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REPRODUCTION AND INFANT PELAGE COLOURATION OF THE BANDED LEAF MONKEY (MAMMALIA: PRIMATES: CERCOPITHECIDAE) IN SINGAPORE

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***ABSTRACT.* –** The banded leaf monkey (*Presbytis femoralis femoralis*) is the largest extant non-human primate in Singapore and its population is known to be critically endangered and restricted to the Central Catchment Nature Reserve. Prior to this study it was uncertain whether the species is reproducing in Singapore and there were conflicting reports about infant colouration, casting doubts on whether the subspecies in Singapore is different from that in Johor, Malaysia. Here we present the first report on reproduction, infant pelage colouration and development of the banded leaf monkeys in Singapore based on 22 months of observational data. We report at least six births from 2008 to 2010, and present evidence that there is at least one birth season in June/July for three consecutive years. Moreover several infants have survived beyond seven months, implying low infant mortality. The infants are born white, with a black line from head, along the spine, to tail that is intersected by a black line passing along the shoulders to the outer surfaces of both forearms thus forming a distinctive cruciform (cross-like) black pattern on the dorsum. This natal pelage pattern is consistent with that of the banded leaf monkey infants in Johor, suggesting no differentiation between the two populations based on infant colouration. These data are preliminary and more long-term research is needed to understand the reproductive behaviour of this native and elusive primate in Singapore.

***KEY WORDS.* –** Banded leaf monkey, infant colour, reproduction, Singapore, Johor.

INTRODUCTION

The banded leaf monkey (*Presbytis femoralis*) is known from the Malay Peninsula (including Singapore and peninsular Thailand) and eastern Sumatra (Groves, 2001; Meijaard & Groves, 2004) (Fig. 1). Several subspecies are recognized; most notably *P. f. robinsoni* in north Malay Peninsula, *P. f. percura* in east-central Sumatra and *P. f. femoralis* in Singapore and Johor, Malaysia. Although *P. f. femoralis* is globally listed as vulnerable (Nijman et al., 2008), it is critically endangered in Singapore due to a small population size (Lim et al., 2008) which was estimated to be only 10 to 15 individuals in the 1990s (Yang et al., 1990). Unfortunately, it is extremely difficult to obtain data on its reproduction because the species is elusive and shy. Hence, there are no published records of infants in the Singapore population and it remained uncertain whether the population is still reproducing. In order to assess the population status of the banded leaf monkeys in Singapore, it is important to determine if there are new infants and when the species reproduces. Here we report several births in the Singapore population and describe the natal pelage and infant development based on 22 months of field data. We also discuss the implications of our findings for conservation and potential adaptive significance of the pelage colouration.

The taxonomy of this species is still subject of much dispute. Groves (2001) and Brandon-Jones et al. (2004) recognize *P. f. femoralis* (Martin, 1838) from Johor and Singapore. On the other hand, Chasen (1940) suggested that the Singapore population is a unique subspecies from the Johor population based on differences in adult pelage

colouration, and Hüttche (1994) described the specimens from Singapore as darker in ventral colour than the specimens from Johor. In addition, while the infants of *P. f. percura* in east-central Sumatra are white (Aimi & Bakar, 1996), there were unconfirmed sightings of orange infants in Singapore obtained during occasional nature surveys over the last 20 years, thus potentially supporting the claim that the banded leaf monkeys in Singapore belong to a separate taxonomic unit than the Johor population. Note that flamboyant natal pelage colour is common within the Colobinae (Newton & Dunbar, 1994). Across primates the natal pelage can either resemble the adult pelage, be flamboyant (striking, highly visible), or dark (different from adult pelage but dark and not highly visible). Hrdy (1976) argues that flamboyant pelage may have evolved to facilitate infant-handling by attracting other females, conferring a benefit to infants.

MATERIALS AND METHODS

Field surveys were carried out from Sep.2008 to Jun.2010 in the Central Catchment Nature Reserve (CCNR). The precise locations of study sites were retained in order to minimize disturbance to the banded leaf monkeys from the public. Teams of two observers walked on existing trails from 0630 hours to 1130 hours and from 1600 hours to 1900 hours whenever the weather permitted. Once the banded leaf monkeys were found, they were followed for as long as possible. We recorded all instances of observing infants, birth seasons, number of infants, and their physical characteristics throughout development. Observations were made using binoculars (Nikon Monarch 10x42 DCF) and video camera (Sony Handycam HDD HDR-SR12E), and data was recorded using *ad libitum* sampling (Altmann, 1974). Video recordings of the infants were analyzed using IMovie '09 (ver. 8.0.2 Apple Inc.).

RESULTS

The total time in the field was 50,570 minutes (843 hours). A total of at least six births were recorded from 2008 to 2010. Two infants were first observed in a group of 14 banded leaf monkeys (Group A) on 1 Aug.2009. This group comprised of at least six adults of which at least two were females. A sex ratio is not provided because the sex of banded leaf monkeys is difficult to determine in the field. Both infants were white with a broad black line from head, along the spine, to tail, and intersected by a black line passing along the shoulders to the outer surfaces of both forearms, forming a distinctive cruciform (cross-like) black pattern on the dorsum. A faint black line ran from the dark spinal stripe along the hind legs to the feet. From the frontal view, the crown and facial fur were completely white. The forehead was slightly dark as compared to the pale colour of the face. These two infants were identified as newborns based on the same characters described for newly-born young of *P. femoralis* from the Malay Peninsula (Pocock, 1928). This neonatal pelage colouration of the banded leaf monkeys is distinct from the adult pelage, which is a uniform black on the dorsum with white bands traversing the underside of the hind limbs. Although there is no published description of the infant of the banded leaf monkeys in Johor, one white infant with natal pelage pattern

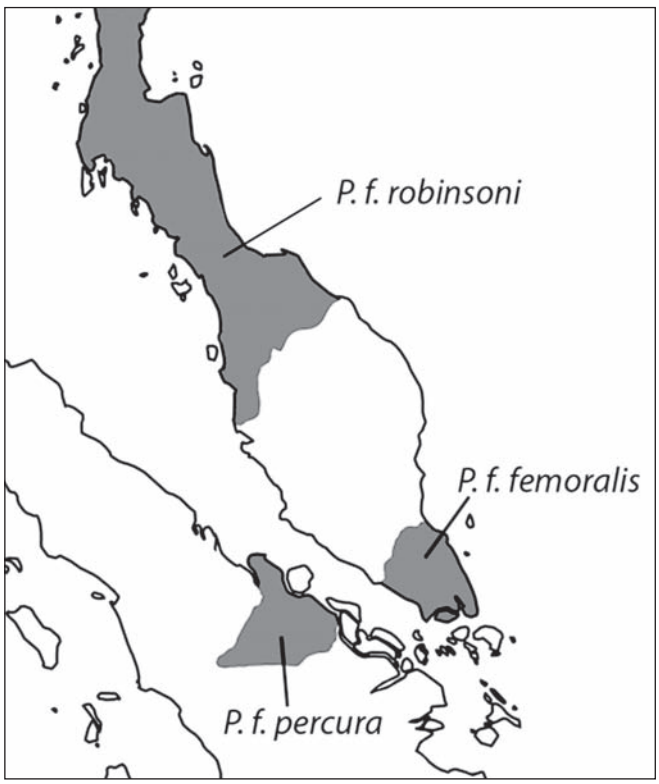

Fig. 1. Distribution of *Presbytis femoralis*. *Presbytis f. robinsoni* is found in north Malay Peninsula, *P. f. percura* in east-central Sumatra, and *P. f. femoralis* in Johor and Singapore.

Fig. 2. Natal pelage pattern of an infant banded leaf monkey from Panti Forest Reserve (Johor). Photo: D. L. Yong.

identical to that of the infants of the Singapore population was recently observed in Panti Forest Reserve, Johor (Fig. 2; Yong, pers. comm.).

We sighted white infants from Group A again on 23 Aug.2009, 24 Aug.2009 and 29 Aug.2009. There were slight changes in the pelage colouration. The infants had more greyish black fur spreading from the black lines (Fig. 3). One infant was able to move unassisted by an adult for a few seconds before the carrying adult, who was close, pulled it back (Figs. 4A, 4B). It appeared that the infants were carried less frequently by the adults even though they might not yet be fully weaned.

On 13 Oct.2009, we saw one white infant in another group of 11 monkeys (Group B). This group comprised of at least five adults of which at least two were females. The natal pelage pattern of this infant did not deviate much from what is shown in Fig. 2. It was able to move and jump beside the carrying adult. On 22 Oct.2009, the white infant in Group B was actively locomoting while the rest of the group was feeding. Loud crashes were heard when some banded leaf monkeys in the group were travelling from tree to tree. This loud noise triggered the infant to leap towards the carrying adult. On 26 Oct.2009, the same white infant was seen playing with members of its group. In the afternoon when the group was not moving, either resting or sleeping, the infant was still very active.

On 10 Nov.2009 and 12 Nov.2009, we saw the same white infant, but also one older, almost completely black infant in Group B. We considered this black infant older because its pelage colour was almost identical to that of an adult, even though some white fur was still visible along its hind legs. This black infant was feeding on its own (Fig. 5), but it was still being carried during travel. On 20 Jan.2010 and 21 Jan.2010, we again observed two black infants travelling independently of their carrying adults in Group B. They were believed to be approximately seven months old.

In Nov.2008, we also observed one black infant with some white fur being carried by an adult in another group of five monkeys (Group C). This group comprised of at least two adults of which one was female. Based on pelage colouration, this infant was likely to have been born in Jul.2008. This black infant had successfully developed into a two-year old juvenile when it was sighted again on 14 Jun.2010, when there was also a new birth of a white infant in the same group.

DISCUSSION

The banded leaf monkeys are critically endangered in Singapore due to their small population size and prior to this study it was unclear whether this species is still reproducing. Based on 22 months of field data, we can confirm that the

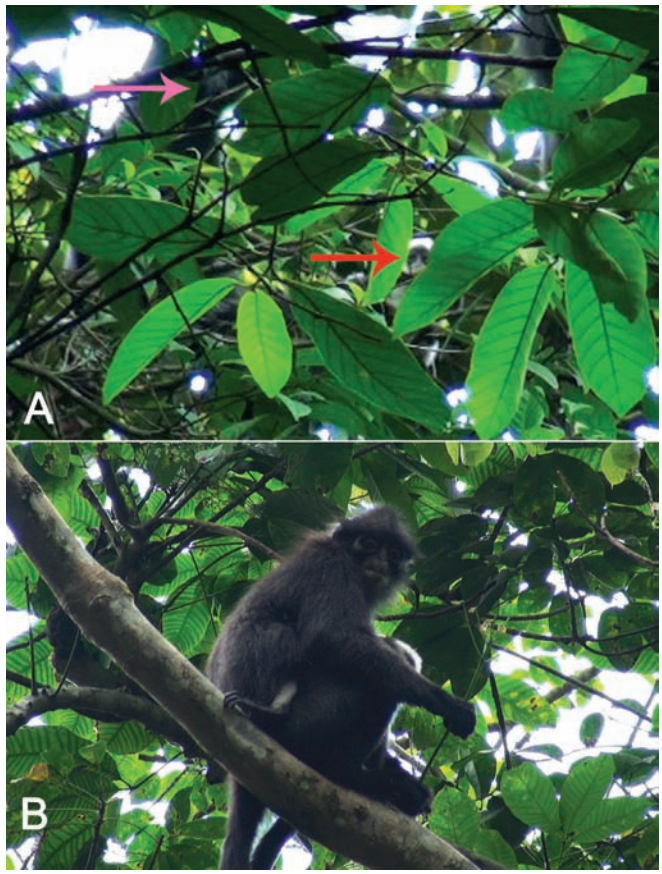

Fig. 4. A, Infant banded leaf monkey from Singapore (red arrow) separated from carrying adult (pink arrow); B, Banded leaf monkey infant being carried by an adult.

Fig. 3. Infant banded leaf monkey (red arrow) from Singapore.

Fig. 5. Black infant banded leaf monkey feeding on vegetation.

banded leaf monkeys in Singapore are regularly reproducing, with at least six births from 2008 to 2010. Moreover infants have survived beyond seven months, indicating low infant mortality. Two births were recorded for a group of 14 monkeys (including infants) and two births in a group of 11 monkeys in 2009. In 2008 and 2010, one birth in a group of five monkeys was observed each year. According to the age categories and distinguishing criteria described by Bennett (1983) for *P. melalophos* [*P. femoralis* was previously recognized as a subspecies of *P. melalophos* (Chasen, 1940; Oates et al., 1994), it takes approximately six months from birth for the pattern on the head to change to adult colour. Therefore, we estimate that the infants from Group A were born around Jul.2009. Even though we did not observe the infants' birth for Group B, we estimate based on size and pelage colouration that they were also born in Jul.2009. Similar inferences lead to the conclusion that one infant in Group C was also born in Jul.2008 and we observed a new infant in Jun.2010. Thus we can conclude that the banded leaf monkeys had at least one birth period in 2008, one birth period in 2009, and one birth period in 2010, all during the months of June/July for three consecutive years. For 2009 we can confirm that this was the only birth period, but since our field work was only carried out from Sep.2008 to Jun.2010, it remains unclear whether there were additional birth periods in 2008, and whether there will be a second birth period in the second half of 2010.

Singapore's weather is classified into four periods according to average prevailing wind directions (National Environmental Agency, 2009): *Northeast Monsoon Season* from December to early March, *Inter-monsoon Period* from late March to May, *Southwest Monsoon Season* from June to September, and *Inter-monsoon Period* from October to November. It appears that the birth season for the banded leaf monkeys in Singapore coincides with the Southwest Monsoon Season in June/July, which is a relatively dry month. *Presbytis melalophos* in Kuala Lompat, Malaysia gives birth not only in June, but also in the drier months of January and February (Bennett, 1983). Continuous monitoring from Jul.2010 to Dec.2010 is thus necessary to investigate if the banded leaf monkeys in Singapore also reproduce during the second half of the year.

The infants of the banded leaf monkeys in Singapore are white with distinctive cruciform black pattern on the dorsum, and no orange pelage colour was observed throughout each infant's development. This finding is consistent with the natal pelage pattern observed for *P. f. percura* in east-central Sumatra and Johor. Thus, we can confirm that the infant colouration does not support a differentiation between the banded leaf monkeys in Singapore and in Johor.

The young of many primate species have distinctively coloured, marked, or patterned natal pelage which is different from the adult pelage. Such age-specific physical traits could be used to distinguish dependent young from older, relatively independent individuals, which may elicit care-giving and protection from older group members (Alley, 1980), hence increasing the survival chances of the young. The neonatal pelage colouration of the banded leaf monkeys is conspicuous and distinct from the adult pelage. As with other leaf monkeys (Newton & Dunbar, 1994), infant transfer and allocare were observed in the monkeys in Singapore. It is expected that the benefits of such social behaviour provided by the reactions of conspecifics to the natal coat would outweigh any increased risk of attracting predators (Alley, 1980).

The seemingly conspicuous infant colouration of the banded leaf monkey infants probably does not interfere with camouflage, because the infants are carried ventrally between the hind legs of the adult. As such, the white fur on the sides of the body, the arms and legs of infants are concealed by the black forearms of the adult, and the white crown of infants blends in well with the white chest pelage of the adult. Only the central black portion of the dorsum and the head of the infant, which is the same as adult pelage, are visible. This may explain the sighting of the black infant in Group B only in November.

Overall, we provide evidence that the banded leaf monkey population in Singapore is reproducing. However, the population viability remains in doubt given the social constraints on reproduction and group formation (with most surviving individuals suspected to be genetically related since the population estimates are low, and mate choice very restricted), fertility, and genetic constraints. These data on infant colouration and development of the banded leaf monkeys in Singapore also highlight the importance of long-term study and comparative work in order to understand the reproductive behaviour of these endangered primates. In addition to pelage colouration and descriptive behavioural data, future genetic analysis is important for resolving the taxonomy of *Presbytis femoralis* and in order to develop a management plan for the species.

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