, normally just prior to detumescence and thus treats the swelling as a probabilistic signal of females' readiness to conceive and there is empirical support for this interpretation from a number of studies [6, 10, 20, 21, 22, 23].

Previous studies on baboons provide more support for the prediction that males prefer larger swellings. Captive experiments shows that male baboons masturbate more in response to females with larger swellings than they do to females with normal swellings [24]. Secondly, Domb and Pagel [25] found that male baboons use female swelling size to determine mating effort, competing more to mate with females possessing longer swellings. The swelling was at its

largest within 2-3days of ovulation and this largest swellings were observed in the females who had not given birth, which confirms the hypothesis that the least fertile females often have larger swellings (adolescent females [26]; females that cycle repeatedly [27]). Similarly, Higham *et al.* and Zinner *et al.* [6, 10] also confirmed the largest swelling of females in Gashaka Gumti National Park to be the ones who had not given birth or who had cycled several times without conceiving.

Additionally, the swellings observed during this study were not constant, but rather fluctuate in size and coloration. The color of the sex skin was seen to change from lighter shades (pale and light pink) with medium and maximum swelling to darker shades (medium and dark pink) associated with low or no swelling and back again. This observation supports the claim of [7] on swelling of the sex skin.

One major physical change observed during the oestrus cycle of *P. anubis* in this study, was the discharge of mucus. This was observed after menstruation and mucus discharge lasted

for two days. Several studies has used the mucus discharge to determine the likely period of ovulation and has also associated mucus discharge as characteristic peak around the time of ovulation, when cervical mucus blocks passage by microbes and abnormal sperm, while guiding normal, motile sperm through the cervix [28, 29]. Additionally, no previous information seems to exist on the display of restlessness and aggression that was displayed by *P. anubis* on the first and second days of menstruation. However, we observed *P. anubis* display menstrual associated symptoms (aggression and restlessness) which is relative to female human primates. However, neither discharge of mucus nor display of restlessness and aggression was observed in *C. torquatus*. Information on the precise timing of ovulation was attributed to the swelling size (maximum swelling), changes in swelling coloration and also back counting since the start of deflation. Observations made infers that ovulation is likely to occur for *P. anubis* and *C. torquatus* during the period their swelling reaches its peak i.e. maximum swelling.

Table 1: Three Consecutive Oestrus cycle observed in days

Species name	Length of Oestrus cycle				Length of menstruation				Length of Swelling				Swelling Type
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean	
<i>Papio anubis</i>	26	46	30	34.0 ± 8.6	4	5	5	4.7 ± 0.5	29	27	29	28.3 ± 0.9	E
<i>Cercocebus torquatus</i>	36	28	27	30.3 ± 4.0	5	6	4	5.0 ± 0.8	26	46	30	30.0 ± 0.5	E

Exaggerated swelling (E)

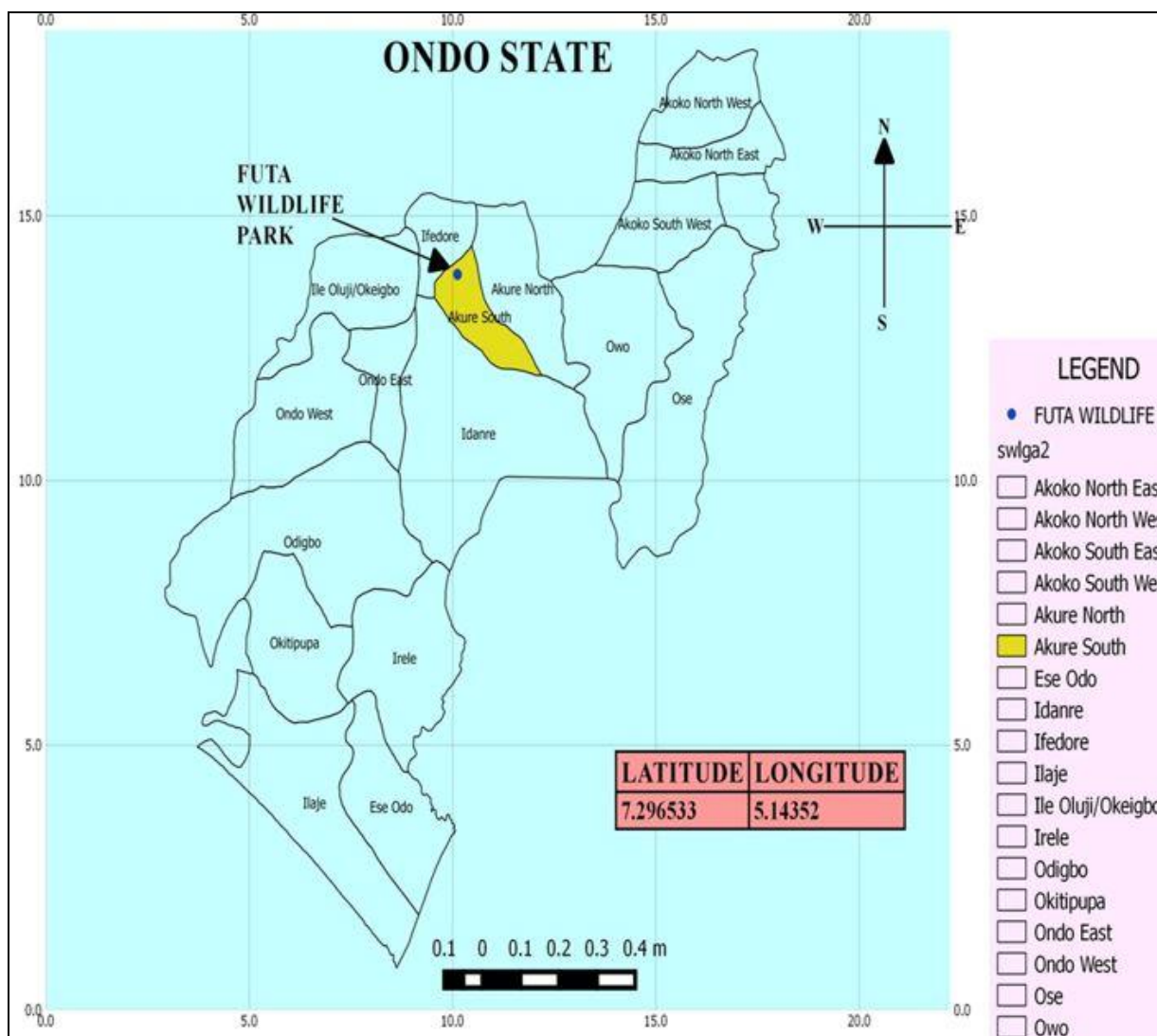


Fig 1: T. A. Afolayan Wildlife Sanctuary Federal University of Technology, Akure, Ondo state, Nigeria.



Swollen sex skin

Menstruation

Fig 2: shows the swollen sex skin and menstruation discharge of *P. Anubis*

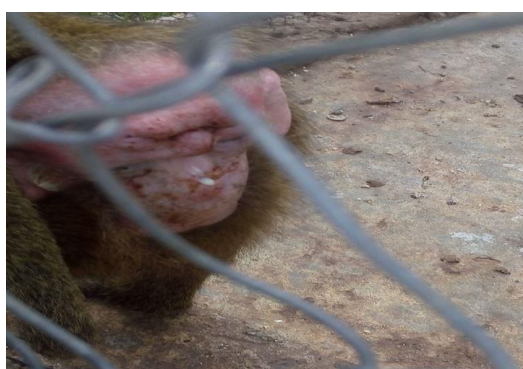


Fig 3: Discharge of mucus from the sex skin of *P. anubis*



Swollen sex skin

Menstruation

Fig 4: Shows the swollen sex skin and menstruation discharge of *C. torquatus*

Conclusion

In conclusion, the reproductive and life-history parameters for captive *P. anubis* and *C. torquatus* are comparable to those known for other *Papio* and *Cercocebus*. The study gives account of primate oestrus cycle in relation to their behavior and physical changes, thus knowledge of the female reproductive cycles will be essential in initiating mating among captive species and help maximize the captive reproductive success of this primate. In order words, since the population of some of this wild species are declining as a

result of human activities, artificial insemination can also be carried out using the information from this study and thus lead to the reproduction of more species in captivity.

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