

The development of pelage coloration in Cat Ba langurs (*Trachypithecus poliocephalus*)

Tilo Nadler

Cuc Phuong Commune, Nho Quan District, Ninh Binh Province, Vietnam. <t.nadler@hust.edu.vn>

Key words: Cat Ba langur, *Trachypithecus poliocephalus*, development pelage coloration

Summary

Cat Ba langurs are endemic to Vietnam and occur only on Cat Ba Island in Halong Bay in northern Vietnam. With currently only about 60 individuals they represent the world's rarest colobine species.

Description and photographic documentation of the development of the pelage coloration from the natal coat to the coat of infants, juveniles and adults can be a helpful tool to assess the age of individuals in field studies and helps to estimate the age of individuals, confiscated from the illegal trade. The documentation of the development of pelage coloration recorded on a number of captive individuals at the Endangered Primate Rescue Center, and also the pelage coloration development recorded of representatives of the wild population on Cat Ba Island show significant differences in the speed of pelage coloration development. This makes an exact determination of the age impossible. The differences between fast and slow development of the pelage coloration become clearer with the age of the individuals.

Cat Ba langurs are born with uniformly light orange fur, which over a period of about one to one and a half years changes to a coloration similar to those of adult individuals. Subadults differ from adults in a somewhat smaller body size and by some individuals only in slightly extended yellow hairs on the shoulders.

Sự phát triển màu sắc lông ở loài Voọc Cát Bà (*Trachypithecus poliocephalus*)

Tóm tắt

Voọc Cát Bà là loài đặc hữu của Việt Nam, loài chỉ phân bố ở đảo Cát Bà trong Vịnh Hạ Long, miền Bắc Việt Nam. Hiện nay chỉ có khoảng 60 cá thể còn tồn tại nên được xem là loài khiếm hiếm nhất trên thế giới. Việc mô tả và tài liệu hóa bằng hình ảnh sự thay đổi hình thái màu sắc bộ lông của loài trong các giai đoạn phát triển là hết sức cần thiết. Đây có thể là một công cụ hữu ích để đánh giá độ tuổi các cá thể trong nghiên cứu thực địa và giúp ước lượng độ tuổi các cá thể được tịch thu từ hoạt động buôn bán động vật hoang dã. Việc nghiên cứu và tổng hợp sự thay đổi màu sắc lông qua các giai đoạn phát triển của loài đã được thực hiện trên các cá thể được nuôi tại Trung tâm Cứu hộ Linh trưởng Nguy cấp. Khi so sánh sự thay đổi màu sắc bộ lông trên các cá thể ngoài tự nhiên tại đảo Cát Bà, chúng tôi đã phát hiện ra sự khác biệt đáng kể ở tốc độ thay đổi màu sắc lông giữa hai nhóm. Điều này đã khiến cho việc xác định độ tuổi của các cá thể một cách chính xác là không thể, nếu chỉ thông qua màu sắc lông. Khác biệt giữa tốc độ thay đổi nhanh hay chậm màu sắc lông chỉ có thể nói rõ khi độ tuổi của cá thể được xác định. Voọc Cát Bà được sinh ra với màu sắc lông vàng cam nhạt, sau khoảng một năm đến một năm rưỡi thì đổi sang màu sắc lông của cá thể trưởng thành. Nhưng cá thể bán trưởng thành chỉ khác cá thể trưởng thành ở kích thước cơ thể chứ không phải màu sắc lông.

Introduction

The Cat Ba langur is amongst the world's rarest and most endangered primates. The species is listed as 'Critically Endangered' (IUCN) and also as one of the 'The World's 25 Most Endangered Primates' (Schwitzer et al. 2019)

Cat Ba langurs occur only on Cat Ba Island in Ha Long Bay in northern Vietnam, an island with a total surface of 285 km². In the past the distribution area was roughly identical with the land area of the Cat Ba National Park comprising 98 km² (Tordoff et al. 2004), but it decreased with the dramatic decline of the langur population during the last decades. Since the first comprehensive surveys in 1999 and 2000 (Nadler & Ha Thang Long 2000; Nadler & Brockman 2014), which estimated the population between 104 and 135 individuals, the population has shrunk dramatically. And while in 2015 the population consisted of an estimated 70 individuals (Leonard & Raffel 2015) it counts currently only about 60 individuals (Cat Ba National Park, pers.comm.).

Over the years ten individuals have been kept at the Endangered Primate Rescue Center (EPRC), Cuc Phuong National Park, Vietnam, including five individuals which were born here and grew up here, and another one born at 2020. These six individuals are the only ones born in captivity. The founders of the small captive population at the EPRC are two animals confiscated from poachers on Cat Ba Island.

Hendershott et al. (2019) gives the first description on pelage coloration development in Cat Ba langurs based on field observations. Our studies are conducted in captivity and on several individuals and give a more detailed insight and show also individual differences.

Such detailed descriptions of pelage development are helpful to identify the age of individuals in the field, assess the age of confiscated individuals and provides an interesting source for taxonomic comparisons.

Material and Methods

The development of pelage and skin coloration of six Cat Ba langurs born at the EPRC (Table 1) was recorded. Photos and notes were taken every one to two weeks from birth until the age of three months and later on every two to three weeks. Additional information on the pelage coloration and its development of four new born individuals was collected during surveys on Cat Ba Island in 1999 and 2000.

Table 1. Cat Ba langurs born at the Endangered Primate Rescue Center, Vietnam.

EPRC Studbook No.	sex	born
15-04	male	2.6.2003
15-06	male	1.3.2010
15-07	female	25.6.2012
15-08	male	2.8.2014
15-09	male	8.2.2018
15-10	female	10.7.2020

Results

New born animals

Cat Ba langurs are born with uniformly light yellow-orange pelage (Fig.1), sometimes already with a brownish tinge on the back. The fur on the distal half of the tail might in newborns already be intermingled with brown hairs and has a dark brown tip (Fig 2). On the crest of the head there might be a few brown hairs, also in individuals with an otherwise uniformly yellow-orange pelage. The skin of the face, ears, fingers, toes and ischial callosities is light and not pigmented. The eyebrows are sparsely but some hairs are very long (up to 3 cm; Fig. 1). The growth direction of the hair at the back of the head points upward and even in the newborn forms a very small crest on the top of the head. There are no sexual differences in pelage coloration of new born individuals.



Fig.1. Cat Ba langur 21 days old (EPRC, male 15-06) with the typical bright orange natal coat. All Photos: Tilo Nadler.



Fig.2. New born Cat Ba langur – first day (EPRC, male 15-04). New born individuals can show already a brownish tinge on the back and a darker coloration of the tail with a dark brown tip.

First month (1 – 30 days)

During the first month there is no change of the pelage coloration and the hairless skin of face, fingers and toes is unpigmented (Fig. 3).



Fig.3. Cat Ba langur 21 days old (EPRC, male 15-06). During the first month are no remarkable color changes of the pelage and the naked parts. Face, ears fingers and toe are flesh-colored.

Second month (31 – 60 days)

At the beginning of the second month the hairless skin areas of face, ears, fingers and toes start to darken and get a grayish tinge (Fig. 4). The hair on the distal half of the tail starts to grow and begins to form a thin tassel (Fig. 5).



Fig.4. Cat Ba langur 42 days old (EPRC, female 15-07). The naked parts, face, ears and fingers start to darken and get a grayish tinge.



Fig.5. Cat Ba langur 42 days old (EPRC, female 15-07). The hairs on the distal half of the tail are growing and form a thin tassel.

Third month (61 – 90 days)

With two and a half month face and ears get darker gray, the fingers and the back of the hands and feet get dark brown and turn black towards the end of the month. The black hair on the back of the hand is then mixed with silvery grey hairs. Grey hairs extend to the wrists and to the ankles (Fig. 6). A thin line of dark greyish hair reaches from the hands on the outer forearm to the elbow. The back starts to darken from the shoulder girdle to the root of the tail and the yellow-orange natal coat changes to very light brown. A small part at the base of the tail darkens and by end of the third month forms a dark brown band around the base of the tail. The color of the ischial callosities changes to grey (Fig. 7).



Fig.6. Cat Ba langur 76 days old (EPRC, female 15-07). Face and ears become darker greyish; the fingers to the dorsum of the hand are dark brown and turn during the month to blackish, mixed with silvery grey hairs.



Fig.7. Cat Ba langur 76 days old (EPRC, female 15-07). The back starts to darken from the shoulder girdle to the root of the tail. A small part of the base of the tail darkens as a ring. The color of the ischial callosities changes to grey.

Fourth month (91 – 120 days)

With increasing age the speed of the pelage change shows individual, but not sex specific differences. In some animals the coloration of the back from below the shoulders to the base of the tail changes to brown already, with the yellow-orange baby fur still shining through (Fig. 8). Sparse silvery hairs mark the triangle over the lower back and the line on the thighs. The brownish parts on the legs extend along the outside of the thighs and form a brownish stripe from the back to the ankle. The inside of the thighs and the knees are still light brown to yellow-orange. A patch around the elbow starts to darken and is connected with a thin darker line along the outside of the forearm to the little

finger (Fig. 9). The fur on hands and feet is no longer uniformly black but there are grey hairs growing on the toes and the proximal phalanges of the fingers. The face gets darker and the ears are already almost black (Fig. 10). This phase of the coloration change was also observed in infants of the wild langurs on Cat Ba Island (Nadler, pers. obs.). These described changes are the ones observed in most infant Cat Ba langurs, however one animal at the EPRC (male 15-06) showed a much slower change in the pelage coloration (Fig. 11). A photo by Hendershott et al. (2019; Fig 5b) also shows a slow coloration change; it shows an infant, which is 119-122 old and still has the nearly complete orange-yellow natal color.



Fig.8. Cat Ba langur 113 days old (EPRC, female 15-07). During the fourth month the back beneath the shoulders to the proximal part of the tail changed to brown.



Fig.9. Cat Ba langur 113 days old (EPRC, female 15-07). Few silvery hairs mark already the triangle over the lower back and the line on the thighs.



Fig.10. Cat Ba langur 113 days old (EPRC, female 15-07). The face becomes darker and the ears are already nearly black. The fur on hands and feet is not completely black, on the toe and proximal phalanges growing grey hairs.



Fig.11. Cat Ba langur 110 days old (EPRC, male 15-06). This individual shows a slow change of the pelage coloration. The dark brown ring at the root of the tail appears mostly already end of the third month and on the back start to grow brown fur (cf. Fig. 9).

Fifth month (121 – 150 days)

During this month the back becomes darker and the yellow-orange natal pelage disappears. More silvery hairs grow on the triangle over the base of the tail. The legs darken and the lower legs are already predominantly brown (Fig. 12; 13). Animals with a slow coloration change still maintain a large area of yellow-orange hair on the back and yellow-orange hair on the lower legs (Fig 14). The color change of the hairless skin parts also differs between animals with slow and those with fast coloration change. The face of the first ones can still be light grey, whilst in the latter ones it is almost black (Fig. 15, 16).



Fig.12. Cat Ba langur 139 days old (EPRC, female 15-07). The back becomes darker and the yellow-orange baby pelage disappears.



Fig.13. Cat Ba langur 140 days old (EPRC, male 15-04). This male has a similar development to the female 15-07 (cf. Fig. 12).



Fig.14. Cat Ba langur 150 days old (EPRC, male 15-06). This male with a slower development has still a large yellow part on the back and yellow lower legs.



Fig.15. Cat Ba langur 136 days old (EPRC, male 15-06). Individuals with slower development of pelage change show also a slower color change of the naked parts. The face can be already nearly black (cf. Fig. 16).



Fig.16. Cat Ba langur 142 days old (EPRC, male 15-08), with a nearly black face.

Sixth to seventh month (150 – 210 days)

The pelage overall darkens, but at this age individual coloration can differ notably and some animals undergo certain coloration changes two months earlier than others. Individuals with fast coloration change have already a dark brown back, brown legs and nearly completely brown arms (Fig. 17). An animal photographed by Hendershott et al. (2019; Fig. 6b, and likely the same individual pictured on Fig. 5b) identified to be between 180-211 days old appears to be an example of slow coloration change.



Fig.17. Cat Ba langur 150 days old (EPRC, male 15-04). The individual shows a fast coloration change. Back and legs are already dark brown. Animals about a half year old can show a markable difference in the development of the pelage coloration (cf. Fig. 14).

Eighth to tenth month (210 – 300 days)

Individuals with faster pelage coloration development changes now rapidly; more silvery-grey hairs grow on the lower back, and the back, legs and proximal part of the tail gets dark brown. Simultaneously the yellow-orange fur on the distal part of the tail thickens to form a tassel (Fig. 18). In individuals with slow coloration change the yellow-orange fur still reaches from the shoulder to the middle of the back and the fur on the lower back is intermingled with yellow hairs. In these individuals arms and lower legs are still light brown and about three quarter of the distal part of the tail is still yellow to light brown (Fig. 19).



Fig.18. Cat Ba langur 228 days old (EPRC, female 15-07). Back and thigh and the proximal half of the tail are preponderant already dark brown. On the distal part of the tail grow the orange hair to thicken the tassel.



Fig.14. Cat Ba langur 221 days old (EPRC, male 15-06). The individual shows a slower coloration change. On the back is still a rest of the yellow natal fur visible. Arms and lower legs are still yellow to light brown and the tail just starts to darken.

Eleventh month to one year (300 – 360 days)

Differences in the pace of pelage coloration might become even more apparent. Animals with fast pelage coloration change are almost completely brown besides the yellow-orange head and shoulders and the brown distal part of the tail. Animals with a slow coloration change might still have extensive yellow-orange pelage areas. There can be as much as a three months coloration development difference between individuals of the same age.

One year to one and a half year (360 days – 550 days)

At the age of one individual with fast coloration development reach almost adult pelage coloration, only the fur of back and tail might be intermingled with very sparse yellow brown hairs. The pelage coloration of these individuals closely resembles the one of the adults only on the fur on the back and tail is intermingled with sparsely light hair. The yellow-light brownish tassel on the tail has now disappeared. The yellow fur area around the shoulders is still broader than in adults, and the silvery band from the thighs to the middle of the back, typical for adults is visible (Fig. 20). Individuals with a slow coloration change have at this age still extensive areas of yellow-light brown fur (Fig. 21).



Fig.20. Cat Ba langur 485 days old (EPRC, male 15-06). Animals with a slower reach coloration similar to adult also with less than one and a half year. The yellow part around the shoulders is broader than in adults.



Fig.21. Cat Ba langur 399 days old (EPRC, male 15-06). With the slow color change there are still larger parts in change from yellow to brown.

Sub adult and adult animals

Sub adult individuals can be recognized by a smaller body size and an area of yellow fur around the shoulders which is more extensive than in older individuals. With about three years the animals have the final coloration of an adult. The fur is dark chocolate-brown; the head and neck down to shoulders are bright golden-brown. The coloration on the head in older males tends to be light almost ivory colored. The hair on the top head form a crest and central hairs of this crest are often brown tipped. A silvery band runs from the thighs to middle of the back and the base of the tail and forms an upside down V-shape with the tip on the lower back. The hairs forming this V are dark brown at the base and only the distal 5-10 mm of the hairs are bright silvery grey, giving the band a frosted appearance.

The dorsal sides of feet and hands have small individually differently sized light patches of the same color as shoulders. The bare skin of face, ears, hands and feet is black. The tail is dark brown like the back. In animals above 15 years grey to white hairs might appear on the distal half of the tail (Fig 22) and then resembles the tail of the closely related white-headed langur, which is brown in the proximal and white in the distal part.



Fig.22. Cat Ba langur female (EPRC 15-01) 14 years old shows in the distal half of the tail intermingled whitish and grey hairs which resembles to the white headed langurs which have the distal half of the tail completely white.

There is no major difference between the pelage of adult males and females other than the pubic patch characteristic for all female Vietnamese “limestone langurs” which has individually characteristic irregular pigmentation, and pale white to yellowish hairs (Fig. 23). Form and pigmentation of this patch can be used for individual identification, though it might be difficult in the wild to get a close enough look to exactly assess the patch. However since there is no other sexual dimorphism the presence of a pubic patch allows to identify the sex of the individuals in a group during field observations, in particular on photographs which show the rear view of walking or jumping animals (Fig. 24).

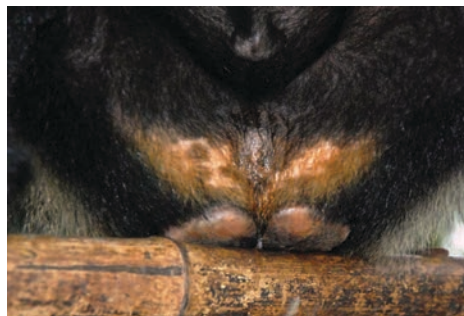


Fig.23. Pubic patch of an adult Cat Ba langur female. Form and extent are individually different.



Fig.24a,b,c,d. During field observation females are to identify from behind on the whitish hairs on the pubic patch.

Discussion

The coloration of young Cat Ba langurs can be helpful to determine the age, but there is a rather large difference in the timing of the various pelage coloration changes. The differences in the timing of the changes in pelage coloration increase with age and become apparent at three to four months. At the age of one year the pelage coloration difference between animals with a slow and those with a fast pelage coloration development can amount several months. This means that an individual with slow pelage coloration change has at the age of one year a similar pelage coloration as an individual with fast pelage coloration change has already at the age of ten months. The observations suggest that the speed of the coloration development is genetically fixed. Animals which are born with a brown tinge on their back and tail will later show a fast pelage coloration development.

Hendershott et al. (2019) observed a difference in the timing of color change between Cat Ba and Francois' langurs (*Trachypithecus francoisi*) and suggested it to be related to infanticide avoidance. Though this is an interesting consideration, but it is to point out that it could also originate in the different coloration of the adults of the species in question - a darker species change the natal coat faster. Adult limestone langurs show subtle differences in the dark parts of the pelage, which are almost impossible to recognize in the field. The fur of these species – Francois' langurs, Hatinh langurs, Cat Ba langurs, white-headed langurs, Delacour's langurs and Lao langurs (*Trachypithecus francoisi*, *hatinhensis*, *poliocephalus*, *leucocephalus*, *delacouri* and *laotum*) - is commonly described as black. But only Francois' and Delacour's langurs actually have a glossy deep black fur. The fur of the Hatinh and Lao langurs is black but has a brown tinge and the fur of the Cat Ba and white-headed langurs is dark-chocolate brown.

The differences in coloration of new born animals and also the different speed of the coloration changes are also typical for other limestone langurs. Within the captive populations at the EPRC more than 20 Delacour's langurs and more than 100 Hatinh langurs were born. Both species belong to the 'limestone langurs' and their offspring are born with a yellow-orange natal coat. But within the captive born Hatinh langurs a great variation in the coloration of new born individuals is to observe - from complete yellow-orange individuals over animals with a partly dark back and tail to animals with an almost black back and a completely black tail. Observations at the EPRC show that the coloration of the natal coat and the pelage coloration development is genetically provoked as all animals at

the EPRC experience the same environmental conditions. Habitat quality, resource availability or social pressure, suggested by Hendershott et al. (2009) as essential drivers for the timing of the coloration change, can be excluded and more likely only affect an already existing disposition. It is also not clear if group size has an influence of the development of the pelage coloration change as observed by Borries et al. (2008) or is a result of the genetic structure of a group. In limestone langurs the females in one group are often sisters and they mate almost solely with the alpha male of the group. Borries et al. (2008) already pointed out the small sample size and cautioned against her own findings.

All limestone langur groups show the same social structure. Therefore the conclusion of a relation between infanticide and the speed of the coloration change (Hendershott et al. 2019) should be treated with utmost caution taking into consideration the individually and genetically fixed differences in coloration change.

Victims of infanticide in langurs are mostly infants less than one year of age (Davies & Oates 1994; Sommer 1996; Qing Zhao et al. 2001; Nadler pers. obs.) (Fig. 25, 26). During this time the animals change the pelage coloration, but more importantly in this respect is that with increasing age increases also the distance of the immature individuals to their mother or to other females, nonmaternal group members, and thereby the chance for an attack through an intruder is higher. But observations on Delacour's langurs (two cases) and Hatinh langurs (one case) (Nadler pers. obs.) show that intruder males also attacked older juveniles aged about one and a half to two years. At this age Hatinh langurs have their completely adult pelage coloration and Delacour's langurs already grey hips, but not yet the typical white trousers. In the observed cases the juveniles were injured but not killed. The killing of younger individuals is probably much more frequent and more often recognized.



Fig.25a,b. Cat Ba langur as a victim of an infanticide. The animal is probably four months old. It died through a puncture to the brain and to the lungs from a canine of a male.

Based on the observed differences in the development of the coat coloration of Cat Ba langurs, which also show other limestone langurs, a hypothesis about their influence on infanticide is highly speculative and not tenable.

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