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Cover: Delacour's langur, male (*Trachypithecus delacouri*). Photo: T. Nadler.

EDITORIAL

The VIETNAMESE JOURNAL OF PRIMATOLOGY strives to perpetuate its yearly edition (although one missing *issue* in 2018) with the publication of all biological aspects and conservation challenges of Vietnamese primate species. The year 2018 brought some changes in the field of primate conservation and research in Vietnam.

After many years and several unsuccessful attempts to provide a clear program for the long-term conservation of Vietnamese primates, in May 2017 the Prime Minister signed the URGENT CONSERVATION ACTION PLAN FOR PRIMATES IN VIETNAM TO 2025, VISION TO 2030. The framework for conservation has been delimited now, but the actual implementation still largely remains to be done. The burden of work lasts predominantly on the shoulders of NGO's working in Vietnam. The last half of 2017 and the year 2018 has seen a number of planning rounds and concept discussions. But after two years – up to now - numerous resolutions are still waiting to be executed. It is to hope that this important document will soon get animated completely. It would be an incentive if the VJP can report continuously about the activities and actions to the realization of the ACTION PLAN.

As the founder of the Endangered Primate Rescue Center, there have been some changes at the end of the year 2018 with my personal involvement with the center. My position as director of the VIETNAMESE PRIMATE CONSERVATION PROGRAM, which I have held for 25 years, was transferred to the next generation of conservationists. After several challenges in the search for a capable leader for the Endangered Primate Rescue Center, Caroline Rowley took over this position. The center will continue its work as important facility for the conservation of Vietnamese primates, such as the rescue and rehabilitation of primates, the captive breeding of highly endangered species with the goal of strengthening extant populations and re-establishing populations in places where they have been eradicated, to serve as a training and research facility and finally to raise awareness to the general public about the urgent need to take concrete conservation actions.

My work for the conservation of Vietnamese primates will continue outside of the Endangered Primate Rescue Center - still a very broad field for urgent activities -- while the VIETNAMESE JOURNAL OF PRIMATOLOGY should also be continued as a support tool. With the changes in the management, the copyright of the VJP will be handed over from the Endangered Primate Rescue Center to the German Primate Centre, the generous donor since the beginning of the edition in 2007.

Tilo Nadler

Rapid population increase of the Critically Endangered Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve due to strict protection

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Key words: Delacour's langur, *Trachypithecus delacouri*, Van Long Nature Reserve

Summary

Van Long Nature Reserve is the sole area with a viable population of the Critically Endangered Delacour's langur (*Trachypithecus delacouri*), which is endemic to Vietnam. A small population was discovered in this area in 1993, and in 2001 the area received protection status as a nature reserve. A Community Protection Unit (CPU) was established in cooperation with Frankfurt Zoological Society to support the protection and the work of the Management Board of the nature reserve. The unit comprised 30 local people and due to its intense protection activities poaching inside the reserve has been eliminated. As a result, the population of the Delacour's langurs which originally comprised about 50 individuals increased rapidly. Repeated surveys document the development of the population over time. In the first half of 2018 a comprehensive survey counted 176 to 184 individuals in 21 groups inside the Nature Reserve, and 31 to 38 individuals in 4 groups in the area adjacent to the reserve. That means over the last 18 years the population has nearly quadruplicated.

Despite good protection of the area further measures are recommended to safeguard the habitat for the expanding population. A part of the habitat is badly affected by limestone quarrying in a neighbouring area through blasting and strepitous transport activities, and by dust formation and smoke from burning car tires to produce road cover material.

About 2000 ha of the Nature Reserve are suitable habitat for the langurs, but 30% of it is in poor condition. These degraded areas should be restored and reforested with a mixture of food tree species for the langurs.

With its successful protection, the excellent community involvement and the continuous growth of the Delacour's langur population, Van Long Nature Reserve hopes to be the first protected area in Vietnam to be included in the newly established IUCN Green List.

Bảo vệ nghiêm ngặt và sự tăng trưởng nhanh chóng của quần thể loài Voọc Mông trắng (*Trachypithecus delacouri*), loài linh trưởng cực kỳ nguy cấp tại khu bảo tồn thiên nhiên Vân Long, Ninh Bình, Việt Nam

Tóm tắt

Khu bảo tồn thiên nhiên Vân Long, nơi duy nhất quần thể Voọc Mông trắng có thể phát triển độc lập, lâu dài. Từ năm 1993 một quần thể nhỏ Voọc Mông trắng được phát hiện ở đây, đến năm 2001 quần thể này được bảo vệ trong lòng khu bảo tồn thiên nhiên Vân Long. Một chương trình bảo tồn loài dựa vào cộng đồng đã được thực thi tại Vân Long. Một nhóm 30 bảo vệ rừng từ cộng đồng đã được thiết lập với sự hỗ trợ của Hội động vật học Frankfurt nhằm triển khai hoạt động tuần rừng và hỗ trợ ban quản lý khu bảo tồn. Hoạt động bảo vệ nghiêm ngặt vùng lõi đã loại bỏ việc săn bắn trộm. Kết quả là từ một quần thể ban đầu khoảng 50 cá thể, số lượng Voọc mông trắng đã tăng nhanh. Kết quả điều tra quần thể trong nửa đầu năm 2018 cho thấy có khoảng 176-184 cá thể thuộc 21 đàn đã được đếm trong vùng lõi của khu bảo tồn. Và có khoảng 31-38 cá thể thuộc 4 đàn được ghi nhận trong vùng rìa của khu bảo tồn. Như vậy, sau 18 năm được bảo vệ số lượng cá thể Voọc mông trắng đã tăng gấp 4

lân. Mặc dù hoạt động bảo vệ được thực hiện tốt đối với quần thể, vẫn cần những nỗ lực bảo vệ an toàn môi trường sống của loài. Hiện tại, hoạt động khai thác đá vôi phục vụ nhà máy xi măng lân cận đã ảnh hưởng đến môi trường sống của loài do đánh mìn, bụi và khói. Có khoảng 2000 héc ta của khu bảo tồn là sinh cảnh sống phù hợp của loài, nhưng khoảng 30% số diện tích này có điều kiện đất và rừng nghèo kiệt. Khu vực này cần được phục hồi sinh thái và trồng bổ sung các loài cây làm thức ăn cho Vọc mòng trắng. Với những thành công trong hoạt động bảo tồn loài và sự tham gia của cộng đồng, khu bảo tồn thiên nhiên Van Long dự kiến là khu bảo tồn đầu tiên của Việt nam được đưa vào danh sách Xanh của tổ chức Liên minh các tổ chức bảo tồn thế giới (IUCN).

Introduction

The Delacour's langur (*Trachypithecus delacouri*) is a Critically Endangered primate species endemic to Vietnam (IUCN Red List of Threatened Species). The species is listed under the World's 25 Most Endangered Primates (Schwitzer et al. 2015), and is included in the Red Data Book of Vietnam (Ministry of Science and Technology & Vietnamese Academy of Science and Technology 2007), resulting in the highest protection status in this country.

The species occurs in a very restricted area of north-central Vietnam covering about 5000 km². In this area, there are 10 isolated sub populations of Delacour's langurs occupying less than 400 km². The population at Van Long is the largest and only viable subpopulation of this species (Nadler 2015).

The Van Long subpopulation was discovered in 1993 during surveys conducted by Frankfurt Zoological Society (FZS) with the aim to provide an overview of the situation for the species. By 2000, the population in Van Long consisted of about 50 individuals (Baker 1999; Nadler 1996), and an increase in the population was recognized during several later surveys (Nadler 2004; 2015; Nadler et al. 2003).

Van Long was established as nature reserve in 2001. Since that time, Frankfurt Zoological Society has provided support for the management of the reserve and the establishment of a Community Protection Unit (CPU) which supports the protection activities of the rangers of the nature reserve. FZS assisted in the recruiting and training of the 30 members of the CPU, equipped them with uniforms and materials for fieldwork and protection activities, and paid their salaries (Fig. 1).



Fig.1. Members of the Community Protection Unit (CPU) at Van Long Nature Reserve. Photo: T. Nadler.

In close cooperation with the surrounding communes, the human impact to the reserve was drastically reduced and primate poaching was completely eliminated. Following these intensive protection activities the population of the Delacour's langurs increased rapidly.

In addition to allow the recovery of the langurs, the reserve has become an eco-tourism site where local people have established eco-tourism by taking visitors around the reserve on bamboo boats. This provides additional income and financial security to formerly very poor local communities.

In 2011 and 2012, the first reintroduction of captive bred Delacour's langurs from the Endangered Primate Rescue Center was carried out to increase the wild population both in number and in genetic diversity (Agmen, 2014; Elser 2014; Elser et al. 2013; Nadler 2012).

In accordance with the 'Urgent Conservation Action Plan for Primates in Vietnam to 2025, Vision to 2030' (Prime Minister of Government 2017) a comprehensive survey was carried out from April to July 2018 in order to assess the development and status of the population.

Objective of the survey

The survey aimed to identify the population status, distribution, and home ranges of Delacour's langur groups at Van Long Nature Reserve. This information will serve as a foundation for estimating the carrying capacity of the nature reserve, which will be used in a government assessment for a possible habitat extension.

General characteristic of the survey area

Van Long Nature Reserve was established under the Decision 2888/QĐ-UB on 18th December 2001 through the Provincial People's Committee of Ninh Binh.

Location of Van Long Nature Reserve

The reserve is located in the North of Ninh Binh Province. In the North Van Long borders Hoa Binh Province, the southern border is formed by a dam running from Xich Tho Commune in the West to Gia Thanh Commune in the East. The eastern border is the Dong Quyen Mountain, and the western border runs along Mot Mountain and Boi River. The area stretches north-south from 20°20'55" to 20°25'45" and west-east from 105°48'20" to 105°54'30" (Fig. 2).

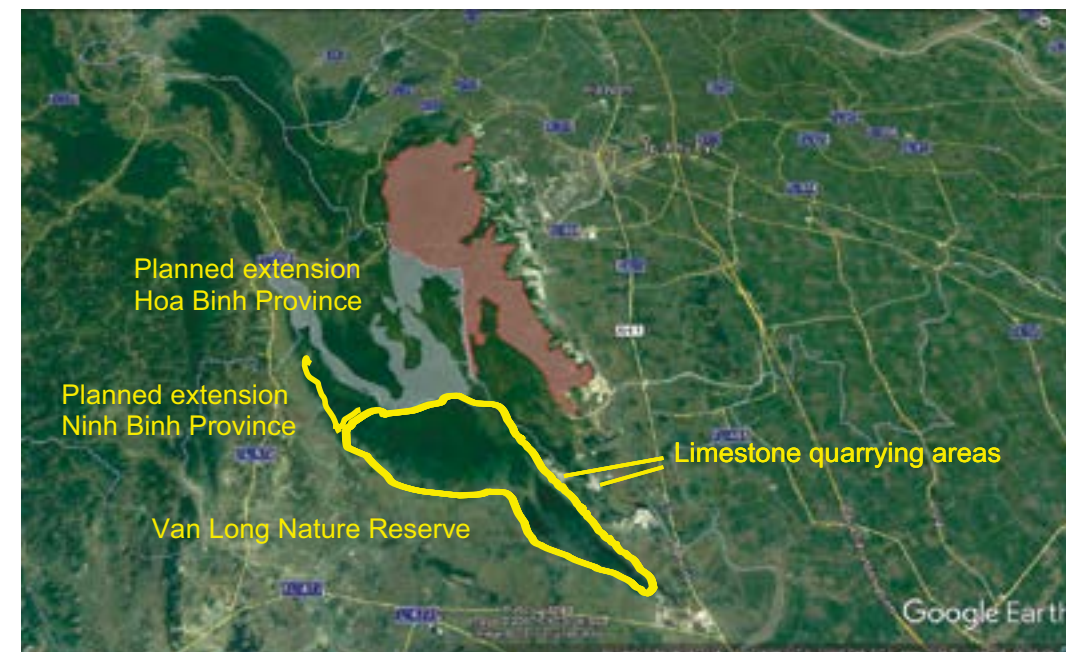


Fig.2. Van Long Nature Reserve with the proposed areas for extension and limestone quarrying areas (white spots).

The adjacent areas in Northwest of the nature reserve is belong to Xich Tho Commune, Nho Quan District, Ninh Binh Province and Dong Tam Commune, Lac Thuy District, Hoa Binh Province with geographical coordination of about 20°24' to 20°31' N and 105°46' to 105°52' E.

Van Long Nature Reserve comprises an area of 2,736 ha and is divided in three zones: a strictly protected area with 1,270.6 ha, a rehabilitation area with 1,463.4 ha and an administrative area with 2 ha.

Forest condition and management

Van Long Nature Reserve consists of natural forest (2,164 ha), plantations (58.5 ha), and water (508 ha). Forested land is divided into three zones: protection forest, special use forest, and production forest. The buffer zone around the reserve comprises 5,990.2 ha (Table 1).

Table 1. Land structure and use of the commune land included into Van Long Nature Reserve. (following Decision 2538/QĐ-UBND - 5/12/2003)

Commune	Total (ha)	Limestone (ha)	Waste land (ha)	Argriculture land (ha)	Water area (ha)	Plantation (ha)
Gia Hung	946	662,90	119,30	103,47	1,93	58,30
Gia Hòa	1.220,63	1.018,15	42,50	159,98		
Liên Sơn	25,25	1,25		24,00		
Gia Vân	320,16	166,50		153,66		
Gia Lập	83,53	31,50		51,90		
Gia Tân	16,58	4,52		12,055		
Gia Thanh	121,36	118,00		3,3950		
Total	2733,51	2.002,82	161,80	508,46	1,93	58,30

Some areas adjacent to the nature reserve (Xich Tho Commune, Nho Quan District, Ninh Binh Province and Dong Tam Commune, Lac Thuy District, Hoa Binh Province) still have natural limestone forests (about 1,000 ha). It is proposed to obtain protection status for these areas, or to include them into the existing nature reserve (Prime Minister of Government 2017).

Van Long Nature Reserve and the forest in the neighbouring Xich Tho Commune are managed through a management board. The protection of the forests in Dong Tam Commune in Hoa Binh Province is contracted through the communes directly to farmers.

Topographical and geographical characteristics

The topography of the survey area consists mainly of forested limestone karst, surrounded by water and wetland. The karst has an abundance of caves, funnels and sinkholes.

Based on geographical characteristics, the nature reserve includes three primary zones:

- high mountain zone about above 300 m, with the highest peak at 436 m
- hilly zone, between 50 and 300 meters
- wetland zone

The high mountain zones in the North and Northwest are divided by a number of large rugged karst formations. Located between these formations are valleys and flat areas, occasionally with ponds (Fig. 3). Some areas have large cave systems below the water level.



Fig.3. The high mountain zone of the nature reserve with the highest mountain 436 m. Photo: T. Nadler.

The hilly zone has gently slopes, some of which are used as agricultural land on a small scale.

The wetland zone partly surrounds the limestone outcrops (Fig. 4). Some areas are seasonally dry; the depth of the water between one and two meters.



Fig.4. The wetland zone is with the limestone outcrops a scenic landscape. Photo: T. Nadler.

The hydrology of the area is characterized by three large river systems which directly supply waters for the wetland; the Day, Boi, and Hoang Long River. These rivers also meander and fill a number of caverns, which helps to maintain water levels stable in the area during dry season.

Climatic conditions

The climate in the area is monsoon tropical climate characterized by profound differences between seasons. The average annual temperature is 23.3°C, and average annual humidity is 84-85%. The winter season lasts from about November to end of March with about 50 to 60 cold days

(below 15°C). The rainfall is 1800 to 1900 mm/year, with significant differences between the seasons (Nguyen Khanh Van et al. 2000).

Human population around Van Long Nature Reserve

The territory of the nature reserve belongs to seven communes with a total population of about 52,000 people (Table 2).

Table 2. Human population in the communes around Van Long Nature Reserve.

Commune	No. people	No. families	No. poor families	People able to work			Population increase (%)
				Total	Man	Women	
Gia Vân	5990	1815	50	2875	1380	1495	1,0
Gia Hung	7200	1882	87	3100	1488	1612	0,7
Gia Hòa	8597	2357	60	5136	2465	2671	0,77
Gia Thanh	6980	2100	45	4563	2190	2373	2,1
Gia Lập	8454	2454	57	3921	2626	1295	1,1
Liên Sơn	5845	1611	64	3120	2097	1023	0,9
Gia Tân	8710	2848	74	4280	2054	2226	0,7
TOTAL	51.776	15.067	437	26.995	14.301	12.694	1

Time of the survey and participants

The survey lasted more than three months, from 10th April to 20th July 2018. A total number of 40 people were involved in the survey including 10 rangers and 30 guards from the CPU.

Methods of the survey

Interview survey

A standard method to gather information before a field survey is to conduct interview surveys with the purpose to more effectively focus field work on areas where primates are often seen. In total, 50 people were interviewed using a standardized form. The locations for conducting interviews were divided into 15 sections (Table 3, Fig. 5).

Table 3. Localities for interview.

Locality	Area	Locality	Area	Locality	Area
1	Kém Châm/ Đôi Sỏi	6	Ba Non	11	Đám Bái
2	Cánh cổng/ Hang bóng	7	Tái Thả	12	Cát Đùn
3	Cánh cổng/ Hang Cá	8	Đầu Voi/ Đồng Rộng	13	Đống Mới
4	Hang Chanh	9	Thung Giếng	14	Suối Tép
5	Mèo Cào	10	Quèn Cá	15	Đôi Bò



Fig.5. For the interview survey the area was divided into 15 sections.

Field survey

Field surveys were carried out using line transects. Most transects followed a patrol path. Areas where langurs had been reported during the interviews, were patrolled more intensively to evaluate the home range of groups. Higher mountains were used as observation points. The field work was carried out normally between 5:30/6:00am to 5:30/6:00pm. On rainy or foggy days with limited view, observation times were more flexible and field work was conducted whenever weather and visibility permitted.

Following the interview results, the trails for the field survey were defined (Table 4). In total, 400 km of trails were surveyed over a total of 500 hours. Data was collected with support from the SMART-Program (Fig. 6).

Table 4. Trails and time for the survey.

Commune	Trail	Survey time
Gia Thanh	Kém Châm	15/4- 29/4
	Vùng Lang - Vùng Vân	
	Trạm Bơm - Cung Sỏi	
Gia Hòa	Hành chanh núi Cò Tiên	4/5 - 30/5
	Hang Chanh - Vùng Đông	
	Hang Chanh- Cửa luồn	
	Hang Cá - Gia Vân	
	Đầu Voi - Thung Ông Quản Nhiếp	
	Hậu Ba Non	
	Ba Non	
Gia Hung	Thung Chuối - Thung Giếng	1/6 - 8/6
	Đồng rộng - Giếng Méo	
Gia Vân	Quèn Cá	9/6 - 30/6
	Đám Bái	
	Hang Bóng	
Khu lân cận	Cánh Cổng	1/7 - 20/7
	Bưng Sóc - Hang Bóng	
	Đôi Bò - Đống Tâm - Hòa Bình	
	Suối Tép - Đống Tâm- Hòa Bình	
	Đại Đống - Đống Tâm- Hòa Bình	
Đống Mới - Đống Tâm- Hòa Bình		

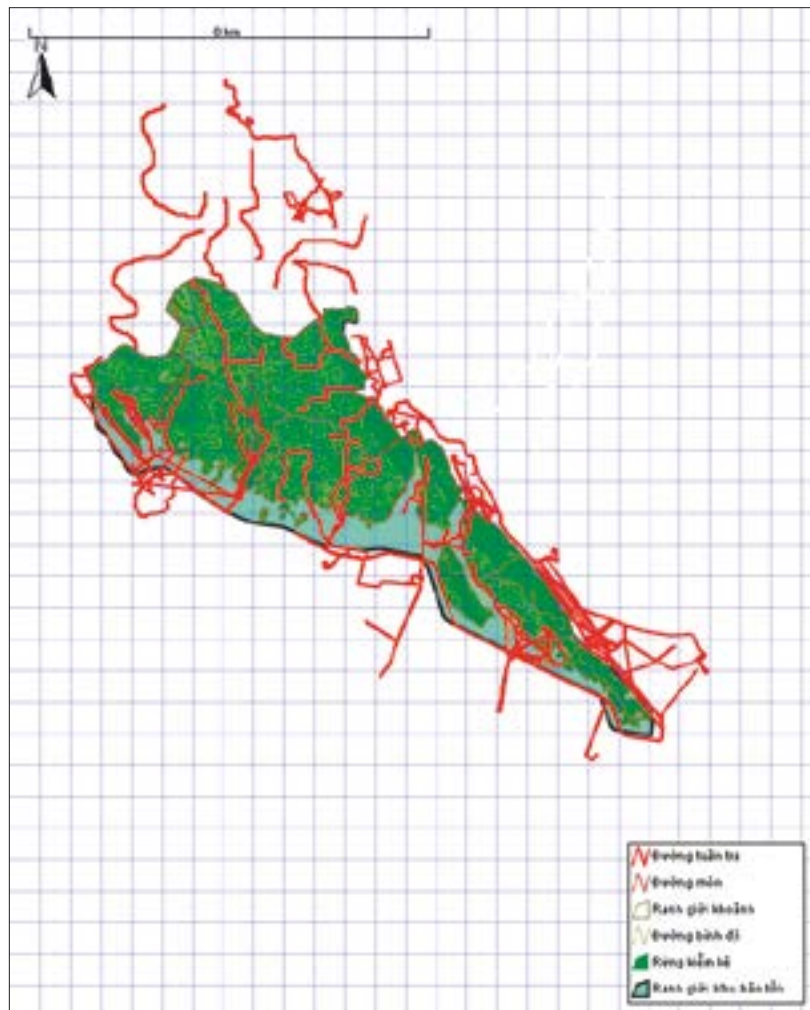


Fig.6. The trails during the field survey are recorded by use of the SMART-Program. The colored part is the area of the nature reserve, the white parts adjacent areas of the nature reserve.

Three teams carried out surveys concurrently with each team consisting of two to three people. Each team was equipped with a GPS, binoculars, and cameras.

If the team spotted langurs they recorded information regarding location, number of individuals as well as age and sex of individuals.

Results of the survey

Result of interview survey

50 people were interviewed. All the interviewees live close to the reserve. All people reported knowing the langurs well, including regularly observing them.

Results of the field survey

Within the nature reserve, 176 to 184 individuals in 21 groups were counted in four primary locations (Dong Quyen Mountain, Hang Chanh, Kem Tram, Ba Non). In the adjacent areas (Dai Dong, Dong Tam), 31 to 38 individuals in 4 groups were counted (Table 5 and 6, Fig.7).

Table 5. Observed and estimated numbers of Delacour's langurs.

Area belongs to commune	Trail	Number of individuals from interview	Observed individuals	Estimated total individuals	Repeated observation	Coordinates Observer	Direction of animals from observer
Gia Hòa	Đầu Voi	8	7 ad.	8	3	20°23'55.91"N 105°51'10.83"E	150 m West
	Hậu Ba Non	6	6 ad.	6	3	20°23'23.54"N 105°51'44.01"E	100 m West
	Thung giếng	5	3 ad.	5	3	20°25'5.05"N 105°51'5.11"E	170 m South
	Khu vực tái thả		4 ad.	4		20°24'27.69"N 105°51'17.32"E	
	Hang Chanh 1		6 ad.	6	4	20°23'5.64"N 105°52'19.78"E	60 m
	Hang Chanh 2		5 ad. 3 subad. 1 immat.	9	3	20°23'33.31"N 105°52'1.97"E	60 m East
	Hang Chanh 3		8 ad. 3 subad.	11	4	20°23'55.04"N 105°52'0.13"E	80 m North
	Hang Chanh 4		6 ad.	6	3	20°23'39.91"N 105°52'24.45"E	120 m West
	Hang Chanh 5		10 ad.	11	3	20°23'9.59"N 105°52'13.73"E	120 m North
	Hang cá	20	14 ad. 1 subad. 2 immat.	20	5	20°22'51.80"N 105°52'32.82"E	60 m North
Gia Hưng	Quèn Cá	0	0	0	0	-	
	Đám Bái	0	0	0	0	-	
Gia Thanh	Thung Lau – khu ông tấn	0	0	0	0	-	
	Kèm Châm	5	5 ad.	5	5	20°21'56.43"N 105°53'45.90"E	South
Gia Tân	Trạm BV Số 2	9	8 ad.	9	3	20°22'47.26"N 105°53'12.57"E	150 m South
	Vũng Lang – Vũng Vân	10	11 ad.	11	5	20°22'11.62"N 105°53'37.36"E	South
	Kèm Châm II	7	7 ad.	7	4	20°21'44.42"N 105°53'46.30"E	North
Gia Tân	10	4	4 ad.	4	3	20°21'4.32"N 105°54'16.77"E	150 m South-West

Gia Vân	Cánh Cổng	8	8 ad.	8	5	20°22'9.06"N 105°53'7.73"E	130 m North
	Bưng Sốc – Cánh cổng I (cửa trạm 7)	10	8 ad.	10	5	20°22'42.48"N 105°52'36.38"E	60 m North
	Bưng Sốc – Cánh cổng II (Bưng sóc 1a)	9	6 ad. 1 subad. 1 immat. 1 juv.	9	5	20°22'31.63"N 105°52'40.80"E	90 m North
	Bưng Sốc – Cánh cổng III (Bưng sóc 1b)	8	8 ad.	8	5	20°22'27.70"N 105°52'44.28"E	20 m North
	Bưng Sốc – Cánh cổng IV (Bưng sóc 2)		14 ad.	15		20°22'16.19"N 105°52'55.83"E	80 m North
	Cánh Cổng – Hang Bồng I (Đá An Tái)	8	8 ad.	8	6	20°21'58.65"N 105°53'10.81"E	100 m North
	Hang Bồng	7	7 ad.	7	5	20°21'49.93"N 105°53'43.18"E	40 m West
Giáp Ranh	Đống Mới	12	10 ad.	12	2	20°25'49.61"N 105°50'55.43"E	130 m South-West
	Suối Tép	14	10 ad.	14	2	20°26'34.67"N 105°50'29.17"E	120 m South-West
	Đôi Bò	4	4 ad.	5	2	20°26'20.32"N 105°49'23.55"E	120 m North-East
	Đền Cát Đùn	7	7 ad.	7	2	20°25'31.34"N 105°49'46.19"E	120 m North-East

Table 6. Localities of Delcaour's langur groups.

No. on map	Locality	No. on map	Locality
1	Hang Bồng	E	HC4
2	Kẽm Châm	F	HC 5
3	Vũng lang- Vũng Vân	G	Hậu BN
4	Đá An Tái	H	Thả ĐV
5	Cánh cổng	I	Thung Giếng
6	Trạm 2	J	Đống Mới
7	Bưng sóc 2	K	Suối Tép
8	Bưng Sóc 1b	L	Cát Đùn
9	Bưng sóc 1a	M	Đôi Bò
10	Cửa trạm 7	X	Kẽm II
A	Hang cá	Y	10- Gia Tân
B	HC 1	w	Nhà máy Vissai
C	HC 2	D	HC 3

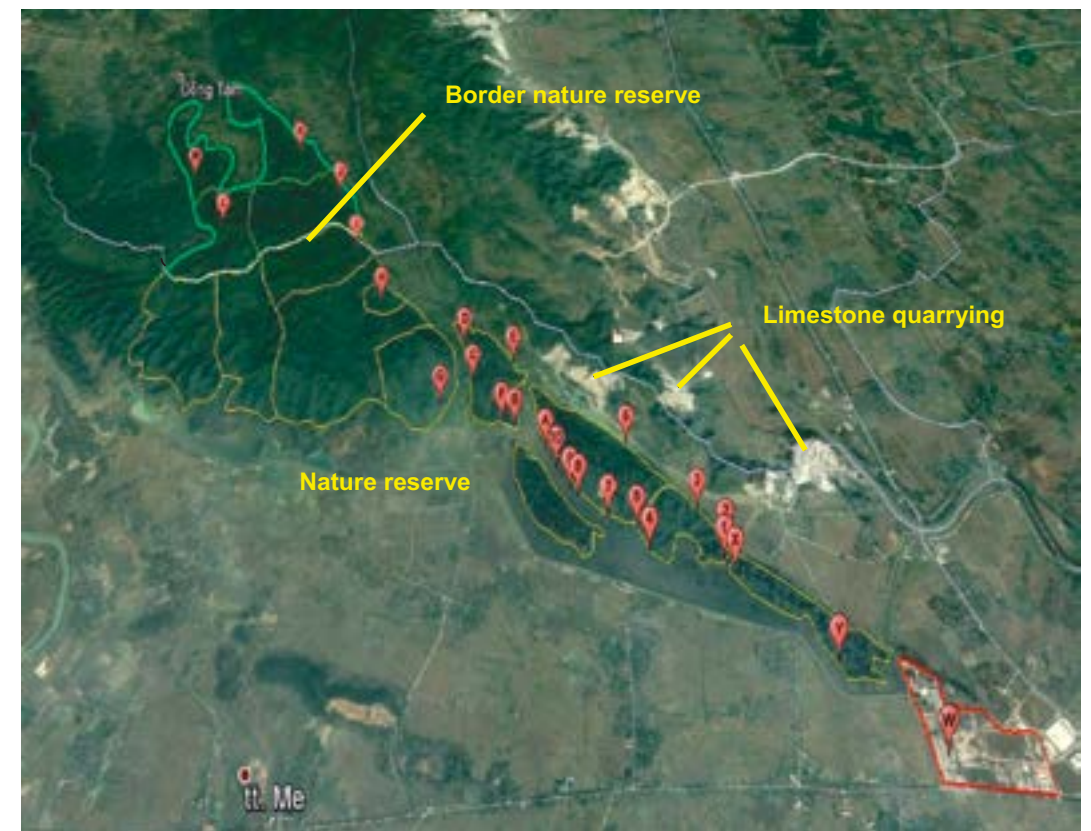


Fig.7. Localities of Delcaour's langur groups inside and outside Van Long Nature Reserve.

Discussion of survey results

According to reports before 2000, Delcaour's langurs were dramatically reduced over their entire area of distribution. With the establishment of Van Long Nature Reserve in 2001 and stricter hunting control, the population has increased significantly in a relatively short period. But the results of this survey suggest a decline in the rate of increase during the last 5 to 6 years (Table 7, Fig. 8). This may be due to the fact that optimal habitat currently is restricted to the south-eastern part of the reserve. Groups are consequently not evenly distributed over the whole nature reserve and are mostly located in the eastern parts (Dong Quyen Mountain and Hang Chanh area).

Table 7. Development of the Delcaour's langur population in Van Long Nature Reserve over the years.

Year	Number of groups	Number of individuals	Organisation carried out the survey
1999	?	45 - 47	Frankfurt Zoological Society
2000	?	51 - 53	Frankfurt Zoological Society
2007	11	55 - 78	Hanoi National University
2010	10 - 14	84 - 100	Frankfurt Zoological Society
2011	14	137 - 147	Frankfurt Zoological Society
2018	21	176 - 184	Van Long Nature Reserve

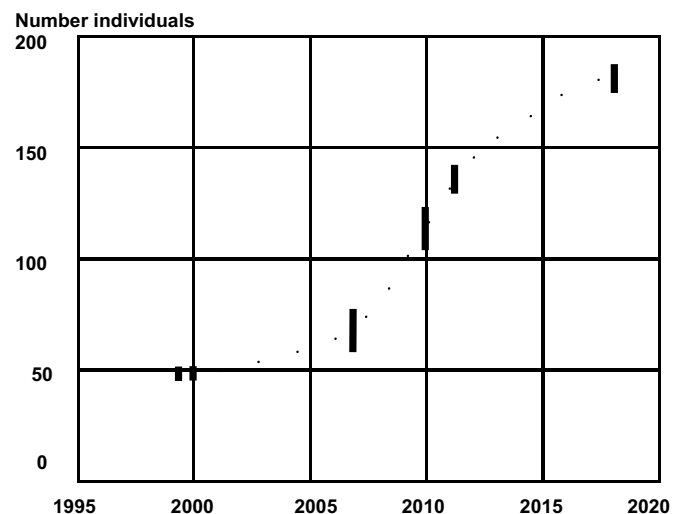


Fig.8. Development of the Delcaour's langur population in Van Long Nature Reserve over the years.

In the large north-western area, consisting of 600 ha belonging to Gia Hung Commune, no animals were observed. Similarly, no langurs were observed in the 77 ha large area Meo Cao; although during the survey a group with three individuals temporarily visited this area. This larger north-western part of the reserve still provides some suitable habitat. It is expected that the population in this area will increase due to dispersal of individuals from the eastern part in search of home ranges to establish new groups. Although movement between the blocks is challenging, movement of single individuals and smaller groups between the eastern and western parts of the reserve has been observed (Fig. 9) and the animals are obviously able to cross the gaps between the limestone blocks.



Fig.9. Moving activities of langur groups between parts of the nature reserve.

There were no observation of langurs in the most eastern part of the nature reserve (Trai Cuon belonging to Gia Thanh Commune). This area is opposite of a large cement quarry belonging to Vissai Cement Company. There is regular blasting and this area is highly polluted with dust (Fig. 2).

Threats and impacts to the Nature Reserve and the Delcaour's langur population

Impact from forest fire

Burning of fields in marginal areas of the Nature Reserve is a common practice by farmers, and can occasionally spark fires which destroy the forest habitat of the langurs. Such forest fires used to

occur four to five times per year, but are now reduced to one or two times due to stricter control by rangers and guards (Management of Van Long Nature Reserve, unpubl. report).

Land conversion into agricultural land

There are some settlements inside the nature reserve. The border of the reserve is not in all areas clearly marked, and about 300 ha within the reserve are used for agriculture. In the past land ownership was not always clear to local communes and they allocated land use rights inside the reserve to families. These localities are also used for grazing domestic animals. Goats are especially problematic as they are food competitors for the langurs.

Impacts from outside

Limestone quarrying which includes blasting and transport activities causes massive dust formation, covering all vegetation in the vicinity. Car tires are burned to produce road cover, leading to the development of thick toxic fumes. The parts of the reserve which are affected by these activities appear to be entirely avoided by the langurs (Fig. 10, 11, 12).



Fig.10. A cement factory in striking distance to the nature reserve. The limestone block on the left is belonging to the reserve. Photo: T. Nadler.



Fig.11. The quarrying area close to the nature reserve is enshrouded in dust. Photo: T. Nadler.



Fig.12. Blasting and heavy traffic along the road close to the nature reserve provoked the langurs to eschew this part of the reserve. Photo: T. Nadler.

Tourism management

The nature reserve has become a tourism hotspot. Tourists are carried in small bamboo boats to enjoy the spectacular landscape and to observe the langurs. However, the management of these tourist activities lacks oversight, regulations and control (Fig. 13).



Fig.13. Tourists can visit the nature reserve only by boat and with a good chance to observe the Delcaour's langurs. To leave the boat and to enter the hills is prohibited. Photo: T. Nadler.

Pollution

Waste from surrounding communes and from tourists is simply dumped in marginal areas of the nature reserve (Fig. 14). Fertilizer and pesticide/herbicide runoff from agricultural areas negatively impacts and kills organisms in the wetlands.



Fig.14. Waste disposal from surrounding communes at the border of the reserve is still a problem. Photo: T. Nadler.

Illegal exploitation of natural resources

A number of plant species growing inside the nature reserve are used for traditional medicine and are illegally extracted from the reserve. The presence of people collecting such plants in the reserve creates additional disturbances such as the creation of trails and the trimming of plants and trees to maintain such trails as well as camping, littering, etc..

Recommendations to secure the long-term existence of the Delcaour's langur

Improvement of protection

The following actions are recommended to improve further protection:

- Setting up more sign boards to inform the public about the exact boundary of the reserve and the regulations about protection
- Abolition of all hunting and trapping activities
- Abolition of collection fuel wood
- Abolition of collection non timber forest product (medicinal plants)
- Abolition of grazing domestic animals
- Reduction of mining outside and adjacent to the nature reserve which impacts the habitat
- Implementation of regulations and strict prosecution of violations

Improvement of the langur habitat, habitat restoration

About 2000 ha is suitable habitat for the langurs, which should be under stricter control and protection. About 30% of the nature reserve's habitat is in poor condition and not an optimal habitat for the langurs. These areas should be restored and planted with a selection of tree species used as food sources by the langurs.

Strengthen Delcaour's langur conservation efforts

It must become an integral part of the protected area management to regularly monitor the Delcaour's langur population and gather information about habitat use and their ecology. The use of the SMART-Patrol program for monitoring activities is recommended to strengthen conservation efforts.

Extension of the protected area

Adjacent areas with suitable habitat and with Delacour's langurs should urgently receive protection status. The groups in these areas are part of the population and it is critical to the survival of this charismatic Vietnamese primate species to preserve their genetic pool.

Safeguarding the livelihood for locals around the nature reserve

The improvement of income from agriculture products through the use of new plant species or technologies and providing alternative sources of income will help to reduce the illegal extraction of forest products and its impacts to the nature reserve. Eco-tourism can be a sustainable safeguard, but needs to be stricter controlled and planned to ensure animals, people, and the environment are protected and remain as a possible ecotourism destination for the future.

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Our gratitude goes to Ostrava Zoo for generous financial support.

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Discovery of isolated populations of the 'Critically Endangered' grey-shanked douc langur (*Pygathrix cinerea*) in Quang Nam Province, Vietnam

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Key words: Grey-shanked douc langur; *Pygathrix cinerea*

Summary

The grey-shanked douc langur (*Pygathrix cinerea*) is one of the world's rarest primate species. Following up on scarce information about the occurrence of this species in the southern part of Quang Nam Province, we carried out surveys to verify the existence of the species and to estimate the population size. We confirmed four extremely small, isolated populations with a total of 48 to 50 individuals.

The results of the survey induced provincial and local authorities to immediately implement actions to protect the douc langurs and the remaining habitat as well. A "Community Forest Protection Team" was established to patrol the area daily and any deforestation to extent an Acacia plantation is now strictly prohibited. Furthermore the provincial authorities plan to develop a conservation action plan for the remaining douc langur populations and to grant the protection status for the four hills, which they inhabit. To this purpose about 80 ha of Acacia plantation will be repurchased from locals in order to set up a 10 years reforestation project and to create forest corridors between the currently isolated hills.

Phát hiện quần thể chà vá chân xám (*Pygathrix cinerea*) bị cách ly tại tỉnh Quảng Nam, Vietnam

Tóm tắt

Chà vá chân xám (*Pygathrix cinerea*) là một trong những loài linh trưởng quý hiếm nhất trên thế giới. Cùng với những thông tin trong các báo cáo trước đây về sự xuất hiện của loài này ở vùng phía nam của tỉnh Quảng Nam, khảo sát này nhằm xác định lại sự tồn tại của loài và đánh giá cấu trúc quần thể và kích thước quần thể. Kết quả đã xác định được 4 quần thể nhỏ và hoàn toàn cách ly trên 4 ngọn núi nhỏ có rừng đã bị suy giảm chất lượng nghiêm trọng tại địa bàn xã Tam Mỹ Tây, huyện Núi Thành, tỉnh Quảng Nam. Chính quyền địa phương đã có những hành động bảo tồn loài và hệ sinh thái ngay lập tức sau khi nhận được thông tin về sự tồn tại của 4 quần thể loài Chà vá chân xám trong khu vực. "Tổ bảo vệ rừng cộng đồng" đã được thiết lập để thực hiện tuần tra giám sát bảo vệ 4 quần thể Chà vá chân xám và việc phá rừng để mở rộng diện tích trồng cây Keo lai bị nghiêm cấm triệt để. Chính quyền tỉnh Quảng Nam đang xây dựng một kế hoạch hành động bảo tồn loài và sẽ đưa khu này vào vùng được bảo vệ nghiêm ngặt. Khoảng 80 ha đất đang trồng cây Keo lai của người dân địa phương sẽ được chính quyền địa phương mua lại để khởi động chương trình trồng rừng phục hồi hệ sinh thái trong 10 năm với mục tiêu mở rộng và tạo hành lang sinh thái kết nối 4 quần thể tách rời hiện nay.

Introduction

The grey-shanked douc langur (*Pygathrix cinerea*) counts among the 'World's 25 Most Endangered Primates' (Mittermeier et al. 2012) and is listed as 'Critically Endangered' on international (IUCN Red-List of Threatened Species 2019) as well as national level (Ministry of Science and Technology & Vietnamese Academy of Science and Technology 2007). The population in Vietnam is highly fragmented and the species is in the focus of the country's protection and conservation activities (Prime Minister of Government 2017).

Following up on scarce information from locals about the occurrence of this species in the southernmost part of Quang Nam Province, we carried out surveys to verify the existence of the species, to estimate the population size, to assess the threats and to recommend measures for its conservation. The occurrence of the species in the central and northern part of the province had been confirmed during a survey in 2004 (Minh Hoang et al. 2004). But a large group close to one of the new discovered populations disappeared already together with the rest of the forest in the area, replaced with Acacia plantations.

Study site

Surveys were carried out in the remaining pieces of evergreen forest in non-protected areas. The area borders the two communes Tam My Tay and Tam Thanh in Nui Thanh District. The nearest village is located about 1 km away and Nui Thanh town is at a distance of about 15 km. The total size of the surveyed areas is 30.5 ha. Natural forest covers hilly and rocky areas on five isolated mountains locally named Hon Duong Bong, Hon Do, Hon Ong, Hon Da Dung and Hon Truc (Fig. 1). The habitat in this area is heavily disturbed by deforestation. The five mountain tops, where the surveys were conducted are completely separated by Acacia plantations, planted by local people in the 1990's to improve their livelihoods (Fig. 2). The altitude of the hills is between 200 to 300 m asl and the highest point is Hon Duong Bong at 450 m asl. The main forest type is poor lowland evergreen forest. The vegetation is dominated by a number of very large ficus trees (*Ficus* sp.) with an understory of shrubs, bushes and vines (Fig. 3). The canopy cover is about 70%. The distance between the hills ranges from 300 m to 700 m.

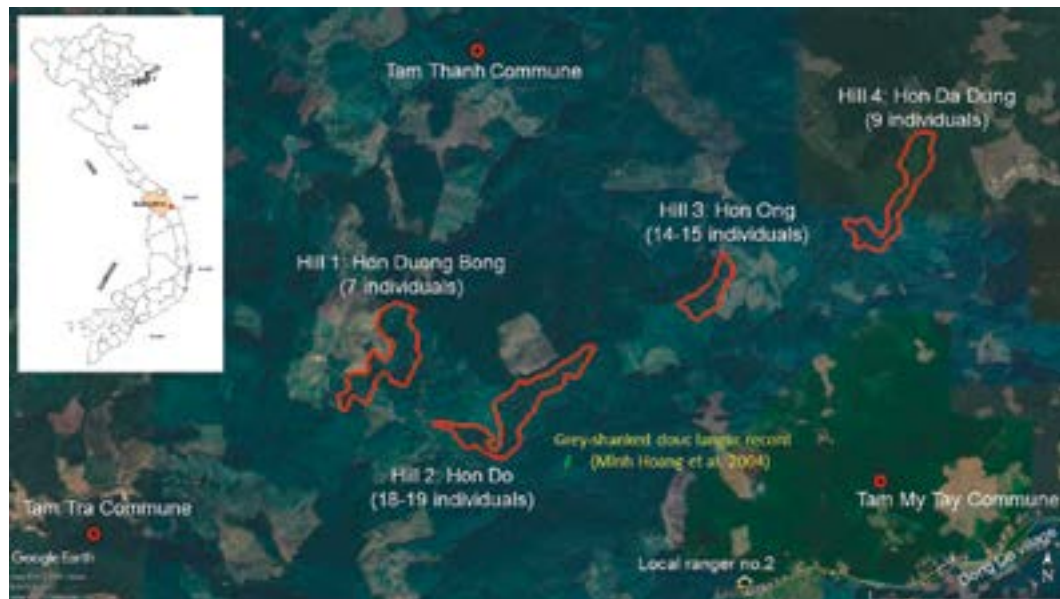


Fig.1. Discovered grey-shanked douc langur populations (*Pygathrix cinerea*) in the southern part of Quang Nam Province.



Fig.2. The remaining natural forest on the top of the hills is surrounded by Acacia plantations. Photo: Bui Van Tuan.

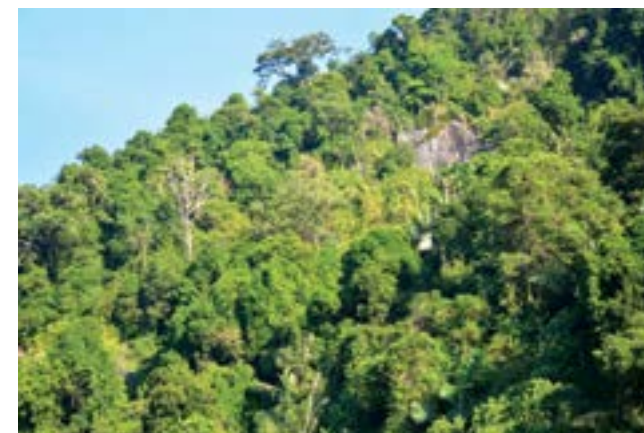


Fig.3. Status of the remaining forest on Hon Do Hill. Photo: Bui Van Tuan.

Material and Methods

Interview survey

For the interviews was used a formal questionnaire with questions which we had already frequently used in previous primate surveys. We interviewed 55 people, including rangers, collectors of forest products, local residents, farmers from the Acacia plantations and staff of local authorities. The questions concentrated on abundance, distribution and population status of the douc langurs and other primate species. Furthermore we asked about changes in forest conditions, the hunting and trapping situation and about maintenance intensity and extension of the Acacia plantations.

Field surveys

Field observations began at 5:00am and finished 6:00pm. In total, 21 people were involved in 7 survey teams for a two-day survey in the field. Each trained surveyor was accompanied by a ranger from the district Forest Protection Department and a local guide who was familiar with the animals and the locality.

Team 1 surveyed Hon Truc Hill (2 ha forest), team 2 Hon Duong Bong Hill (8 ha forest), and team 3, 4 and 5 Hon Do Hill (10.5 ha forest), team 6 covered Hon Ong Hill (5 ha forest), and team 7 Hon Da Dung Hill (5 ha forest). The douc langurs were recorded from the areas surrounding the hills by observing the hillsides from a distance of about 150 m. We intended to record the group compositions, the number of individuals, as well as sex and age of the animals. The GPS coordinates

of the locations, where douc langurs were observed, were noted and marked on a map. Samples of plant species eaten by the douc langurs were collected for identification.

For the observations and recordings we used telescopes mounted on tripods, binoculars, a digital camera with 150-600 mm lens, and a digital camera with 2000 mm optical zoom.

Results

Interview results

All local residents were readily able to describe and recognize the grey-shanked douc langurs and 90 % of the interviewees reported actual sightings of douc langurs. Locals estimated the size of the douc langur population from 20 to 100 individuals. Additionally, collectors of forest products reported the occurrence of pygmy lorises and pig-tailed macaques.

Field survey

The survey team recorded four small populations of grey-shanked douc langurs; one on each remaining forest patch: 7 individuals on Hon Duong Bong (8 ha forest), 18 to 19 individuals on Hon Do (10.5 ha forest), 14 to 15 individuals on Hon Ong (5 ha forest) and 9 individuals on Hon Da Dung (5 ha forest). In total 5 infants were observed (Fig. 4). No observation were made on the 2 ha Hon Truc hill (Table 1).

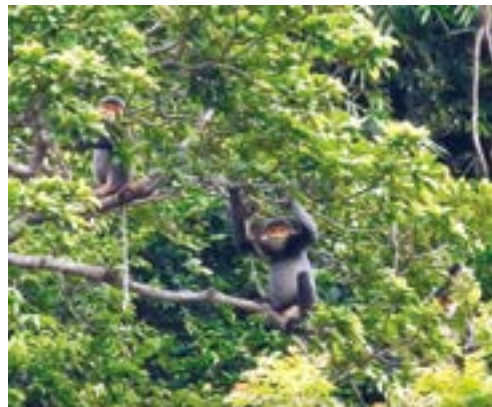


Fig.4. Grey-shanked douc langur group (*Pygathrix cinerea*), left female, right male with juvenile. Photo: Bui Van Tuan.

Table 1. Group composition of the observed grey-shanked douc langurs.

Locations	No. of groups	No. of individuals	Group structure				
			adult male	adult female	subadult	juvenile	infant
Hon Duong Bong	1	7	1	3	1	2	
Hon Do	1	18-19	2	unknown	unknown	unknown	2
Hon Ong	1	14-15	1	unknown	unknown	2	2
Hon Da Dung	1	9	1	3	2	2	1
Hon Bang Truc	0	0	0	0	0	0	0
TOTAL	4	48-50					

A group of 35 northern pig-tailed macaques (*Macaca leonina*) and a red muntjac (*Muntiacus muntjak*) were also recorded during the survey (Fig. 5).



Fig.5. A large group pig-tailed macaques (*Macaca leonina*) stay together with the grey-shanked douc langurs in the remaining forest on the hill top. Photo: Bui Van Tuan.

Poaching and habitat destruction

Locals stated that the douc langurs in this area are quite easy to hunt because their habitat is extremely small, poachers can find them easily and the forest is not well protected. The douc langurs, macaques and other wildlife are hunted with handmade guns and snare traps. Local residents claimed that douc langurs were common in the area before 2000 when Acacia plantations started at a large scale.

Poaching and trapping is still common in the area. In September 2018 the killing of a pig-tailed macaque was reported by rangers. The survey team 1 removed 25 snare traps from the Hon Truc Hill.

In the past thirty years local residents have converted about one thousand hectares of primary evergreen forest into Acacia plantations to improve livelihood and to cover the increasing demand on timber for construction and furniture industry (Maraseni et al. 2017).

Remarks about the distribution of red- and grey-shanked douc langurs in Quang Nam Province

Quang Nam Province is the region where red- and grey-shanked douc langurs occur parapatric, probably with a small sympatric zone. The northern part of the province is home to red-shanked douc langurs (*P. nemaeus*), and grey-shanked douc langurs live in the southeastern part. Historical observations are not helpful for species identification because until the recognition of the grey-shanked douc langur as subspecies of the red-shanked douc langur (Nadler 1997) and the following elevation to species level (Roos & Nadler 2001) all douc langurs in the region were referred to as red-shanked douc langurs. The border between the distribution of the two douc langur species are most probably the Thanh and Cai River (Fig. 6). Hunters and locals in the area reported about separate groups of red- and grey-shanked douc langurs (Ha Thang Long 2000; Nadler pers. comm.). But there are also observations of animals with possible signs of hybridization, like grey-shanked douc langurs with small white markings on the forearms (Ming Hoang et al. 2004). Currently there is no genetic evidence of hybrids or a hybrid population.

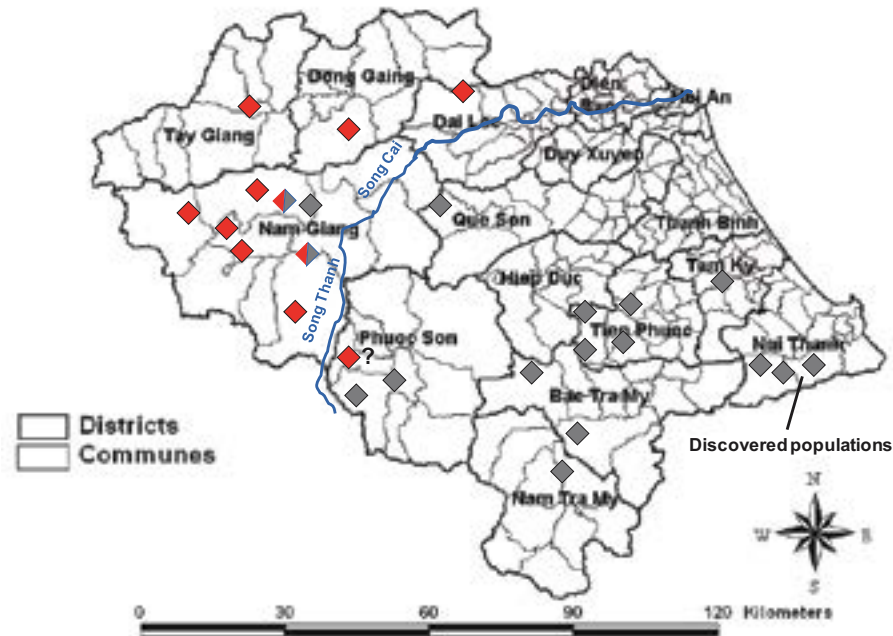


Fig.6. Distribution of red-shanked and grey-shanked douc langurs (*Pygathrix nemaeus* and *P. cinerea* – red and grey quads) in Quang Nam Province, and an area with potential hybridization (divided quads).

The localities are based on survey data, information from locals and confiscated individuals which were transferred to the Endangered Primate Rescue Center (Ha Thang Long 2000; Harding & Groves 2001; Minh Hoang 2004; Nadler et al. 2003; Vu Ngoc Thanh pers. comm. cf. in Nadler et al. 2003.)

Conservation initiatives

The results of the survey motivated provincial and local authorities to implement immediate actions to protect the douc langurs and the remaining habitat. A “Community Forest Protection Team” (CFT) was established consisting of local rangers and three local people, familiar with the area and the douc langurs. The team is managed by the People’s Committee of Tam My Tay commune. The duty of the team is to patrol the area daily to ensure the safety of the douc langurs and to monitor potential deforestation through local residents.

Local authorities also prohibited any deforestation to extent the Acacia plantations. Two large sign boards were set up to inform locals about the protection status of the douc langurs.

Several meetings were organized in the surrounding villages to publicize the information about the existence of the douc langurs and the necessity to protect them and their habitat.

The government of Quang Nam Province called conservation organizations in Vietnam for support to carry out further surveys and conservation activities. The provincial authorities plan to develop a conservation action plan for the remaining douc langur populations, to grant the protection status for the four hills and to repurchase 80 ha of Acacia plantation from locals in order to set up a 10 year reforestation project to create forest corridors between the currently isolated hills (Dac Thanh 2018).

Recommendations to support the conservation of the douc langurs

- Establishment of two more “Community Forest Protection Teams” in Tam Thanh and Tam Tra Commune
- Preparation of a feasibility study to obtain protection status for the hills and for the establishment of forested corridors between the hills
- Implementation of a campaign to inform people in the surrounding areas about protection, conservation activities, and applicable laws

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A large population of the northern yellow-cheeked gibbon (*Nomascus annamensis*) and new records on the primate diversity in Ba Na-Nui Chua Nature Reserve, Danang, Vietnam

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Key words: *Nomascus annamensis*, *Pygathrix nemaeus*, *Macaca arctoides*, *Macaca leonina*, *Nycticebus pygmaeus*, listening posts, trail surveys, camera traps, Annamite Mountains

Summary

Primates are in the focus of conservation in the Central Annamite Mountains, and biological assessments, such as on-the-ground surveys, are essential for providing necessary data to develop suitable conservation strategies to ensure their long-term survival. Ba Na-Nui Chua Nature Reserve (BNNC), is located in the vicinity of Danang City in Vietnam and encompasses a stretch of evergreen forests that has not been surveyed extensively. Especially for the newly included expansion areas, northwest of the original reserve boundaries, there is only limited information. Of particular concern in this area are the crested gibbons (*Nomascus* spp.) and douc langurs (*Pygathrix* spp.) and information on their distribution and population status are urgently needed. From June 2016 to July 2017, we conducted mixed methodology interview surveys of reserve rangers and local residents in order to assess the presence of primate species in the area. The study revealed that at least six primate species occur. Five of these species were confirmed during the subsequent surveys: northern yellow-cheeked gibbon (*Nomascus annamensis*), red-shanked douc langur (*Pygathrix nemaeus*), stump-tailed macaque (*Macaca arctoides*), northern pig-tailed macaque (*M. leonina*), and pygmy loris (*Nycticebus pygmaeus*).

We surveyed the 2000 ha of the expansion areas and recorded 14 to 16 groups of the northern yellow-cheeked gibbon, which lead us to estimate a total population in the expansion areas of more than 100 groups.

Based on these findings, we recommend conservation and research activities in BNNC and promote the long-term protection of primates at this site by incorporating BNNC as part of the critical conservation priority area in the Central Annamite Mountains.

Ghi nhận mới về 2 loài linh trưởng quý hiếm vượn đen má hung phía bắc và voọc chà vá chân nâu và những thông tin chung về khu hệ linh trưởng ở khu bảo tồn thiên nhiên Bà Nà – Núi Chúa, Đà Nẵng.

Tóm tắt

Khu bảo tồn thiên nhiên Bà Nà – Núi Chúa (BNNC) nằm ở phía Tây Bắc thành phố Đà Nẵng, miền trung Việt Nam, với hơn 30.000 hecta rừng thường xanh mùa mưa mùa nhiệt đới ẩm. Khu bảo tồn bị tác động mạnh từ các khu du lịch, đường cao tốc, và dân cư sống xung quanh khu vực vùng đệm. Kết quả khảo sát trước đây đã từng ghi nhận có mặt của loài Voọc chà vá chân nâu, 1 loài Vượn, và các loài Khỉ tại khu bảo tồn BNNC, tuy nhiên, chưa có thông tin chi tiết về hiện trạng quần thể của các loài. Từ tháng 6.2016 đến tháng 7.2017, chúng tôi đã sử dụng kết hợp nhiều phương pháp khác nhau gồm: phỏng vấn 40 người tại địa phương, khảo sát trên 30.1km tuyến và 5 điểm nghe Vượn hót, và

lắp đặt 24 điểm đặt bẫy ảnh (Camera Trap) để điều tra thành phần loài và hiện trạng quần thể các loài Linh trưởng tại đây. Kết quả, chúng tôi xác định được có ít nhất 5 loài linh trưởng phân bố trong khu bảo tồn thiên nhiên BNNC gồm Vượn má hung phía bắc (*Nomascus annamensis*), Vượn chà và chân nâu (*Pygathrix nemaeus*), Khỉ đuôi lợn bắc (*Macaca leonina*), Khỉ mặt đỏ (*Macaca arctoides*); và Cu li nhỏ (*Nycticebus pygmaeus*). Trong đó, chúng tôi ghi nhận được 14 -16 đàn Vượn đen má hung phía bắc tại 5 điểm nghe. Ngoài ra, trên các tuyến khảo sát ghi nhận được 6 đàn Vượn chà và chân nâu với khoảng 36 – 44 cá thể và đặc biệt có hình ảnh từ 3/24 điểm đặt bẫy ảnh ghi nhận loài này hoạt động dưới đất. Cán nhân mạnh là loài Khỉ đuôi lợn và Khỉ mặt đỏ rất hiếm gặp trực tiếp khi khảo sát trên tuyến, nhưng cả 2 loài này đều cùng xuất hiện và được ghi lại hình ảnh từ 15/24 điểm đặt bẫy ảnh.

Introduction

The Central Annamite Mountains are home to an incredible diversity of wildlife and have been identified as an area of global conservation priority area of critical biological importance (Tordoff et al. 2003). Primates are a conservation focus within this priority landscape, and biological assessments, such as on-the-ground surveys, are essential for providing the necessary data to develop suitable conservation strategies. Of particular concern are the crested gibbons (*Nomascus* spp.) and douc langurs (*Pygathrix* spp.). Information on the species distribution and population status is either lacking or incomplete (Pham Hong Thai 2015).

Ba Na-Nui Chua Nature Reserve (BNNC), is located in the vicinity of Danang City, Vietnam (15°57'-16°08'N, 107°49'-108°04'E) and encompasses a stretch of evergreen forest spanning from the foothills of the Central Annamites to the lower montane level. The reserve was established in 1986 and originally covered 8,134 ha. It was enlarged in 2013 to a total size of 32,377 ha through the addition of two expansion areas.

The diversity of flora and fauna in BNNC is high. Of particular interest is that many plant species possess transitional characteristics between those of the northern and those of the southern eco-regions of Vietnam (Dinh Thi Phuong Anh et al. 2005). Several notable surveys have been conducted since the 1990's. Currently 739 vascular plant, 77 mammal, 214 bird, 81 reptile, 38 amphibian, 33 fish and 126 butterfly species are recognized for the area (Pham Hong Thai 2015; Le Vu Khoi et al. 2011; Dinh Thi Phuong Anh et al. 2005; Hill et al. 1996).

However, all surveys were conducted in the original parcel of BNNC, and none of them focused on primates. Consequently there is not only no data on the status of primates in the expansion area but data reflecting the primate diversity within the original nature reserve is also lacking.

This study constitutes the first inventory of primate species in the BNNC expansion areas.

Study sites

The primate surveys were conducted within the two expansion areas of BNNC Nature Reserve. The southern expansion is locally known as Song Nam and comprises 12,401 ha and the northern expansion as Song Bac and comprises 11,841 ha (Fig. 1). The surveyed areas represent approximately 2,000 ha or about 10% of the total expansion area. The study sites ranged from 70 to 1200 m asl, with an elevations increasing from south (maximum 900 m asl) to north (maximum 1,200 m asl). Comparatively, the terrain of the northern expansion is more rugged than the south, consisting of a number of deep river valleys, and steep ridges with prominent rock outcrops.

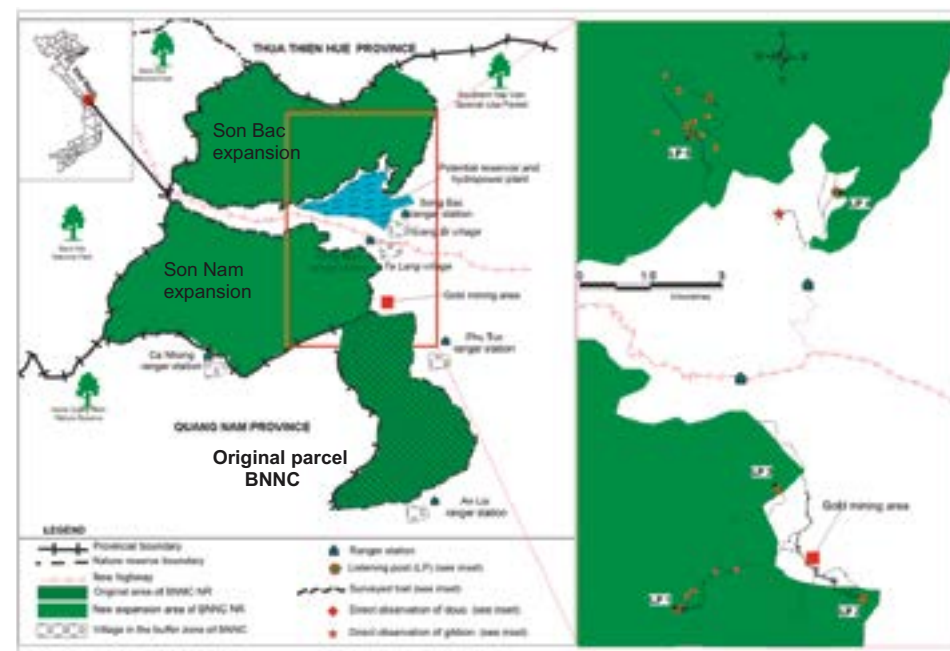


Fig.1. Ba Na-Nui Chua Nature Reserve and the expansion areas Song Nam and Song Bac. Insert map show the study site and surveyed trails, listening posts and direct sightings of red-shanked douc langurs (*Pygathrix nemaeus*) and northern yellow-cheeked gibbons (*Nomascus annamensis*).

As BNNC is situated in the Central Annamite Range, the climate is characterized as tropical monsoon climate with two distinct seasons; the wet season lasts from August to December, with the greatest amounts of rainfall in October and November, the peak of the dry season falls between February and June. The total annual rainfall averages about 2,500 mm. Average daily temperature ranges from approximately 20°C in December and January, to approximately 29°C in June, July and August (Nguyen Khanh Van et al. 2000).

The main vegetation types at BNNC are lowland evergreen forest (<1,300 m asl) and lower montane evergreen forest (>1,300 m asl) (Fig. 2). Dipterocarpaceae dominate the lowland evergreen forest, but are absent in the lower montane evergreen forest, which is characterized by Fagaceae, Lauraceae and Podocarpaceae (Hill et al. 1996).



Fig.2. Lower montane evergreen forest at Ba Na-Nui Chua Nature Reserve. Photo: T. Nadler.

Selective logging occurred in the Annamite Mountains in the early 1900's, and the habitat suffered further devastation during the Vietnam War. Consequently the forests at all elevations in BNNC have been impacted. Previous clearings support only secondary growth, which varies in vegetation structure and composition depending on the time that has elapsed since the disturbance. The original parcel of BNNC has been opened for tourism in 2002 and in the past 15 years habitat disturbance has increased dramatically, especially on Ba Na Mountain where a major tourism development transformed the forest area into a resort and amusement park, which included the installation of a 5.8 km long cable car system. The area is a very popular tourist destination and averaging 5000 visitors daily, the number of visitors to Ba Na Mountain surpassed 1.5 million in 2015 (Data: Ba Na Cable Car Co., Ltd) (Fig. 3).



Fig.3. Mountain top in Ba Na-Nui Chua Nature Reserve in 2012 during the conversion in a Mega-Tourist Amusement Park. Photo: T. Nadler.

The original BNNC Nature Reserve forest is contiguous with the southern expansion. However, the northern expansion is separated from the southern expansion and the original nature reserve's forest by the nearly completed La Son-Tuy Loan Highway, which connects Thua Thien Hue Province and Danang City (Fig. 1).

Approximately 10,000 people (about 90% Kinh and 10% Co Tu ethnicities) live in several villages bordering the reserve. Although public access to the expansion areas is strictly prohibited, hunting, logging and harvesting of non-timber products still occur. There is also a small governmentally approved gold mining concession that operates on property adjacent to the eastern boundary of the southern expansion area, Song Nam.

Survey methods

Interviews

Prior to implementing the field surveys interviews were conducted in order to gather information about BNNC, and specifically, about the study sites Song Nam and Song Bac. Such interviews are important to assess the general distribution, status, and threats to the different primate species, as well as trends in primate populations during the last 15 years. The interviewees included 10 rangers of the nature reserve and 30 local residents from Ta Lang and Giang Bi villages, of whom five were retired or active hunters, 15 were non-timber forest product collectors, and ten were farmers. No rangers were present during the interviews with local residents to avoid any bias in their responses. The interviews were semi-structured; and though we used a prepared questionnaire, with a strict order in the questions, but the format also allowed the interviewees to provide additional information freely. A set of color images of primate and other mammal species, which inhabit the Central Annamite Mountains was shown to the interviewees to assess their knowledge and responses regarding species identification.

Field surveys

Different survey efforts but the same methodologies were used at the two study sites. In Song Nam three teams and in Song Bac two teams conducted the survey using three methods:

1. listening posts (LP) to record gibbon vocalization and to define locations
2. trail surveys (TS), walking along existing trails to detect the presence of diurnal primates by direct observation
3. camera traps (CT), deploying camera traps to capture images of terrestrial species along or near the trails

Listening posts (LP)

Based on the information obtained during the interviews, each team selected a LP location near their camp (100-300 m distance) to record gibbons singing every morning (Nguyen Ai Tam et al. 2017) (Fig. 4). As the camps were located at least 3.4 km apart in Song Nam and 3.3 km apart in Song Bac, it was assumed the auditory range, which the LP's covered, were non-overlapping because any gibbon songs more than 1.5 km from listening posts can not be recorded reliably and consistently (Channa & Gray 2009).

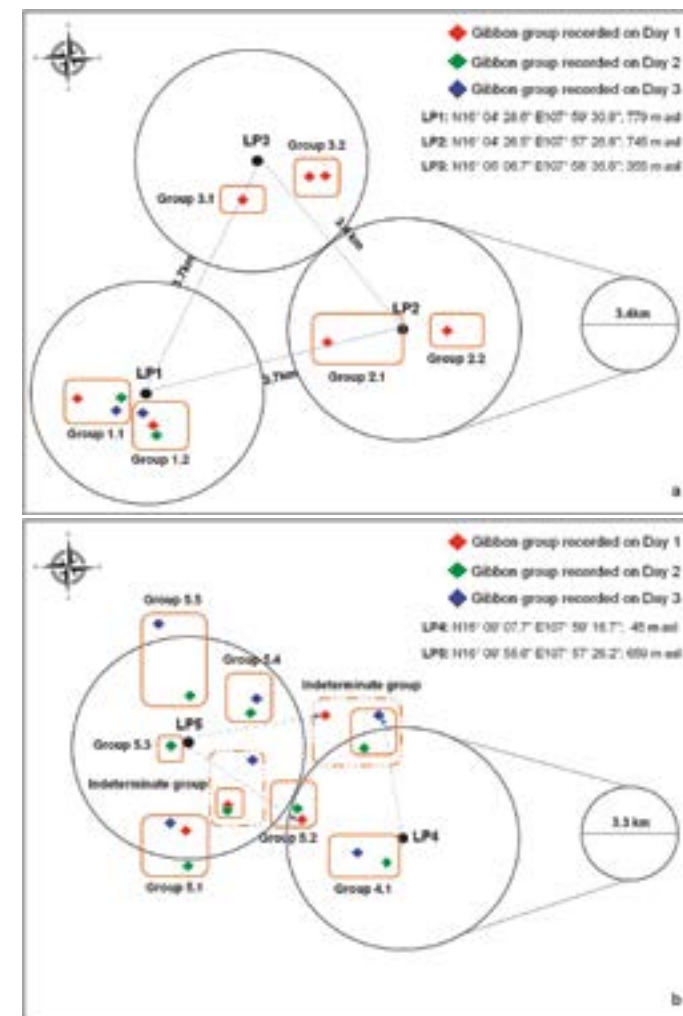


Fig.4. *Nomascus annamensis* groups based on acoustic data collected at listening posts and during trail surveys in Song Nam (a) Song Bac (B).

Between approximately 5am and 7:30am gibbon songs were recorded on either a Sony ICDPX370 Mono Digital Voice Recorder or Roland R-26 6-Channel Digital Field Audio Recorder with a Takstar SGC-568 directive interview microphone. The distance and direction of the vocalization were noted to a field diary (Brockelman & Srikosamatara 1993).

Trail surveys (TS)

Diurnal surveys were conducted along 13 existing trails in Song Nam (n=7) and in Song Bac (n=6). Each trail was walked only once. The survey began at about 8am and ended between 4pm and 6pm, depending on the length of the trail (range: 1.7-3.4 km). The species of primates observed were identified directly or with the aid of binoculars. Photographs were taken when the situation allowed. The numbers of individuals in the group, sex and age classes were recorded when possible. The time of encounter, habitat type, and forest condition and GPS coordinates were noted using a Garmin 62Sc GPS unit.

Camera traps (CT)

We deployed 21 digital camera traps with infrared sensor and no glow 'black' LED flash (Bushnell Trophy Cam, models 119445, 119446) along the survey trails in locations deemed suitable to monitor terrestrial mammals. The location of each camera trap was recorded by GPS with the distance between cameras being 100 to 500 m. Cameras were mounted on trees at a height of 50 to 100 cm above the ground. No baits or lures were used. The trapping effort lasted from June 28th 2016 to July 5th 2017.

Each camera was programmed as follows: still image, 8 M pixel image size, 3 photos in sequence per trigger, 5-sec interval between triggers, time and date stamp on. Each camera was fitted with a 16 GB SD card (SanDisk Ultra). Although the camera's internal battery compartment can accommodate eight AA batteries, we loaded only four (Energizer alkaline batteries) and placed four 5 g silica gel desiccant packs in the remaining slots. To further reduce the possibility of moisture accumulating inside the battery compartment, the rubber gasket around the battery compartment was coated with silicone grease (Nikon WP-G1000) before closing the camera case (Tan et al. 2015).

The cameras were examined at 37-275 day intervals depending upon remoteness of location. Batteries and/or SD cards were replaced as necessary. The images were evaluated, and if the quality was poor and/or the number of animal pictures captured was low, the cameras were remounted at a different location. The number of trap days (24-hr period) from date of camera deployment until date of retrieval was calculated. Any data resulting from false-triggers, (i.e. when a camera continuously captures images even though there is no subject) were excluded. Three cameras were stolen during the study, and one camera failed. For the report we used images captured at 24 camera locations of which 14 were located in Son Nam and ten in Song Bac.

Results and Discussion

Using this mixed methodology we were able to confirm the presence of five primate species in the expansion areas of the nature reserve, namely the northern yellow-cheeked crested gibbon (*Nomascus annamensis*), red-shanked douc langur (*Pygathrix nemaeus*), stump-tailed macaque (*Macaca arctoides*), northern pig-tailed macaque (*M. leonina*), and pygmy loris (*Nycticebus pygmaeus*). Besides these species, long-tailed macaque (*M. fascicularis*), rhesus macaque (*M. mulatta*) and Bengal slow loris (*Nycticebus bengalensis*) have been reported in the original parcel of the reserve during the interviews (Table 1).

Table 1. Primate species and their conservation statuses as confirmed by previous and current studies in Ba Na-Nui Chua Nature Reserve.

Scientific, English and local names ¹	Conservation status		This study ²			Previous studies ³
	IUCN Red List	Viet Nam Red Book	DO	VA	CT	
<i>Nomascus annamensis</i> Northern yellow-cheeked crested gibbon Vuon	n/a	n/a	+	+		a, b, d
<i>Pygathrix nemaeus</i> Red-shanked douc Doc	EN	EN	+		+	d
<i>Macaca arctoides</i> Stump-tailed macaque Khi cộc	VU	VU	+		+	b, c
<i>Macaca leonina</i> Northern pig-tailed macaque Khi đầu chó	VU	VU			+	c
<i>Macaca fascicularis</i> Long-tailed macaque Khi nước	LC	LR	+			d
<i>Macaca mulatta</i> Rhesus macaque Khi đất	LC	LR				b, c, d
<i>Nycticebus pygmaeus</i> Pygmy loris Khi gió" or cù lân nhỏ	VU	VU	+			c, d
<i>Nycticebus bengalensis</i> Bengal slow loris Khi gió" or cù lân lớn	VU	VU				c

¹ Local name is based on the Kinh dialect.

² Survey conducted in the new expansion areas of Ba Na-Nui Chua Nature Reserve (DO = direct observation, VA = vocal analysis, CT = camera trap).

³ a = Ghazoul et al., 1994; b = Hill et al., 1996; c = The People's Committee of Da Nang 1997 unpublished report; d = Le Vu Khoi et al., 2011. All surveys conducted in the original reserve parcel.

Northern yellow-cheeked gibbon (*Nomascus annamensis*)

The majority of our interviewees recognized the gibbons in the photograph we showed but we were not able to determine if this was based solely on field sightings or if it was related to the fact that a primate information poster produced by GreenViet has been on display in the village communal areas since 2015. Rangers stationed at An Loi and Phu Tuc near the original parcel reported the extirpation of gibbons in this area around 2006 when massive deforestation occurred at Ba Na Mountain for tourism development. And during the following construction phase, many primate species have become increasingly rare. The rangers assumed that the animals migrated from the disturbed original parcel into the forest northwest of the original parcel.

Near the expansion areas, rangers of Song Nam, Song Bac and Ca Nhung stations, as well as residents of Ta Lang and Giang Bi villages all provided recent information about gibbons. Specifically the forest product collectors and hunters reported direct gibbon sightings, farmers from Giang Bi

reported hearing gibbon songs every morning while working in their fields next to the primary forest of Song Bac, and Ca Nhung rangers described hearing gibbon calls from their station (Fig. 1).

During the trail surveys in Song Bac, two groups of gibbons were observed, one group with four individuals (one adult female, one adult male and two subadult black individuals). The second group consisted of five individuals (one adult male, two yellow females, two black subadults and one juvenile) and was observed in the buffer zone.

Data on calls collected from the listening posts and during trail surveys suggested that there are 14-16 gibbon groups residing in the two study areas; six of them in Song Nam and eight to ten in Song Bac (Fig. 3). The estimated distance from the listening posts to the singing groups ranged from 200 – 2100 m. Groups located near LP5 in Song Bac were singing throughout the day, whereas other groups mainly vocalized in the early morning between 5am and 7am and occasionally in late afternoon (Fig. 4). In total 75 minutes of gibbon songs were recorded.

For species identification the recorded sound data files were first converted into WAV files and then analyzed using Avisoft-SASLab Pro. To validate the gibbon species the vocal recordings were analysed based on the methodology described by Nguyen Van Thien et al. (2017). The song of the northern yellow-cheeked crested gibbon is distinct from those of the southern yellow-cheeked crested gibbon and the southern white-cheeked crested gibbon (Van Ngoc Tinh et al. 2010a)

The current known distribution of *N. annamensis* reaches from the Thach Han River in the North (about 16°40'-16°50' N) to the Ba River in the South (about 13°00'-13°10' N) (Van Ngoc Tinh et al., 2010a, b), although this southern boundary is still in dispute (Hoang Minh Duc, pers. comm.).

Populations of *N. annamensis* are known from 18 protected areas (Rawson et al. 2011).

Our survey covered only about 10 % of the extension area of BNNC Nature Reserve and the survey areas were close to areas of human activities. We suppose that remote parts of the expansion areas still hold a significant population of the species, and estimate that there might be as more than 100 further groups.

Previous surveys referred this population to the northern white-cheeked gibbon (*N. leucogenys*) (Geissmann 2002; Hill et al. 1996; Ghazoul et al. 1994).

Red-shanked douc langur (*Pygathrix nemaeus*)

All interviewees recognized the red-shanked douc langur in the photographs shown to them. As was the case with gibbons, rangers of An Loi and Phu Tuc stations had not seen any signs of *P. nemaeus* since about 2006, which they attributed to habitat loss linked to tourism and continuous infrastructural development which started in 2004 and still continues. In contrast, rangers of Ca Nhung station reported seeing *P. nemaeus* often. In total, 24 out of the 40 people interviewed had seen douc langurs directly; so of all primate species the douc langur was the one most frequently observed

During the trail surveys, which covered a total distance of 30.1 km, 6 groups of *P. nemaeus* were observed; two were spotted in Song Nam and four in Song Bac. The animals were observed at elevations ranging from 440 to 1034 m asl (Table 2). Most of the groups were encountered along streams in complex terrain. At observations were made at locations, where the habitat disturbance was low and the canopy consisted of multiple layers of trees averaging 20 – 25 m in height. The smallest group comprised only three to five individuals, whereas the largest group comprised between 12 and 15 animals. We estimated the total number of animals at this location at 44 individuals. As the individuals were wary of humans only the numbers of individuals were counted, sex and age classes could not be recorded.

Table 2. Red-shanked douc langur groups (*Pygathrix nemaeus*) encountered during trail surveys in Song Nam and Song Bac of Ba Na-Nui Chua Nature Reserve

Site	Trail no.	Length (km)	Date	Time	Group no.	Individuals observed (estimated group size)	Coordinates	Elevation (m asl)
Song Nam	TS7	2.5	06/29/2016	07:21	1	12 (15)	N16° 04' 35.0" E107° 57' 31.9"	756
				12:04	2	3 (5)	N16° 04' 30.5" E107° 57' 30.2"	775
Song Bac	TS8	3.4	07/09/2016	15:48	3	3 (5)	N16° 09' 52.1" E107° 57' 28.9"	570
				11:48	4	4	N16° 10' 23.8" E107° 57' 13.1"	1034
				14:27	5	10 (11)	N16° 10' 09.8" E107° 57' 29.9"	725
16:34	6	4	N16° 09' 58.2" E107° 57' 38.6"					

Photographs of *P. nemaeus* were taken at three of 24 camera trap locations (Song Nam: SN05, SN07; Song Bac: SB6) (Table 3). Camera SN05 captured three juveniles of similar age playing on the forest floor (Fig. 5). This group contained at least seven individuals and in this exceptional case we were able to record sexes and age; we recorded one adult male, three adult females and three juveniles. Camera SN07 captured three individuals traveling on the ground. Camera SB6 captured one individual foraging on the ground.

Table 3. Camera trap locations showing presence of red-shanked douc langurs (*Pygathrix nemaeus*), stump-tailed macaques (*Macaca arctoides*) and northern pig-tailed macaques (*M. leonina*) in Song Nam and Song Bac of Ba Na-Nui Chua Nature Reserve.

Location	Coordinates	Elevation (m asl)	<i>P. nemaeus</i>	<i>M. arctoides</i>	<i>M. leonina</i>
SN02	N16° 04' 44.8" E107° 57' 48.4"	817		+	+
SN03	N16° 04' 41.4" E107° 57' 43.6"	506		+	+
SN04	N16° 04' 37.5" E107° 57' 39.0"	819		+	+
SN05	N16° 04' 34.1" E107° 57' 32.6"	508	+	+	+
SN06	N16° 04' 28.1" E107° 57' 29.9"	764		+	+
SN07	N16° 04' 26.9" E107° 57' 27.6"	743	+	+	+
SN10	N16° 04' 20.9" E107° 57' 32.8"	727		+	+
SN16	N16° 04' 28.2" E107° 59' 28.9"	754		+	
SN17	N16° 04' 28.6" E107° 59' 29.7"	761		+	+
SN18	N16° 04' 28.7" E107° 59' 30.7"	773		+	+
SN19	N16° 04' 25.9" E107° 57' 33.6"	670			+
SB05	N16° 10' 04.0" E107° 57' 21.6"	786		+	+
SB06	N16° 10' 09.3" E107° 57' 15.6"	924	+	+	+
SB07	N16° 10' 15.4" E107° 57' 11.1"	1081		+	+
SB08	N16° 10' 19.4" E107° 57' 13.0"	1058		+	+
SB09	N16° 10' 27.3" E107° 57' 14.0"	1030		+	+
SB10	N16° 10' 30.5" E107° 57' 15.6"	998		+	+
SB12	N16° 10' 09.6" E107° 57' 50.1"	643			+



Fig.5. Camera trap photo shows three juvenile red-shanked douc langurs playing on the ground. Photo: LVDI International/GreenViet.

P. nemaus is generally considered an arboreal species, but it has been already reported that individuals occasionally descend to the ground (Vu Ngoc Thanh et al. 2008; Timmins & Duckworth 1999). Our camera trap photos confirm terrestrial behavior of douc langurs. We suspect that douc langurs spend more time on the ground when undisturbed. However they might be forced to travel on the ground in disturbed habitats with forest and canopy gaps.

That douc langurs crossed roads on the ground in areas where no closed canopy remained has previously been observed in nearby Son Tra Nature Reserve (Bui Van Tuan pers. obs.), exposing the douc langurs to an increased risk of traffic accidents. The La Son - Tuy Loan Highway which divides the expansion areas of BNNC also poses a great risk to crossing wildlife, including the douc langurs.

To date no surveys investigating the presence of douc langurs have been attempted in BNNC and reports that *P. nemaus* is common in the western and eastern parts of this nature reserve (Anonymous 1994) have not yet been verified.

Stump-tailed macaque (*Macaca arctoides*) and northern pig-tailed macaque (*Macaca leonina*)

As with *P. nemaus*, interviewees readily recognized the photographs of the stump-tailed macaque and the northern pig-tailed macaque and reported many sightings. 16 people could identify *M. arctoides* and 20 people recognized *M. leonina* and reported recent sightings, 11 of the 16 people who recognized *M. arctoides* were forest product collectors and hunters. Of the 20 people who reported seeing *M. leonina* in the expansion areas 17 were forest product collectors and hunters, and two were rangers. Two groups of *M. arctoides* were detected during the trail surveys in Song Nam at 670 and 741 m asl. A group with more than ten individuals was observed traveling on the ground and another with 15-20 individuals was seen in the canopy about 35 m above ground. During the survey was no direct sighting of *M. leonina*.

The camera trap photos indicated that *M. arctoides* groups were present at 16 locations and *M. leonina* groups were present at 17 locations. The species coexist at 15 locations, occupying the lowland evergreen forest of Song Nam and Song Bac (Table 3, Fig. 6, 7). We did not observe any behaviors that suggested direct competition.

Interestingly only *M. leonina* treated the novel object "camera trap" as a potential threat e.g. by showing aggressive facial expressions and body posture. This species might be more protective and might defend its home range from perceived intruders.



Fig.6. Camera trap shot a stump-tailed macaque (*Macaca arctoides*). Photo: LVDI International/GreenViet.



Fig.7. Camera trap shot a northern-pig-tailed macaque (*Macaca leonina*). Photo: LVDI International/GreenViet.

Long-tailed macaque (*Macaca fascicularis*) and rhesus macaque (*M. mulatta*)

The occurrence of long-tailed macaques and rhesus macaques was also confirmed by the interviewees. But during our survey we could not confirm the species by camera trap or direct sighting.

M. fascicularis and *M. mulatta* occur sympatrically in Vietnam between 16°30'N and 12°N, which includes also BNNC (Nguyen Van Minh et al. 2012). These species prefer secondary forests and areas associated with human activity. There is no information about their current status in the reserve. In 2012, three to four rhesus macaques were observed in cages in Ta Lang and Giang Bi villages (Bui Van Tuan, pers. obs.), and possibly the monkeys were trapped in the secondary forests nearby, but this was not confirmed and the animals might as well have come from another area. Between 2004 and 2010 the Department of tourism released a group of about 20 non-native long-tailed macaques of unknown origin on the top of Ba Na Mountains as tourist attraction and provisioned them there. Within a short time the habituated animals of this group became increasingly aggressive towards tourists and the group largely disappeared due to unknown reasons and at the time of this report only three individuals remain.

Pygmy loris (*Nycticebus pygmaeus*)

All interviewees recognized lorises but not everyone could differentiate between pygmy loris and Bengal slow loris. Both species are reported to occur in BNNC. Lorises were directly observed by 22 interviewees. Hunters from Ta Lang and Giang Bi mentioned that they are common in secondary forest near their villages. The Co Tu ethnic minorities in this area eat lorises but among the Kinh people eating lorises is a taboo.

The survey didn't focus on lorises and no night survey was conducted. But the presence of *N. pygmaeus* was confirmed through a trapped individual from a local Co Tu hunter, who was

encountered in the forest close to a survey trail. The animal was confiscated by the accompanying ranger and released back to the forest.

Threats to the primates in Ba Na – Nui Chua Nature Reserve

Mining, logging, monoculture plantations, over-harvesting of medicinal plants and the associated habitat destruction as well as hunting have been, and remain the major threats faced by all wildlife in BNNC (Pham Hong Thai 2015). But our survey identified several additional immediate threats to the primates in BNNC.

The rising demand for water in fast-growing Danang City, induced the People's Committee of Danang to build a dam at a narrow gorge on the Bac River near Ta Lang and Giang Bi villages. It is projected that the entire area below 100 m asl will be inundated (Fig. 1). The group of *N. annamensis* observed in this area at this elevation, will lose its territory. The flooding of forest with to will further reduce the already limited habitat currently available to primates and other wildlife. *N. annamensis* was only recently described as a new primate species (Van Ngoc Thinh et al. 2010a), and its status has not been assessed for the IUCN Red List and the Vietnam Red Data Book. Thus, a more intensive survey of *N. annamensis* in the expansion areas is urgently needed to quantify the size of this population.

Moreover, the new La Son-Tuy Loan Highway divides the northern and southern expansion areas and does curtail the movements of primates; reduce the exchange of individuals and the necessary gene flow within this population. The highway also will provide easy access for hunters and trappers to areas which were previously difficult to reach. The camera traps captured many images of people, clearly non-timber forest product collectors and some hunters with dogs.

With support from the BNNC rangers a large number of snare traps were removed and hunter camps destroyed during this study. As *P. nemeus*, *M. arctoides* and *M. leonina* exhibit terrestrial activities these primates are particularly vulnerable to snare traps.

The Son Tra Nature Reserve close to Danang may serve as a lesson regarding the negative consequences of an easy access to a protected area. In April 2015, Danang FPD arrested four hunters from the northern provinces of Vietnam in this reserve. These hunters established a camp, deployed snares, and killed at least two red-shanked douc langurs, and several other mammals. Five months later Son Tra rangers found a dead douc langur near the road with six bullets in its body. Additionally, four rhesus macaques were run over by motorbikes and electrocuted on power lines (Bui Van Tuan et al. in press). The Management Board of BNNC, needs to find preventative measures to combat poaching and to reduce wildlife accidents in the reserve.

Conclusions

Using mixed methodologies the study revealed that at least six primate species occur in the extension areas of BNNC, of which five were directly observed during our field surveys. The surveys provided the first records of the northern yellow-cheeked crested gibbon and red-shanked douc langur in these areas. Based on the high diversity of primates and other wildlife species found in the reserve (Bui Van Tuan et al. pers. com.), we recommend to increase research and conservation activities. BNNC should become part of a contiguous green corridor stretching from Phong Dien Nature Reserve to Bach Ma National Park (Thua Thien Hue Province) (Dickinson & Van Ngoc Thinh 2006).

Concerning the primate populations we recommend following:

Research

- A comprehensive survey within BNNC and the expansion areas should be conducted, using mixed methodologies outlined in this paper to determine presence, abundance and habitat preference of diurnal and nocturnal primate and to assess the threats;
- Surveys specifically for the northern yellow-cheeked gibbon and douc langur populations should be carried out in the buffer zone and the unprotected areas adjacent to BNNC and assess habitat

disturbance to develop conservation strategies (e.g. highway, hydropower dam construction and other human activities)

Conservation activities

- A ranger patrolling and monitoring program using the Spatial Monitoring and Reporting Tool (SMART) should be implemented to evaluate the impact on wildlife and to monitor primates and other endangered species
- Awareness and education activities conducted in cooperation with Danang FPD and the environmental police should combat wildlife consumption in local households and restaurants in Danang City and particularly in the buffer zone around BNNC;
- A conservation education and outreach program targeting children living in communities in the buffer zone should raise awareness and encourage stewardship in protecting endangered wildlife and essential habitats
- A master plan for eco-tourism development in the region should be prepared and incorporate jobs for local people to reduce the dependence on forest products

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Unexpected incidents during reintroduction of Hatinh langurs (*Trachypithecus hatinhensis*)

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Key words: reintroduction, Hatinh langur, *Trachypithecus hatinhensis*

Summary

The Hatinh langur (*Trachypithecus hatinhensis*) is listed as an endangered species and occurs in a restricted area of central Vietnam and eastern Laos. The largest population in Vietnam lives in Phong Nha-Ke Bang National Park, Quang Binh Province. Several isolated smaller populations are dispersed along the border to Laos, but their long-term existence is precarious due to hunting pressure and habitat destruction.

The Endangered Primate Rescue Center (EPRC) maintains a very successful captive breeding program for the species and using this as a founder population it aims now to establish a larger second wild population in Vietnam. A number of surveys were carried out in areas, where smaller populations of Hatinh langurs were known to still exist, and in areas, where the species formerly occurred but has been eradicated. The aim was to locate an adequate area for the reintroduction of a new population. Finally Ke Go Nature Reserve in Hatinh Province was chosen.

In June 2015 a group of five captive born individuals from the EPRC – one adult male, two adult females each with a juvenile female offspring was transported to the nature reserve, where they were kept for one day in a temporary cage at the release site. The adult individuals were equipped with satellite radio collars. The monitoring of the animals started after release and coordinates were continuously downloaded.

During the first month after release, the group established a home range using an area of approximately 9 ha. Over the second month the langur group gradually extended the home range and the travel distances increased.

Three months after release – in August 2015 – the langur group had a confrontation with an unusually large and aggressive rhesus macaque troop (*Macaca mulatta*). The macaques harassed the langurs for several days and the conflict finally split the langur group. The critical situation started end of August with another attack of the large macaque band and soon proved critical for the released Hatinh langurs. One female died end of August soon after the attack, most probably due to stress caused by the continuous harassment which prevented normal foraging and rest time for digestion, a necessary sequence for this leaf eating primates. At the end of October the second adult female was found on the ground where she subsequently died. One of the juvenile females was found dead in the water of the lake with injuries in the face. We assume that the macaques caused the deaths of the animals. The second juvenile female was observed to travel alone but as she was without radio collar. Her movements could not be followed when she finally disappeared deeper into the forest. The decision was made to catch the remaining male and to return it to the EPRC.

Early in 2016 further surveys were conducted to locate another release site. A 35 ha peninsula at the Ke Go Lake was identified as potentially suitable. In July 2016 three captive born adult Hatinh langurs - one male and two females - were reintroduced at this site. Mid August, after one and a half months, all three individuals moved from the peninsula through a stretch of 100 m open grass land to the main area of the nature reserve. In October 2016 a century high flood in the area interrupted the monitoring for some time.

The tracking and monitoring of the last released three individuals had to end unfortunately by the end December 2016, which was the end of the planned project period.

From the moment of the release from the temporary cage the reintroduced Hatinh langurs showed

no difficulties in finding adequate food sources.

The confrontation of the langurs with the macaques was very surprising. The occurrence of macaques in the nature reserve is known and was also confirmed during the preliminary surveys. In Indochina most langur species occur sympatrically with macaque species. The macaques are on joint sleeping places dominant, but such aggressive behaviour during daytime has to date not been observed. Probably the captive bred langurs lacked the experience and behavioural norms of a canny wild group; they showed no adequate reaction but displayed symptoms of extreme stress.

The final goal is the establishment of a second viable population of this endangered species in Vietnam. To reach this goal reintroduction of several groups with more than one or two females is necessary and hopefully within this project reintroduction will continue.

It has to be considered how the released langurs can be better prepared for confrontations with macaques in the future. The release of a group not solely composed of captive bred individuals but with a wild born and experienced male is a possible solution.

The establishment of a new population is not only a logistic challenge it needs also long-term financial support. Reintroduction always requires a long-term financial and personal commitment.

Những sự cố không mong đợi trong quá trình tái thả loài Voọc Hà Tĩnh (*Trachypithecus hatinhensis*)

Tóm tắt

Voọc Hà Tĩnh (*Trachypithecus hatinhensis*) có tên trong danh sách loài nguy cấp và có vùng phân bố rất hẹp ở miền trung Trung bộ và phía đông Lào. Quần thể lớn nhất ở Vườn quốc gia Phong Nha – Kẻ Bàng, Tỉnh Quảng Bình. Một số quần thể nhỏ, tách biệt khác phân bố dọc biên giới với Lào. Tuy nhiên sự tồn tại lâu dài của các quần thể nhỏ này đang bị đe dọa do nạn săn bắn. Mục tiêu của dự án tái thả là tạo lập một quần thể bền vững thứ hai ở Việt nam. Tại trung tâm cứu hộ thú linh trưởng (EPRC), một quần thể Voọc Hà Tĩnh sinh sản trong nuôi nhốt có đủ điều kiện để thiết lập quần thể ban đầu phục vụ cho tái thả. Khu bảo tồn thiên nhiên Kê Gồ được lựa chọn làm nơi tái thả sau khi các nghiên cứu đánh giá thực trạng hệ sinh thái được tiến hành. Tháng 6 năm 2015, một quần thể 5 cá thể gồm một con đực trưởng thành, hai con cái trưởng thành, hai con nhỏ được đưa đến khu bảo tồn. Cá thể đực được gắn định vị vệ tinh trên vòng đeo cổ. Việc giám sát động vật được tiến hành ngay sau khi thả, các dữ liệu về vị trí, tọa độ được liên tục cập nhật. Trong 6 tháng đầu, quần thể Voọc đã thiết lập một vùng sống cho bầy với diện tích khoảng 9 ha. Ở tháng thứ hai sau khi thả, bầy bắt đầu mở rộng vùng sống và di chuyển xa hơn. Tháng thứ ba sau khi thả, bầy có sự đối đầu với một quần thể loài khỉ vàng rất lớn và hung dữ. Quần thể khỉ vàng luôn đe dọa bầy Voọc và tạo áp lực. Việc đối đầu dẫn đến sự chia cắt của bầy Voọc. Một cá thể cái trưởng thành được phát hiện chết, có thể do stress. Một cá thể con nhỏ khác cũng bị giết, có thể do loài khỉ vàng. Đợt tái thả lần thứ hai vào tháng 7 năm 2016 vẫn được tiến hành với 3 cá thể trưởng thành sinh tại trung tâm cứu hộ thú linh trưởng gồm 1 đực, 2 cái. Lần này các cá thể được thả vào một bán đảo rộng khoảng 35 hecta cạnh hồ Kê Gồ. Sau một tháng rưỡi tái thả, cả ba cá thể vượt khu vực bán đảo di chuyển vào bên trong núi. Tháng 10 năm 2016, trong khu vực diễn ra một đợt lũ lụt lớn nên hoạt động giám sát các cá thể này bị đình trệ và mất dấu. Sự đối đầu giữa các cá thể Voọc và loài khỉ vàng là một sự ngạc nhiên lớn mà chúng tôi đã ghi nhận. Một số loài Voọc khác ở Đông dương việc chia sẻ môi trường sống với các loài khỉ là rất phổ biến, và không có hành động gây hấn. Những nghiên cứu về tái thả sẽ được tiếp tục trong tương lai.

Introduction

The Hatinh langur is listed as an endangered species (IUCN Red List of Threatened Species) and occurs in a restricted area of central Vietnam and eastern Laos (Nadler & Brockman 2014). The largest population in Vietnam lives in Phong Nha-Ke Bang National Park, Quang Binh Province, but there is no reliable size estimation of this population. About 150 individuals are estimated to remain in the park as of 2013 (Nguyen Van Truong 2013). Former surveys estimated a population of 520-750 individuals (Le Xuan Canh et al. 1997), about 800 individuals (Pham Nhat 2002) and most probably

an over estimation with about 2000 individuals (Haus 2008). Several isolated smaller populations are dispersed along the border to Laos, but their long-term existence is precarious due to hunting pressure and habitat loss (DARD 2015; Nguyen Ai Tam 2012; Nguyen Manh Ha 2006).

The Endangered Primate Rescue Center maintains a successful captive breeding program for the species and using this as a founder population it aims now to establish a second wild population in a protected area in Vietnam.

To find a suitable habitat for the establishment of the new population a number of surveys were carried out in areas where smaller populations of Hatinh langurs were known to still exist and in areas where the species formerly occurred but has been eradicated (Forest Protection Department Quang Binh Province 2015; Nguyen Ai Tam 2012; Nguyen Hai Ha 2015; Nguyen Manh Ha 2006; Tran Huu Vy 2013; 2014a; 2014b) (Fig 1). Ke Go Nature Reserve in Hatinh Province was chosen as a reintroduction site based on the information on the occurrence of the species, the condition of the forest, the limited human disturbance in the area, the capability and activities of the nature reserve's Management Board and its forest rangers and the favorable logistics.



Fig.1. Distribution of Hatinh langurs (*Trachypithecus hatinhensis*) in Vietnam. (Nadler et al. (2003) and additional records).

The populations of Hatinh langurs in Ke Go Nature Reserve and in the adjacent Khe Net Nature Reserve in Quang Binh Province are eradicated or the number of remaining individuals is very small, if they still exist at all (Nguyen Manh Ha 2006; Tran Huu Vy 2013; 2014a; 2014b).

Preparation of the reintroduction

Reintroduction site

Once Ke Go Nature Reserve was chosen as reintroduction site a plant survey was carried out to confirm the occurrence of food trees for the langurs. Plant samples were collected in the surrounding of the location identified for release and were stored in a herbarium for identification. There are numerous water sources in this area like small forest streams feeding into Ke Go Lake, the largest freshwater lake in northern Vietnam, which partly belongs to the nature reserve (Fig. 2, 3).



Fig.2. Stream in the release area in Ke Go Nature Reserve. Photo: Tilo Nadler.



Fig.3. Ke Go Lake and forest of Ke Go Nature Reserve. Photo: Tilo Nadler.

Close to the designated release site a research hut was constructed (Fig. 4).



Fig.4. Research hut for the monitoring team in Ke Go Nature Reserve. Photo: Tilo Nadler.

Contact to stakeholders, information material

The reintroduction project was introduced to the Management Board of the nature reserve and all its aspects were discussed in detail, to ascertain the project had the necessary support at all stages. A meeting was organized for the surrounding communes to inform them about the project and to get them to commit to support the project (Fig. 5). The appeal to the honour to reintroduce the species which carries the name of the province was enthusiastic appreciated. Being the largest lake in northern Vietnam Ke Go Lake is a major tourist destination. To prevent tourist boats from landing at the reintroduction area, sign boards were installed, which indicated this area was closed for tourist activities. A sign board explaining the project was set up at the tourism center and information material on the project was distributed in the surrounding communes (Fig. 6).



Fig.5. Stakeholder meeting to introduce the reintroduction project for Hatinh langurs. Photo: Tilo Nadler.



Fig.6. Information board about the reintroduction project at the tourist area at Ke Go Nature Reserve. Photo: Tilo Nadler.

Animals for reintroduction

Five individuals from the EPRC were selected for the first reintroduction. These animals have been living together as a group at the Endangered Primate Rescue Center on a 5 ha semi-wild area with primary forest. The group consisted of one adult male (6 years old), two adult females (7 and 19 years old) with their female offspring (both 8 months old). All animals were born at the EPRC.

Prior the translocation to Ke Go Nature Reserve the langurs underwent a health check including a complete blood profile and tests for tuberculosis, Herpes, Hepatitis and were screened for ecto- and endo parasites.



Fig.7. Tracking equipment: 1- VHF Receiver, 2-Yagi antenna, 3-radio collars, 4-base station for coordinate downloads.

Radio collars

To allow post-release monitoring the three adult individuals were equipped with satellite radio collars (e-obs Company, Germany). The collars use GSM/GPRS technology. They consist of a GPS receiver for data storing and transfer, a UHF transmitter for field tracking and a cell battery as power source. The system works completely wireless to maximize field reliability. The collar takes GPS positions at preprogrammed intervals and stores the obtained position data. Up to 120.000 positions can be stored. The GPS positions recorded in the collar are downloaded remotely via the GSM/GPRS network and the GPRS modem of the base station. The UHF beacon generates radio waves at a certain frequency. These waves can be received with conventional radio receivers to locate a collared animal. The system works very similar to conventional VHF tracking but on a higher frequency (868 MHz or 916 MHz) compared to conventional VHF beacons (150 MHz).

The weight of a collar is 120 g. As the langurs weigh between six and eight kg this means they weigh about 1.5 to 2% of the body weight (Fig. 7).

First reintroduction of Hatinh langurs

Transportation and release

On 13th June 2015, the animals were anesthetized and loaded into transport boxes, which were loaded onto the transport vehicle. The transport by car started as soon as the animals were fully recovered in the late evening (Fig. 8). The distance to the release site was about 500 km and the drive took about eight hours. After arrival at Ke Go Nature Reserve in the early morning the transport boxes with the animals were transferred to a ranger boat and transported for another hour to the final release site (Fig. 9).



Fig.8. Hatinh langur transport from the Endangered Primate Rescue Center by car to Ke Go Nature Reserve. Photo: Tilo Nadler.



Fig.9. Transportation of the Hatinh langurs over the Ke Go lake to the release site. Photo: Hoang Quoc Huy.

At the release site a temporary enclosure was set up just prior to the arrival of the animals. Iron elements were assembled to a frame and covered with fishing net. The transportation of the construction elements was easy and the cage was erected in about one hour (Fig. 10, 11).



Fig.10. To set up a temporary cage iron frames covered with fishing net were used. Photo: Tilo Nadler.



Fig.11. Hatinh langur group was kept after arrival at the release site in a temporary cage for one day and one night to check the animals after transportation and to familiarize the animals with the natural surroundings. Photo: Tilo Nadler.

The animals were released from their transport boxes into this enclosure to let them settle down after the stress of transport, assess their condition and to allow them visual contact with the new environment. They were provided with food and water and were kept in the cage for the rest of the day of arrival and the following night.

In the morning of the second day – 15th June 2015 - the animals were released from the cage into the forest of the nature reserve.

Monitoring

The monitoring of the animals started immediately after release. The GPS coordinates were downloaded depending on the contact to the animals. The distance for downloading amounted 300 to 500 m. The animals were directly observed whenever possible, but care was taken not to disturb the animals and they were not approached at a close distance. When the animals were observed feeding samples from the food trees were collected for identification.

Results of the first reintroduction

During the first month after release, the group established a home range near the release site and the research station comprising an area of roughly 9 ha (Fig. 12). During this time the group travelled together through the home range area, feeding on selected tree species (Fig. 13). During the second month the langur group extended their home range and the travel distance increased. The group split up occasionally, so the travel distances are different for each individual (Fig. 14).

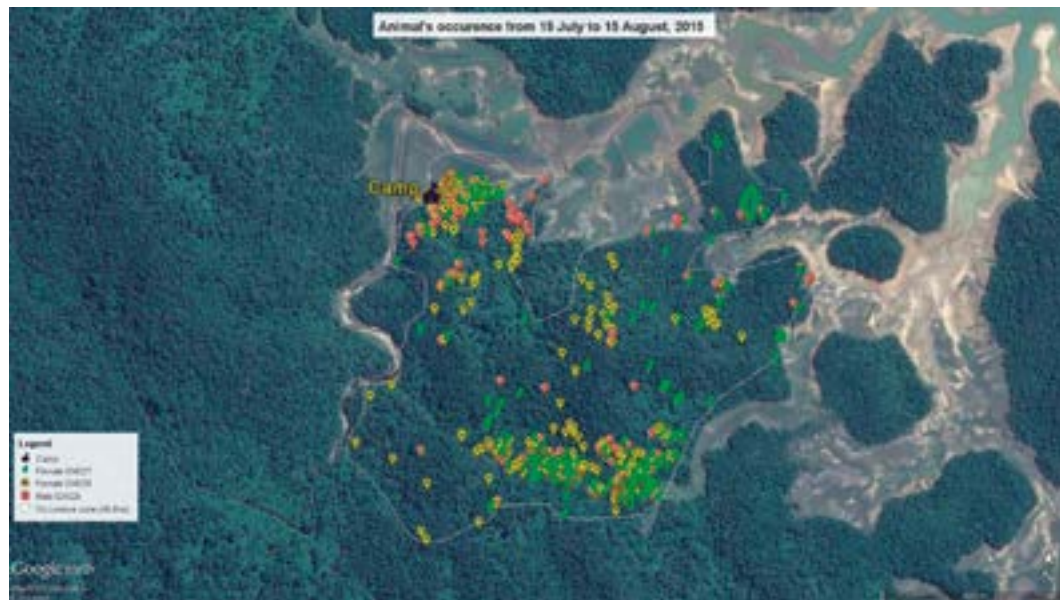


Fig.12. Coordinates of the locations of the three adult Hatinh langurs during the first month after release. The preferred area is close to the release site and the research hut.



Fig.13. Hatinh langur group after release. Photo: Tilo Nadler.

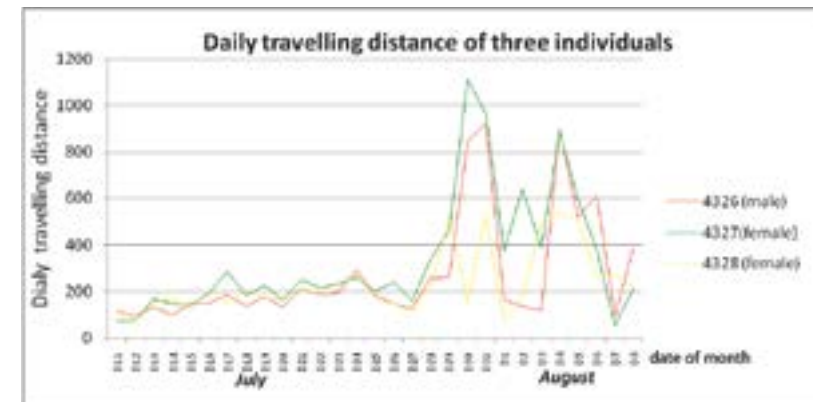


Fig.14. The daily travel distances show a high increase and a difference between the individuals during the conflict with the macaques.

Three months after release – in August 2015 – the langur group had a confrontation with an unusually large and unexpectedly aggressive troop of rhesus macaques (*Macaca mulatta*). The macaques harassed the langurs for several days, and finally the langur group split up. Direct physical attacks or fights were not observed, but as the langurs were continuously harassed through aggressive snarl and vocalization at close distance and from alternating individuals they covered much larger daily travel distances (Fig. 15).

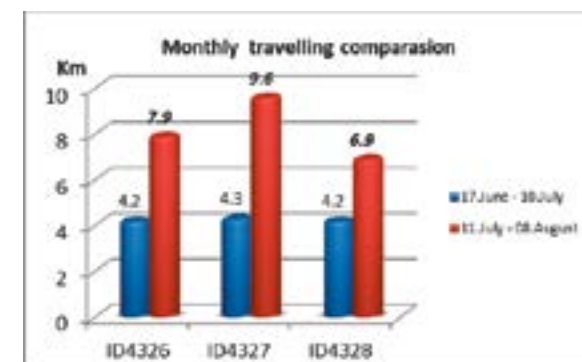


Fig.15. Travel distances of three released Hatinh langurs. The increase in the second period (11th July to 8th August) resulted most probably from the harassment of the rhesus macaques.

The situation became critical for the released Hatinh langurs by end of August, with another major attack of the large macaque band. One female died shortly after, most likely due to the harassment by the macaques and stress which prevented normal foraging and rest time for digestion, a necessary sequence for this leaf eating primates. The daily travel distances of the male and the remaining female increased, probably to avoid confrontation with the macaques. The animals travelled also into different areas probably for the same reason (Fig. 16). By end of October the second adult female was found on the ground where she subsequently died. One of the juvenile females was found dead in the water of the lake with injuries in the face. There are no observations about an actual fight, but only days before both individuals were found active and in apparently good condition. We assume that the macaques caused the death of the animals, but the course of the events remains unclear. The second juvenile female was observed to travel alone but she was not equipped with a radio collar and her movements could not be monitored and finally this individual disappeared into the forest. However we obtained occasional reports from local people who entered the area by boat and observed the animal weeks later.



Fig.16. The Hatinh langur group splitted of, most probably resulted through the harassment of the Rhesus macaques. One female (radio collar 4328) with a subadult moved far from the research camp where the male (radio collar 4326) settled.

The decision was made to capture the remaining male, take it back to the EPRC and to carry out more surveys to identify another suitable release site hoping to avoid a similar confrontation with macaques. The male was caught in December 2015 and returned to the EPRC.

Second reintroduction of Hatinh langurs

Early in 2016 further surveys were conducted to locate another release site. A 35 ha peninsula at Ke Go Lake was identified as a suitable location. The research camp was moved to the isthmus of the peninsula. An about 100 m wide stretch of grassland separates the forest of the peninsula from the main contiguous forest of the nature reserve. If the water level is very high the peninsula becomes an island (Fig. 17).

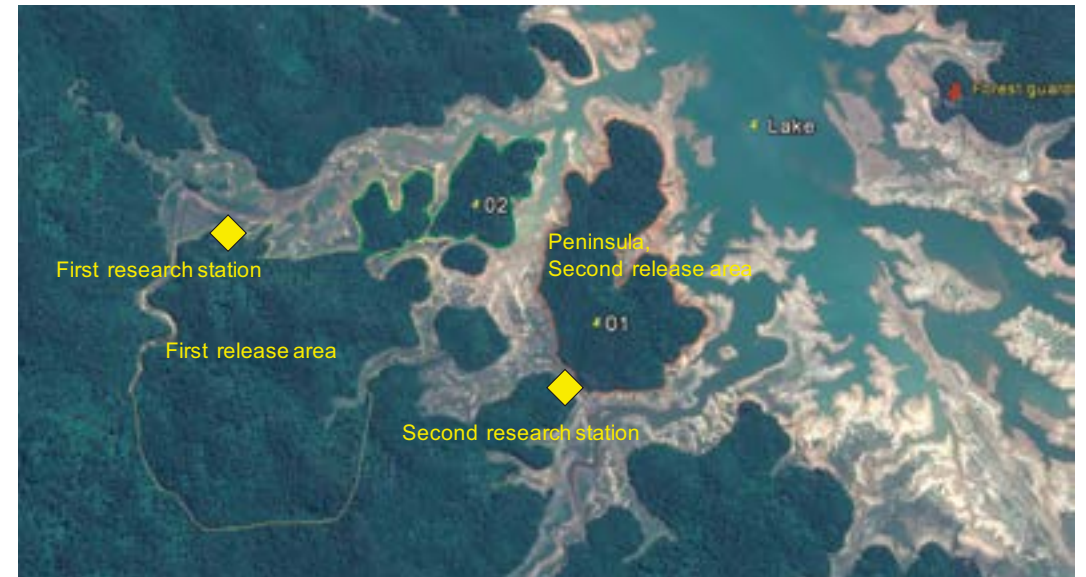


Fig.17. Overview about the areas for release and the localities for the monitoring camps.

Three captive born Hatinh langurs were chosen for reintroduction; one seven years old male, and two females, four and ten years old. The animals underwent the same obligatory health checks and were equipped with the same type of radio collars as described above. They were transported by car and boat to the release site and after one day in the temporary cage they were released on 2nd July 2016 into the forest of the peninsula.

After one and a half months, all three individuals moved away from the peninsula across the 100 m open grassland into the main forest area of the nature reserve. At this time the radio collar of the male didn't work properly anymore and the monitoring team lost the contact to this individual. The two females moved and foraged together. The male was occasionally observed alone but it was not possible to download the coordinates due to the malfunction of the radio collar (Fig. 18).

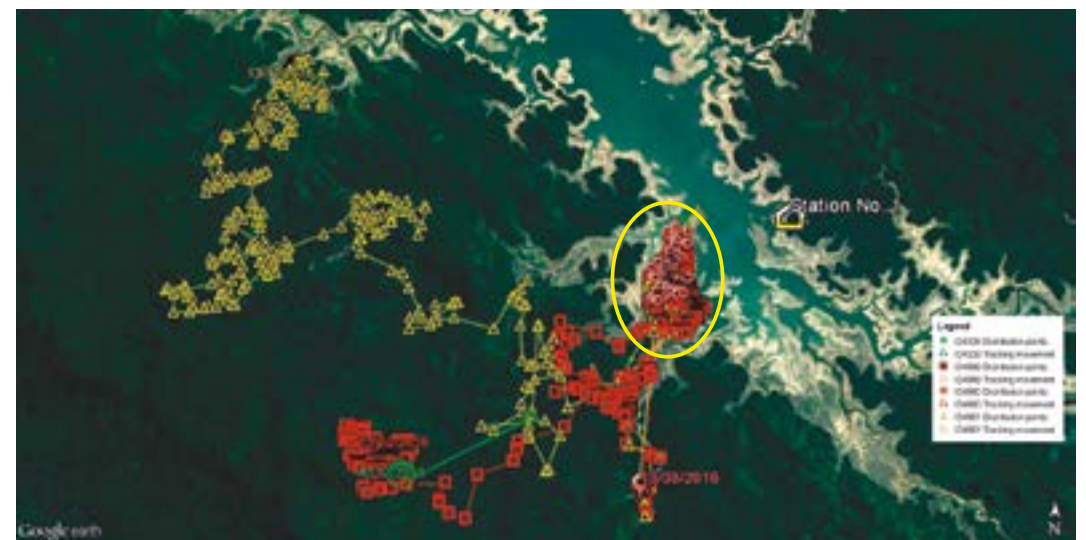


Fig.18. Movement of the four Hatinh langurs from the second release (male 4328 and females 4900 and 4901) until loss of contact and ending of the project phase. The oval marks the peninsula.

In October 2016 the highest flood of the century interrupted the monitoring for about three weeks. The monitoring team had to leave the research camp and a makeshift camp was established at a slightly higher and flood safe elevation to continue the monitoring (Fig. 19). After this interruption only one female could be located and her coordinates could be downloaded. The contact to the second female was lost. Probably the flood caused her to move out of range or her collar had become faulty as well.



Fig.19. For about two months after the flooding the monitoring team used a simple shelter to continue the monitoring and data download. Photo: Tilo Nadler.

After the forced interruption in monitoring the male was also no longer observed in the area and we assume he also moved away to escape the water.

In the attempt to establish at least one possible breeding couple at this site a second captive born Hatinh langur male from the EPRC was released close to the female which was still monitored on the 9th of December. This male was also equipped with a radio collar.

The tracking and monitoring of the last released individuals had to be unfortunately terminated by the end December 2016, which was the end of the project period and the available project budget.

Discussion

From the moment of the release from the temporary cage at the release site the reintroduced Hatinh langurs showed no difficulties to find adequate food sources. After a short inspection of the vicinity all individual started foraging about 30 min after release and in nearby food trees which had been identified prior release.

There were no natural water sources close to the release site and water bowls were provided and used by the langurs. After 15 days the first released langur group covered a distance of about 300 m and moved into an area with dense forest and a small stream, where the animals were observed drinking. The group remained in this area until the incident with the large and aggressive macaque band.

The occurrence of macaques in the nature reserve was known and was also confirmed during the preliminary surveys. Macaque species, especially the preferential arboreal species *M. mulatta* and *M. assamensis* occur sympatric with langur species like *T. hatinhensis*, *T. delacouri*, *T. francoisi* and *T. crepusculus*, in fact in all known areas, where langurs live (Duckworth et al. 1999; Nadler & Brockman 2014; Rowe & Myers 2016). Sympatric occurrence of langurs with macaques is also known for *T. leucocephalus* in China (Chengming Huang et al. 2002) and *T. laotum* in Laos (Phiapalath 2010; Nadler pers. obs.). In many limestone areas langurs and macaques use sleeping sites on cliffs (Nadler pers. obs.). If the species compete for such a sleeping site, the macaques mostly arrive earlier in the evening than the langurs, and they are always dominant, occupy the sleeping place on the cliff and chase the langurs away. But aside from this, aggressive behavior of macaques towards langurs during daytime has - according to our knowledge - not yet been observed. Langurs usually avoid confrontation with macaques and this conflict avoidance behavior is probably socially transmitted in areas where langurs and macaques live in sympatry. The extreme stress of the langurs and their failure to adequately react to the macaques was possibly caused by the lack of experience and a behavioral norm, which an experienced and canny wild group would both have.

Even though physical contact never occurred the continuing harassment caused the langurs to travel larger distances requiring more energy and at the same time reducing feeding time and consequently energy intake. The energy deficit and the stress probably were responsible for the rapid physical deterioration and eventual death of some individuals.

It could be considered to make sure that a released group of Hatinh langurs comprises at least one adult wild caught individual, which has experience tackling such situations.

During the second release an unexpected flood occurred in Hatinh Province which influenced the movement of the animals and prevented continuous radio telemetric monitoring. The high water level also prevented visual observation of the animal whose radio collar had failed and the contact to this animal was consequently lost after this period.

However the plan to establish a second population of this endangered species in Vietnam remains unchanged and reintroductions should continue within this project at this site. To achieve this it is necessary to introduce several groups with more than one female each. The normal social units of this species are one-male-groups with three to five females and the offspring from several years. A group with more females produces understandably over their life span a much higher number of individuals. The time of reproduction for a female is limited to the maximum of about 20 years (Nadler, pers. obs.). A group with one male and one female would within this time span grow to a population with about 20 females – not considered any limiting factors, like hunting, diseases or accidents. A group with four females therefore grows to a population with 80 females, supposed reproduction (Fig. 20). In order to establish the new population within an acceptable time frame it is necessary to release groups with several females. And even then it will be a very long process.

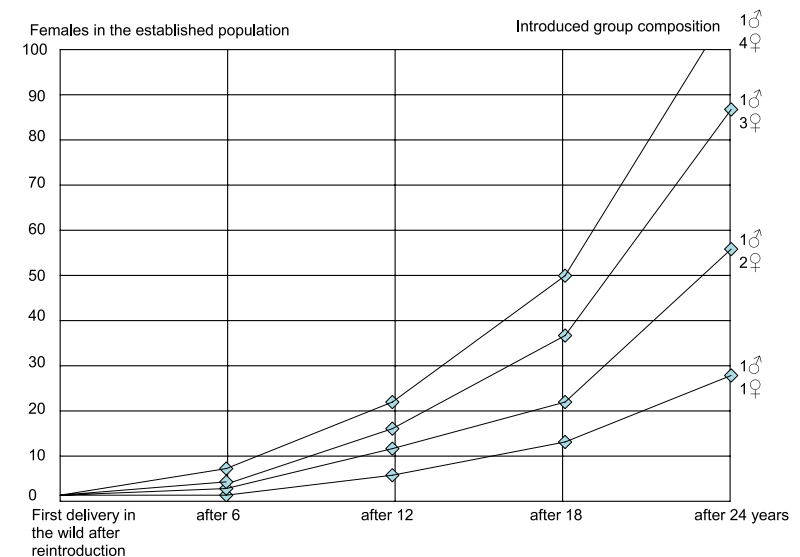


Fig.20. The diagram shows the theoretical maximal increase of the number of females in a langur population after reintroduction. The increase is depending from the number of females in a released group (one, two, three, four). The begin of reproduction for the females is supposed with six years, a sex ratio of born individuals 1:1 (males : females) and the involvement of all females in reproduction until the age of 18 years with a birth interval of 24 month.

To establish a population large enough to remain stable is not only an enormous logistic challenge, it also needs considerable reliable long-term financial support and organizational commitment.

Acknowledgements

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Natal-to-juvenile pelage change in free-living François' (*Trachypithecus francoisi*) and Cat Ba langurs (*T. poliocephalus*)

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Key words: limestone langurs, pelage, natal coat, Cat Ba langur, François' langur

Summary

This article discusses the timing, patterning, and implications of natal pelage loss for two species of limestone-dwelling Asian colobines – François' (*Trachypithecus francoisi*) and Cat Ba (*Trachypithecus poliocephalus*) langurs. It considers why some primate species, such as those in the *Trachypithecus* genus, are born with a flamboyant, orange natal coat and what purpose it may serve in promoting allocare and reducing the threat of infanticide. With 11-12 months of observation of each species, this study assesses the pattern of natal coat loss for three François' langur infants living in Mayanghe Nature Reserve (China) and three Cat Ba langur infants living on Cat Ba Island (Vietnam). There was conflicting evidence for our first hypothesis, as the pattern of natal coat loss is similar in both species, although the timing is sped up in François' langur infants. Using previous data on these species, and confirming our second hypothesis, there does appear to be an association between increased independence and decreased group member interest in infants that were progressively developing an adult coat colouration, suggesting that the coat does signal dependence and promote allocare. Finally, in analysing the pattern of where the natal coat is lost first, observations suggests that both species of langurs may be using a paternity cloaking approach to avoiding infanticide. Ultimately, it is unclear if François' and Cat Ba langurs are experiencing different degrees of infanticidal threat given the contradictory evidence, nor is it known how or if their divergent patterns of development are related to habitat quality.

Sự thay đổi màu lông từ lúc sinh ra đến tuổi bán trưởng thành ngoài tự nhiên của loài Voọc đen má trắng (*Trachypithecus francoisi*) và voọc Cát Bà (*T. poliocephalus*)

Tóm tắt

Bài báo này thảo luận về thời gian, mô hình, và ý nghĩa của việc thay đổi màu lông khi mới sinh của 2 loài Voọc thuộc nhóm Asian colobines gồm Voọc đen má trắng và Voọc cát bà. Giả thuyết là các con non mới sinh của các loài linh trưởng thuộc nhóm *Trachypithecus* có bộ lông với màu vàng cam sặc sỡ có mục đích tăng cường sự quan tâm chăm sóc từ các cá thể khác trong đàn và giảm thiểu nguy cơ bị giết chết. Qua 11-12 tháng thu dữ liệu với 3 con nhỡ của loài Voọc đen má trắng François' ở khu bảo tồn thiên nhiên Mayanghe (Trung Quốc) và 3 con nhỡ của loài Voọc cát bà ở Vườn quốc gia Cát bà (Việt Nam), nghiên cứu này kiểm nghiệm quá trình mất màu lông tự nhiên của cả 2 loài Voọc này. Có bằng chứng mâu thuẫn cho giả thuyết thứ nhất được ghi nhận ở cả 2 loài này về quá trình thay đổi bộ lông, mặc dù thời gian thay đổi màu lông ở loài Voọc François' nhanh hơn.

Cùng với các dữ liệu đã ghi nhận trước đây và xác nhận trên giả thuyết thứ hai cho thấy có mối liên hệ giữa sự tự lập tăng lên và sự quan tâm của các thành viên trong đàn giảm xuống với con non có bộ lông đang dần biến đổi sang bộ lông của con trưởng thành, điều này gợi ý bộ lông là dấu hiệu của sự tự lập và thúc đẩy sự quan tâm.

Cuối cùng, kết quả phân tích dữ liệu cũng chỉ ra rằng con non của cả 2 loài đều có phương thức

giấu mối quan hệ cha con để tránh việc bị giết trong tiến trình thay đổi màu sắc bộ lông.

Sau cùng, không rõ liệu 2 loài Voọc này trải qua các mức độ đe dọa bị giết khác nhau với các bằng chứng mẫu thuẫn, cũng không rõ các quá trình phát triển khác nhau có liên quan đến chất lượng môi trường sống hay không.

Introduction

Some primates are born with coats that differ from adult coat colouration and patterns (Ross & Regan 2000). Of these, a particular group is born with coats that are flamboyant and stand in sharp contrast to the adults of those species. Asian langurs fall within this category, with bright orange natal coats that conspicuously stand out against the grey, black and/or white adult colouration (Blaffer Hrdy 1976; Oates & Davies 1994; Groves 2001; Nadler et al. 2003).

The eventual loss of the natal coat can be used to age individuals (Treves 1997) as infants tend to show increased independence by spending less time proximate to (Horwich 1974; Stanford 1991) and nursing from (Treves 1997) their mother at approximately the same time that the natal coat changes. It is also around this stage that nonmaternal group members lose interest in handling infants (Jay 1963).

The timing of the loss of natal coat colouration may be affected by available resources, habitat quality, and social pressures. For example, it is proposed that Pharye's leaf monkeys (*Trachypithecus phayrei*) in larger groups experience an increase in scramble competition, resulting in a delay of the acquisition of adult coats by infants (Borries et al. 2008). This is presumably due to mothers being nutritionally deprived, thus limiting the nutrients they can pass on to their developing young. This effect of food-limitation is supported by the fact that places (e.g. captivity) or periods (e.g. provisioning) with reliable availability of higher-quality resources increases maturation and reproductive rates for primates (Altmann et al. 1981; Sugiyama & Ohsawa 1982; Newton 1987; Altmann et al. 1993; Mori et al. 1997; Altmann & Alberts 2005).

Additionally, the speed at which natal coats are lost may be related to infanticidal pressures. Ursine colobus (*Colobus vellerosus*) infants that live under high threat of infanticide (specifically, male infants and infants living in multimale groups) develop adult colouration faster than those that do not face as high of infanticidal pressures, possibly because of increased maternal investment (Bădescu et al. 2016). This hastened transition away from natal coats may reduce infanticide risk despite the fact that the infants are still nursing (Bădescu et al. 2016). In other words, the loss of the natal coat is acting as a visual code for 'independent' to infanticidal males, even though the infants are behaviourally dependent on their mothers.

There is debate as to the advantages and disadvantages to a contrasting natal coat, with several hypotheses focusing on infanticide-avoidance benefits. This is because while dependent and unweaned infants that have a conspicuous natal coat may be more obvious to potentially infanticidal males, they are also highly attractive to group members; thus the high coat contrast may be indicative that the group will unite in protection of the infant against infanticidal males. This hypothesis has been termed the infant defense hypothesis (Treves 1997). This idea has been somewhat supported in Asian langurs as the orange natal coat seems to have care-eliciting effects on group members, which may reflect a psychological and evolutionary tactic to induce caretaking and to create a safe social environment for young at their most vulnerable and dependent stage, by increasing group member interest and tolerance and decreasing aggression; although natal coats certainly are not necessary for such purposes (Alley 1980). There is a pattern for species with high rates of allocare (caretaking by nonmaternal group members) to have more adult-to-infant colour contrast especially in areas that are highly-visible on clinging infants (Blaffer Hrdy 1976; Ross & Regan 2000). This suggests that areas such as the crown, legs, and back will be the last to change colouration, since these are the body parts that are most obvious to potential caretakers (Treves 1997). However, research suggests that these areas are often the first to change, as seen in a number of primates, such as Guatemalan black howler monkeys (*Alouatta pigra*), agile mangabeys (*Cercocebus agilis*), king colobus (*Colobus polykomos*), stump-tailed macaques (*Macaca arctoides*), hamadryas baboons (*Papio hamadryas*), and Hanuman langurs (*Semnopithecus entellus*) (Treves 1997).

Alternatively, the paternity cloaking hypothesis states that a natal coat may mask paternal phenotypic indicators, thus protecting infants from males that may recognise the infant as not being his own (Treves 1997). For example, when a female mantled howler monkey (*Alouatta palliata*) was born with white patches on her feet, similar to the male that took over the group and that the mother had previously consorted with – and dissimilar to the previous resident male or her mother – she was spared from infanticide, unlike some of her infant group mates (Clarke 1983). Only areas that a male is able to see on his own body are relevant to this hypothesis; thus, this hypothesis excludes backs, heads, and faces, as males cannot gauge how similar an infant is to these areas of his body (Treves 1997); instead this hypothesis predicts that ventrums, limbs, and tails will be the last features to change, so as to confuse paternity for potentially-infanticidal males.

Limestone langurs are Asian colobines that live on limestone karst in China, Vietnam, and Laos (Groves 2007; IUCN 2015). The species-group can be divided into a northern clade with François' (*Trachypithecus francoisi*), Cat Ba (*T. poliocephalus*), and white-headed (*T. leucocephalus*) langurs – and a southern clade with Delacour's (*T. delacouri*), Lao (*T. laotum*), Hatinh (*T. hatinhensis*), and Indochinese black (*T. ebonus*) langurs (Roos 2003; Roos et al. 2007), divided by the Red River (Groves 2007). Limestone langurs, as with several other primates with unimale-multifemale social structures (Struhsaker & Leland 1987), experience infanticide (Li & Rogers 2004; Zhao et al. 2011; Yao et al. 2012), and nonmother-group mates show an interest in allocare that declines with infant age (Hu 2007; Yao et al. 2012; Jin et al. 2015). Thus, both infanticide (which, as a reproductive strategy, is focused on unweaned individuals: Blaffer Hrdy 1979; Struhsaker & Leland 1987) and allocare are associated with neonates. For example, one-to-eight month-old white-headed langur infants disappeared after takeovers of unimale-multifemale groups by a strange male – i.e. those who were not old enough to be weaned and were still dependent on their mothers – which accounted for 42.9% of all white-headed langur infant mortality during this study period (Zhao et al. 2008; 2011). White-headed langur infants under one month spend 20-30% of daytime observations being handled by someone other than their mothers, but there is little handling for those over two months of age (Jin et al. 2015).

This study aims to document the progression of natal-to-adult coat colouration for François' and Cat Ba langurs in order to compare and contrast closely-related species to one another and to other Asian colobines living in different habitats, and to draw connections between natal coats, independence and allocare interest. We hypothesise (Hypothesis 1) that the two species will follow a similar timing and patterning of natal coat loss. We further hypothesise (Hypothesis 2) that the timing of the loss of the natal coats will be related to measures of independence and allocare interest (e.g. time spent in proximity), which will be analysed based on data from other sources. Our data can also be used to assess whether the pattern of natal coat loss is related to allocare interest (Alley 1980) or paternity cloaking (Treves 1997) on behalf of infanticide avoidance (Hypothesis 3); if the former, we would expect the dorsum, head, and legs to retain the natal coat the longest, and if the latter we would expect the ventrum, limbs, and tail to take the longest to shift to adult colouration. The methods used are an easy, noninvasive way of assessing development (Treves 1997), which is important for age-estimates by survey team members, researchers, and conservation groups as it will allow for more accurate censusing.

Methods

Study Species

This study looks closely at François' and Cat Ba langurs, who diverged 0.50-0.25 million years ago due to geographic barriers (Liu et al. 2013). François' langurs are 'Endangered' (Bleisch et al. 2008a), and live in southern China; Cat Ba langurs are 'Critically Endangered' (Bleisch et al. 2008b) and are endemic to Cat Ba Island (northeastern Vietnam). Both species live on limestone karst hills that are threatened with degradation and fragmentation, ultimately resulting in a loss of habitats; hunting is another cause for drastic population declines (Nadler et al. 2003; Hu et al. 2004; Stenke & Chu Xuan Canh 2004).

Author GH has documented two takeover events in François' langurs; one failed but another was successful and led to a group split. However, only one infant in seven years of study was

presumed to have died from an invading male (Hu 2007), suggesting that takeover may be a rare occurrence. There are two observations of infanticide and takeover among Cat Ba langurs from 1998-1999 (Nadler pers. comm.), in addition to a more recent (2018) observation of an adult male injuring an infant (Rawson pers. comm.). It is likely that with more hours of observation, reported infanticides would increase.

Both François' and Cat Ba langurs show the typical pattern of neonate attraction. Group members, including juvenile females, show great interest in being able to touch, groom, suckle, or hold François' langur infants, although mothers do not allow anyone else to handle their infants until they are over two weeks of age (Hu 2007). Although Cat Ba langur individuals were not individually recognisable, it is clear that nonmothers are interested in handling young group members because of the amount of infant transfers that have been observed, which are focused on newborns (68% of transfers) and infants (32% of transfers) but never occur in young juveniles or juveniles (Hendershott unpubl. data).

Both of the closely-related François' and Cat Ba langur adults have dark brown/black pelage, a crest on their head, white 'moustaches' that go ear-to-ear, and a black 'cape' of hairs (Nadler & Ha Thang Long 2000; Nadler et al. 2003; Groves 2007) (Fig. 1). While François' langurs are entirely black except for the moustache (Fig. 1b), Cat Ba langur shoulders, head, and crest are orange/golden and they have a V-shaped saddle band of grey hairs across their lower back, stretching from thigh to thigh (Groves 2007) (Fig. 1a). Both species exhibit flamboyant orange natal coats at birth (Groves 2001), and the only areas that are sexual dichromatic are pale pubic patches on the inner thighs (Brandon-Jones 1995; Nadler et al. 2003).



Fig.1. Adult Cat Ba (a) and François' (b) langurs with young attached.

Behavioural Observations

François' langurs were studied by one of the authors (GH) in Mayanghe Nature Reserve (northeastern Guizhou, China) from January 2005 to January 2006, while Cat Ba langurs were studied by another author (RH) on Cat Ba Island (northeastern Vietnam) from February 2014 to January 2015. The François' langurs were observed on foot, with or without binoculars depending on distance between researcher and langurs, while the Cat Ba langurs were observed from a boat 50-300 metres away with binoculars. Boats are often used in the study of limestone langurs living nearby water (Schneider et al. 2010; Workman 2010; Agmen 2014; Phan Duy Thuc et al. 2014), as traversing the karst is dangerous and time consuming. At both field sites data collection began around sunrise and concluded at sunset.

Age-related changes to coat colouration and body size were noted ad libitum and documented with photographs; they are mentioned descriptively. Descriptions are roughly divided into the first (days 0-30), second (days 31-60), third (days 61-90), and fourth (days 90-120) months, followed by months 5-8 (days 121-240), 9-11 (days 241-330), and 12-36 (over 330 days). Note that when mentioning 'the second month' or 'months 5-8', this refers to changes that occur *during* those months (i.e. the 'second month' includes 'after the first month' and 'before the third month').

Among both species, the same individuals were observed over time to assess stages in natal

coat loss, and all immature individual coat colourations were documented. This includes the six infants born during the study (three François' and three Cat Ba langurs) as well as a Cat Ba langur female born January or February 2014 and three juvenile François' langurs and five juvenile Cat Ba langurs. During the study periods, there were three infants born (one in January and two in February 2005) to the François' langur group under study (LYY-G1; total 9-12 individuals), and three infants born (one in August 2014, one in October/November 2014, and one in December 2014/January 2015) to one of the Cat Ba langur groups under study (Group A; total 10-13 individuals). The date of birth is assumed to be between the last sighting of the group without a newborn and the first sighting with a newborn; this ranges from 1 to 13 days for individuals born during the study.

A note on authorship

GH was collaborating with CG on a manuscript on pelage shifts, and had given him all of his photographs and some notes, at the time he died. When RH approached CG about a manuscript on pelage shifts, he provided useful feedback and recommended the data be combined with that of GH and passed on those photographs and notes. While working on this manuscript, CG died. Thus, RH and AB are left with data obtained by GH, shared with CG, and then passed on to them. Both RH and AB are extremely grateful for the hard work that both GH and CG put into this topic, and want to make it clear that the data have been given to them third-hand. Despite this, however, it seems a waste to not publish the results of GH and CG's hard work in combination with their own, as it is so similar. The holders of the estates of CG and GH have approved this manuscript and their co-authorship. All photographs were taken by the authors in the course of their fieldwork unless otherwise noted.

Results

When first born, both langur species are completely bright orange with pink-grey face, ears, and hands, a small bald spot on the forehead (with no crest) and pinkish ischial callosities (Fig. 2a,b). While François' langur newborns have black hairs scattered along the tail, newborn Cat Ba langur tails are completely orange. By one month of age Cat Ba langurs have a slightly faded orange coat, especially on the head, where dark-tipped hairs – the beginnings of a crest – start to develop. Over the first month (days 0-30), the face and digits of both species of langur infants begin to darken (Fig. 2c,d), and the lower three-quarters of the François' langur tail shifts to black (Fig. 2d). In both species, the animals are extremely skinny, without the characteristic distended gut of a leaf-eating primate.



Fig.2. A newborn Cat Ba langur 3-6 days after birth (a), a 15-18 day-old (photo by Kayla Hartwell) (b) and 24-35 day-old (c) Cat Ba langur infant. A 13-15 day-old François' langur (d). Note the pink exposed skin and bright orange coat at birth; the skin darkens in two-week-old François' langurs, while Cat Ba langurs retain more of the natal coat throughout the first month.

In the second month (days 31-60), the face, ears, hands, and feet darken in both species (Fig. 3). Among Cat Ba langurs, the crest continues to darken, and although the orange natal coat is dulled (especially on the limbs), black hairs are not yet visible (Fig. 3a). Among François' langurs, black hairs appear on the torso, arms, and upper legs, and the beginnings of a yellowish-white moustache spread from both ears towards the mouth, and black hairs begin to form above the forehead (Fig. 3b).



Fig.3. Infant Cat Ba langur at 41-44 days of age (a). A 60-day-old François' langur (b). Note darkened skin in both species.

In the third month of life (days 61-90), both langur species' face, ears, hands, and feet have become a dark grey, which is still lighter than adult colouration (Fig. 4). Cat Ba langurs continue to become a duller orange colour, with dark hairs beginning to show (Fig. 4a). They have a small black spot above the base of the tail, and the tail is darker on the underneath side than the top. François' langurs develop a fully-darkened and pointed crest, their moustache lightens from yellow to white, and their fur continues to darken, including on the lower legs (Fig. 4b,c,d). In both species, ischial callosities start to become more white than pink.



Fig.4. A 57-68 day old Cat Ba langur (a). A 68 (b), 72 (c), and 88 (d) day-old François' langur infant. Note the drastic differences in pelage between the two species at this stage.

Drastic pelage changes occur for both species in the fourth month of life (days 91-120). Among Cat Ba langurs, all exposed skin is now dark (Fig. 5a,b), the beginnings of a white moustache appear, and the limbs are lighter-coloured than the torso. An undercoat of dark grey/black stretches across the lower back (making the coat a lighter shade of orange), as does the beginnings of the greyish saddle (Fig. 5a,b). The basal third of the tail is dark with black hairs, although the remaining tail is still mostly orange (Fig. 5a,b). Among François' langurs, the pelage has become almost entirely black in a short period (from days 125-130), with only some yellow fur retained on the head and shoulders (Fig. 5c,d). Both the moustache and crest become more adult-like (although the moustache is wider than those of older individuals), and it is at this stage that sex can be determined in François' langurs.



Fig.5. Young Cat Ba langur 99-102 (a) and 119-122 (b) days since birth. Infant François' langurs at 97 (c) and 115 (d) days old. Note the drastic difference between the dark coat of François' langurs and the slowly-transitioning coat of the Cat Ba langur.

From months five to eight (days 121-240), both langurs develop adult-coloured black skin. Among Cat Ba langurs, the back has shifted from an orange coat with a dark undercoat to being a dark coat with a slight orange tinge (Fig. 6a,b); there is a small orange spot between the shoulder blades. The neck and shoulders are still pale orange, as are the limbs (upper legs and lower arms are darker than lower legs and upper arms) and lower tail (by the end of this period only the lower third of the tail is orange, and the underside remains darker than the top). The blanched thigh patches of females and the saddle become more visible (Fig. 6a). It is at this stage that Cat Ba langurs gain the larger abdomen characteristic of leaf-eaters. François' langurs continue to have pelage darkening (albeit yellow hair is still visible on the head and crest), a whitening of the moustache, and a more pointed crest (Fig. 6c,d).



Fig.6. Young Cat Ba langur 168-199 (a) and 180-211 (b) days since birth. François' langurs at 130 (c) and 146 (d) days old.

From months nine to 11 (days 240-330), Cat Ba langurs' lower back is black while the upper back is grey; most of the limbs are dark with the exception of small orange patches on the tops of wrists and feet (Fig. 7a). Although a dark patch of hairs become visible on the tip, there are still some light patches in the lower third of the tail (Fig. 7a). François' langurs develop a jet-black coat, and the last of the yellow hairs on the head are lost (Fig. 7b). Their moustache is predominantly white, yet remains wider than those of older individuals (Fig. 7b).

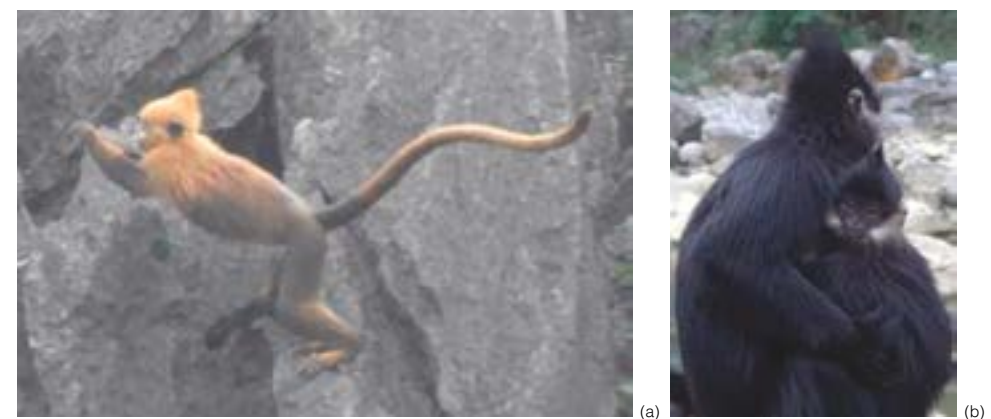


Fig.7. A Cat Ba langur at 264-295 days of age (a). A François' langur at 320 days of age (b). Note that both species have gained the large abdomen, although they differ markedly in the retention of the natal coat.

Animals one to three years old (over 330 days old) are juveniles (based on their foraging and locomotor independence) in both langur species. Among Cat Ba langurs, colouration is also similar to adults and subadults, except that the orange colours on their head and neck are brighter and their torso, limbs, and skin are a duller black (more of a faded orange-brown, especially on the front of the torso and the lower legs, with small spots of pale yellow e.g. between the shoulder blades and on the tops of the wrists and feet) (Fig. 8a). A dark-tipped crest and light-grey saddle are easily visible, the tail retains some pale orange colouration, and the underside is still darker than the top. A fully distended stomach is visible in juveniles (Fig. 8a). Among François' langurs, the moustache narrows and becomes whiter during this stage; colouration is similar to adults (Fig. 8b).



Fig.8. Cat Ba juveniles over one year old (birthdate unknown) (a). François' langur at 13-14 months of age (b). Note the lighter pelage colouration of Cat Ba langurs in contrast to François' langurs.

Discussion

This study is one of the first to assess natal pelage shifts in two [Critically] Endangered species, for which little is known on this topic (although the pelage development of Delacour's and Hatinh langur have been described by Nadler 1997). These shifts in pelage can be a useful way of aging individuals, as well as providing evidence for various theories related to dependence, allocare and interest by group members, as well as infanticidal pressures and resource availability.

Hypothesis 1

Similar Timing and Patterns for François' and Cat Ba Langurs

In regards to our first hypothesis: there are parallels and divergences in the timing and patterning of natal coats loss between François' and Cat Ba langurs, although generally the gradual shift from natal-to-juvenile pelage changes are similar to those noted for other Asian colobines (Horwich 1974; Blaffer Hrdy 1977), including another species of limestone langur – the Delacour's langur; although the latter was a study in captivity (Nadler 1997; Agmen 2014). Both study species are born bright orange with pink-white skin on the face, hands, and feet; by four months they have lost the majority of their natal coat; and by one year of age they are mostly adult-coloured with species-typical coats; including moustaches for both species, a grey saddle and a yellow head/neck for Cat Ba langurs and a black head/neck for François' langurs.

Cat Ba and François langurs differed in several aspects of developmental timing. François' langurs are born with black hairs on their tail, while Cat Ba langurs have a completely orange tail. In the first month, three-quarters of François' langur tails are black (Fig. 9b), whereas the tail does not start to darken for Cat Ba langurs until the third month, and faded orange colouration remains on the tail into the juvenile stage (12+ months) (Fig. 9a). Reports of Cat Ba langurs in captivity indicate that one year old juveniles have orange-brown on just over half of their tails, and the tail does not really begin to darken until six months of age (Nadler & Ha Thang Long 2000). In contrast, a captive Delacour langur infant of two weeks of age had a predominantly black tail (Nadler 1997; Agmen 2014).



Fig.9. A Cat Ba langur infant (left, 99-102 days old) and juvenile (right, 264-295 days old) (a). A François' langur newborn, less than 20 days old (b). Note the very different patterns of tail colouration.

François' langurs have the beginnings of a moustache by the second month, and a crest begins to develop in the third month; both are relatively adult-like by the end of the fourth month (the moustache continues to whiten and narrow, and the crest becomes more pointed, until François' langurs are juveniles). Conversely, Cat Ba langur moustaches start to become visible in the fourth month. Their crest is visible within the first month and starts to darken in the second month; it is more adult-like by the tenth month. The captive Delacour langur also had the beginnings of a crest at a month of age (Nadler 1997; Agmen 2014).

While François' langurs have black hairs appearing on their torso, arms, and upper legs by the end of the second month, this does not occur for Cat Ba langurs until the third month. François' langurs have an almost entirely jet-black pelage by the fourth month, while Cat Ba langurs still have a dull black coat with species-typical orange on the head and neck at 12+ months of age. Among captive Cat Ba langurs, the back does not darken until around six months of age, and two year olds have still not acquired a full adult colouration as their head and shoulders are more golden than those of adults (Nadler & Ha Thang Long 2000). In a captive male Delacour langur, the coat became dark orange in the second month, and by three months the chest started to darken while the dorsal side of the back and limbs were black; at five months he was 75% black, with patches of orange on the head, shoulders, and groin (Nadler 1997; Agmen 2014). Thus, François' and Delacour langurs develop dark colouration faster than Cat Ba langurs on their tails, torsos, and limbs. François' langurs also have moustaches that appear two months earlier than Cat Ba langurs. The Cat Ba and Delacour langurs, however, have earlier crest development. It is possible that the earlier loss of François' and Delacour langur natal coats is due to the fact that adult coats are darker black than the 'dark chocolate-brown' coats of Cat Ba langurs (who may retain yellow-brown hairs on the feet into adulthood: Groves 2007) (Nadler & Ha Thang Long 2000), thus making them easier to observe from a distance as they sharply contrast with orange natal coats and white moustaches. This does not, however, account for the drastic differences in tail colouration between these species, nor the fact that Cat Ba langurs in captivity (i.e. those that can be observed at a closer range) have similar development to those observed living in the wild, but not other captive Delacour langurs kept at the same facility (Endangered Primate Rescue Center - EPRC) in Vietnam.

Hypothesis 2

Independence and allocare interest

Across other primate species, this shift in natal-to-adult pelage is accompanied by an increase in independence (Jay 1963; Blaffer Hrdy 1976; Stanford 1991; Treves 1997), which is the same pattern we report here based on comparing our results with other data on measures of independence. For example, at the time when the skin darkens and dark hairs starts to show up on one-to-two month old François' langurs, the infants start to explore, rest, and play within a short distance of their mother or handler (Hu 2007). By the time drastic colouration shifts are happening in the fourth month, 42% of

infant locomotion is independent, and 50% of foods are solid (Hu 2007). By the time François' langurs are predominantly adult coloured, 90% of their food is solid (with weaning being complete around 12-14 months) and 98% of their locomotion is independent (Hu 2007). Among Cat Ba langurs, the 3-16 week old infants included in this study spent 26% of their time alone (i.e. not within arm's reach of another langur), 19% of their time on another langur, and are starting to locomote and forage on their own (Hendershott 2017). At about four months of age, around the time when the coat darkens significantly, Cat Ba langurs spend twice as much time alone as 3-16 week old individuals (50%) and only 1% of their time on another langur; their locomotion, foraging, and play rates also increase significantly compared to the previous age period (Hendershott 2017). A similar trend is seen in captive Delacour langurs. During their second and third months of life a drastic colour change is seen, which is also the same time that Delacour's langurs start foraging on their own more often and clinging to adults less often – their locomotion is frequently independent by one month of age (Agmen 2014).

This reported increase in independence associated with pelage changes is also related to a reduction in interest by group mates, at least in Cat Ba langurs. Among Cat Ba langurs, the average number of group members that are in proximity to young langurs (a proxy measure for interest) is inversely proportional to the infants' age category (Hendershott 2017), and newborns with full natal coats (0-3 week olds) receive twice as many transfer attempts as infants that have started to lose their natal coat (3-16 week olds) (Hendershott unpubl. data), despite the shorter time period of 'newborn'. Similarly, a captive Delacour's langur infant was handled by nonmaternal group mates most often during his second month of life (29% of the time), decreasing to 24% in the third month, which coincides with the darkening coat (Agmen 2014). This supports both our second hypothesis (pelage is related to dependence and allocate interest) and the infant defence hypothesis for Cat Ba langurs, in that group members are attracted to individuals with a natal coat, and their attraction, proximity, and caretaking may help in preventing the infant being killed by a strange male during their most vulnerable period (Alley 1980).

Hypothesis 3

Pattern of Natal Coat Loss

Both François' and Cat Ba langurs started to change pelage colouration on their heads and backs first, with limbs and tails being the last body parts to shift away from the orange natal colouration. In terms of understanding this pattern in relation to infanticidal pressures, these results suggest that the flamboyant natal pelage is not acting as a signal to group members – otherwise these areas that are visible while an infant is carried would retain orange longer (cf. Alley 1980). Instead, it suggests that paternity cloaking may be the selective pressure they are responding to; by masking areas that a male can use to identify his offspring (such as the ventrum, limbs, and tail), infants are protected from phenotypic-identification (Treves 1997).

Implications

The faster shift to adult colouration for François' langurs suggests that they suffer higher infanticide pressure than Cat Ba langurs (cf. Bădescu et al. 2016); development may have been sped up so as to seemingly avoid a long period of dependence and, thus, vulnerability to infanticide. Interestingly, this visual indicator of dependence does not directly correspond to behavioural dependence: François' langurs do not appear to be fully weaned until 12-14 months (Hu Gang 2007), although their pelage shift is relatively complete by five months of age. Either way, this result suggests that François' langurs may have historically suffered higher infanticide pressure. Although the current François' langur populations are less fragmented and more populous than those of Cat Ba langurs – which means that takeovers are more likely, and infants would benefit from masking their maternal dependence (indeed, GH observed group splits, takeovers, and infanticide in the course of fieldwork) – it is unknown how long this difference may have been in place or when the differences in natal coat loss evolved. Interestingly, and in contradiction to the above implication, the paternity cloaking that seems to be happening among Cat Ba langurs suggests that *they* may experience higher threats of

infanticide from strange males than François' langurs; by retaining their natal coat longer, they are better able to confuse paternity.

These data and the hypotheses analysed thus present somewhat conflicting implications: developing into an adult coat may indicate that an individual is past the point of suckling (and thus not a target for infanticide), but retaining a natal coat may mask paternity (thus reducing infanticide threats). The key difference between the theories is that the former focuses on *timing* of natal coat loss, while the latter focuses on the *pattern* of body parts from which the natal coat is lost. The theory about increasing the speed of development (cf. Bădescu et al. 2016) suggests François' langurs are facing higher infanticidal pressures, while the theory about paternity cloaking (cf. Treves 1997) suggests Cat Ba langurs are under higher infanticidal threat. Ultimately, more detailed data and further research is needed in order to assess takeovers, infanticides, and infanticidal threats in these species.

Another implication of delayed maturation in Cat Ba langurs is that this island-living species may be exposed to poorer-quality habitat or resources than François' langurs (cf. Borries et al. 2008). However, this does not explain the differences in development between captive Cat Ba and Delacour's langurs, who were presumably supplied with similar foods at the Endangered Primate Rescue Center (Nadler & Ha Thang Long 2000; Agmen 2014), nor does it explain why the captive Cat Ba langurs are more similar to their free-living counterparts than other captive limestone langurs at the same facility. Research into comparative habitat quality would help address this possibility.

Conclusion

In conclusion, both François' and Cat Ba langurs are born with flamboyant orange coats typical of *Trachypithecus* species, which are progressively lost as infants age (Hypothesis 1). By one month of age, both François' and Delacour langurs have predominantly black tails, whereas this does not occur in Cat Ba langurs until after they are a year old. At four months of age, François' and Cat Ba langurs have lost their bright coats, and have started to darken. By the time François' langurs are 9-11 months old they have their dark black coats; Cat Ba langurs gain adult colouration after one-two years of age. The loss of the natal coat is related to increased independence (in both species) and decreased interest in infants by group members (for Cat Ba langurs) (Hypothesis 2). The pattern to which areas of the body shifts colouration suggests that of the infanticide-avoidance hypotheses, the objective appears to be paternity cloaking (Hypothesis 3). Overall, Cat Ba langurs appear to lose their orange natal coat slower than François' langurs. This might be explained by differences in infanticidal pressure and habitat quality between the two species, although further research is necessary.

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Preliminary results on the food intake and nutrient digestibility of southern white-cheeked gibbons (*Nomascus siki*) and red-shanked douc langurs (*Pygathrix nemaeus*) at the Endangered Primate Rescue Center, Vietnam

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Key words: food intake, diet, primate, protein to fibre intake, comparative nutrition

Summary

During a period of 6 days, we recorded the amount of food ingested, their nutrient content and the amounts of each nutrient in grams within the faeces (analysed in a laboratory) to determine the apparent digestibility for each nutrient for both the red-shanked douc (*Pygathrix nemaeus*) and the southern white-cheeked gibbon (*Nomascus siki*) housed at the Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam. Based on our results, both the gibbons and the douc langurs were able to ferment structural carbohydrates with the gibbons having a slightly higher apparent digestibility for both Neutral Detergent Fiber (NDF), Acid Detergent Fibre (ADF). The douc langurs digested a much larger amount when compared to the gibbons given the higher proportion of fibre they ingested by weight. The protein to NDF intake ratio is different between douc langurs and gibbons. Douc langurs were very specific and stringent in their selection of protein to fibre, choosing 2.7g of fibre to every gram of protein. Gibbons were less restrictive in their selection but ingested more fibre than was thought necessary for this apparent frugivorous species which suggest that fibre may be more important in their diets than previously thought.

Những kết quả ban đầu về việc lấy thức ăn và khả năng hấp thu dinh dưỡng của loài Vượn đen má trắng phía nam (*Nomascus siki*) và loài Voọc chà vá chân nâu (*Pygathrix nemaeus*) tại trung tâm cứu hộ linh trưởng, Việt nam

Tóm tắt

Trong 6 ngày, nhóm nghiên cứu đã ghi chép lượng thức ăn tiêu thụ, thành phần dinh dưỡng và hàm lượng mỗi chất dinh dưỡng ở đơn vị đo gam. Việc phân tích trong phòng thí nghiệm dựa trên mẫu phân thu tại trung tâm cứu hộ linh trưởng Cúc Phương của hai loài chà vá chân nâu và vượn đen má trắng phía nam. Mục tiêu nhằm xác định khả năng hấp thu chất dinh dưỡng của mỗi loài. Kết quả cho thấy, cả hai loài đều có khả năng hấp thu các chất carbohydrates nhờ quá trình lên men. Vượn có khả năng hấp thu chất xơ trung tính (NDF) và chất xơ không hòa tan axit (ADF) cao hơn loài Voọc một ít. Tuy nhiên, loài Voọc tiêu thụ một lượng lớn chất xơ trong khẩu phần ăn so với Vượn. Tỷ lệ protein chuyển hóa từ chất xơ trung tính (NDF) của hai loài cũng khác nhau. Voọc có sự lựa chọn rất đặc biệt và nghiêm ngặt đối với chất xơ ăn vào. Trung bình sự lựa chọn là 2.7 gam chất xơ cho mỗi gam protein hấp thụ. Loài Vượn không có sự hạn chế trong lựa chọn chất xơ ăn vào, tuy nhiên việc ăn chất xơ nhiều hơn đối với một loài chuyên ăn quả điển hình chứng tỏ chất xơ có vai trò quan trọng trong thành phần thức ăn của Vượn so với những nghiên cứu trước đây.

Introduction

Given the current status of southern white-cheeked gibbons (*Nomascus siki*) and red-shanked douc langurs (*Pygathrix nemaeus*) across their range, some urgent action is needed to improve their *in-situ* and *ex-situ* conservation management. Understanding the ecology of these species is one of the first steps in the development of conservation management plans and guidelines.

One aspect of the study of their ecology involves understanding the nutrition of both species and notably how they digest nutrients. This information allows us to determine how much of the nutrients they eat in the wild are physiologically used and therefore can help suggest nutritional needs of the species. This is an essential first step to improve *in-situ* conservation in terms of habitat requirements and *ex-situ* conservation with the improvement of captive management, breeding programs and rehabilitation and release, especially so for species that are highly threatened of extinction in the wild, such as the two focal species of this study.

Food intake and nutrient digestibility are best studied in captive settings. In the wild this would require full day follows of known individuals for focal sampling and detailed knowledge and quantification of food intake, which would be logistically unfeasible. The red-shanked douc is a member of the subfamily Colobinae, defined by their sacculated stomachs (Chivers 1994). Their stomach has favourable conditions to house microflora capable of digesting plant fibres (notable hemi-cellulose and cellulose) (Hale et al. 2017), allowing them to have heavily folivorous diets (Caton 1999; Wright et al. 2008). Their highly specialized diet and physiology is why they tend not to thrive under human care. Gibbons on the other hand, are described as frugivores (Conklin-Brittain et al. 2001) and are easier to maintain and reproduce when kept under human care. Fibre is expected to be an important nutrient for the health of langurs, but not for primates given the label of "frugivore" (National Research Council 2003).

In July 2015, we conducted a food intake study and collected data to assess the digestibility of both the southern white cheeked gibbon and the red-shanked douc langur at the Endangered Primate Rescue Center in Cuc Phuong National Park, Vietnam where both species have been maintained for over two decades. We present the preliminary results of this research and discuss implications and future needs for additional data collection.

Methods

Study species

Eight southern white-cheeked gibbons, housed in two enclosures (three and five individuals) and seven red-shanked douc langurs, housed in two enclosures (four and three individuals) were included in the study (Table 1).

Table 1. Southern white-cheeked gibbon (*Nomascus siki*) and red-shanked douc (*Pygathrix nemaeus*) individuals at the Endangered Primate Rescue Center included in the digestibility study.

ID No	Name	sex	Date of birth	Sire	Dam
<i>Nomascus siki</i>					
9-08	Simba	F	1998	WILD	WILD
9-12	Rafi	M	17/12/02	9-05	9-02
9-18	Zazu	M	4/08/13	9-12	9-08
9-02	Daisy	F	1993	WILD	WILD
9-05	Gorbi	M	1992	WILD	WILD
9-13	Gosy	F	21/11/06	9-05	9-02
9-15	Jonas	M	15/07/09	9-05	9-02
9-19	Matilda	F	4/10/14	9-05	9-02
<i>Nomascus siki</i>					
6-77	Fish	F	18/04/12	6-06	6-38
6-62	Basti	M	17/03/09	6-28	6-31
6-53	Chips	F	2003	WILD	WILD
6-38	Tine	F	? adult	WILD	WILD
6-09	Butz	M	1997	WILD	WILD
6-55	Laura	F	2/02/08	6-28	6-46
6-83	no name	M	25/02/14	6-09	6-55

Data collection

The data collection was carried out from the 10th July to 16th July 2015.

We followed the exact same feeding schedule in place at EPRC. Douc langurs are fed three times a day (approximately at 6:30am; 10:30am; 3:30pm) and gibbons four times a day (approximately at 6:30am; 9:00am; 10:30am; 3:30pm). Enclosures are systematically cleaned before each feeding for douc langurs, while for gibbons enclosures are cleaned two to three times per day. To facilitate the study, douc langurs were fed only with the same five plant species during the study period, for which only leaves are consumed: *Averrhoa carambola*, Oxalidaceae (Vietnamese name Khè); *Dalbergia assamica* [*D. lanceolata*], Fabaceae (Vietnamese name: Co Khet); *Sterculia lanceolata*, Malvaceae (Vietnamese name: Sàng); *Alangium kurzii*, Cornaceae (Vietnamese name: Chang Bang); *Clerodendrum paniculatum*, Lamiaceae (Vietnamese name: Bán Bán, Mò dó). Gibbons were fed their regular diet, which varies daily and depends on food seasonality and availability at the market.

All the food prepared for the animals was weighed for each cage separately before each feeding session. Rice porridge fed to gibbons in the morning and sweet potatoes given to doucs during the day as enrichment food were however weighed only once to use as standard value for analysis. All food items/plant species were weighed separately. Food for gibbons was weighed using a digital scale (Denver Instrument XP-300) and leaf bundles for douc langurs were weighed using a mechanic kitchen scale.

After each cage cleaning session, feces were collected and placed into Ziplock bags labeled with date and coded. One feces sample per cage per day was collected. All fecal samples were frozen immediately after collection.

The left-over food from each cage was sorted by food item/plant species and weighed separately.

A total of 57 samples were collected: 24 food samples, 28 feces samples and 5 leaf samples. The samples were tested at the Central Lab, Faculty of Animal Science and Aquaculture (FASA), Vietnam National University of Agriculture (VNUA) for their content in Neutral Detergent Fiber (NDF), Acid

Detergent Fibre (ADF), crude protein, crude fat, ash, moisture, energy, calcium, phosphorus, and lignin. Only the parts actually consumed by the animals were tested for nutritional content.

Preliminary Results and Discussion

Over the course of the study period (six days), the gibbons were fed with a diet of rice porridge, 13 types of vegetables, 10 types of fruits, boiled eggs and peanuts. The douc langurs were fed five browse species in similar quantities and sweet potatoes. Different proportions by weight of each food item were fed and eaten (Table 2).

Table 2. Proportion of fresh weight of food items fed and eaten by southern white-cheeked gibbon (*Nomascus siki*) and red-shanked douc (*Pygathrix nemaeus*) over a 6-day study at the Endangered Primate Rescue Center.

Food Item (%)	<i>P. nemaeus</i>		<i>N. siki</i>	
	given	eaten	given	eaten
Browse	98.60	95.73	-	-
Vegetables	1.40	4.27	57.86	61.58
Fruits			33.07	29.37
Egg			0.54	0.52
Grains			6.76	7.07
Peanuts			1.76	1.47

Note: the browse that gibbons were fed is negligible and was not recorded.

Interestingly, the gibbons chose to eat more vegetables and less fruits than the proportions provided overall. Historically these species are fed high fruit diets in captivity. Using the amounts of food ingested, we were able to calculate the nutrients ingested on a dry matter basis (Table 3).

Table 3. Concentration of nutrients ingested by southern white-cheeked gibbon (*Nomascus siki*) and red-shanked douc (*Pygathrix nemaeus*), on a dry matter basis, from the diet fed over a 6-day study period at the Endangered Primate Rescue Center.

	Ash	Protein	Fat	ADF	NDF	TNC	Ca	P	Energy	Ca:P
<i>P. nemaeus</i>	8.1	18.5	3.9	20.4	44.8	24.5	2.7	0.2	6.3	13.5
<i>N. siki</i>	4.7	11.1	3.6	9.0	30.1	50.3	0.5	0.2	2.8	2.1

All nutrients are in % dry matter; Energy is in kcal/g.
 ADF=Acid Detergent Fibre; NDF=Neutral Detergent Fibre; TNC= Total Non-structural Carbohydrate; Ca=Calcium P=Phosphorus

The almost entire leaf diet of the douc langurs was high in protein, fibre and calcium while being low in soluble carbohydrates. These values are expected for a frugivore fermenting primate although the high calcium content was a surprise (Nijboer et al. 2006). The gibbons chose to ingest a higher than expected fibre content (Neutral Detergent Fibre [NDF] = 30.1%) for a “frugivore” (National Research Council 2003). Ingesting and processing this amount of fibre takes significant morphological and physiological adaptations. Fruits given to primates in captivity are not equivalent to the fruits eaten in the wild (Schwitzer et al. 2009). Cultivated fruits are typically much higher in sugars and lower in fibre (Hon et al. 2018). Our misconception of frugivores having low fibre and high sugar requirements may therefore be erroneous (with some possible exceptions, e.g. spider monkeys) (Cabana et al. 2018).

The nutrients ingested multiplied by total dry mass ingested equals the number of each measured nutrient ingested in grams. These values were divided by the amounts of each nutrient in grams within the faeces to determine the apparent digestibility for each nutrient for both species (Table 4).

Table 4. Percentage (mean and standard deviation SD) of the apparent digestibility of macronutrients for southern white-cheeked gibbon (*Nomascus siki*) and red-shanked douc (*Pygathrix nemaeus*) fed at the Endangered Primate Rescue Center.

	Energy	Protein	Fat	ADF	NDF	Ca	P
<i>P. nemaeus</i> - Mean	86.61	80.17	54.4	83.92	89.15	86.59	51.34
<i>P. nemaeus</i> - SD	8.41	12.12	29.20	10.14	6.71	8.26	26.39
<i>N. siki</i> - Mean	91.26	87.99	81.01	86.63	92.58	88.74	84.44
<i>N. siki</i> - SD	4.52	9.27	19.74	6.52	3.34	5.69	8.53

ADF=Acid Detergent Fibre; NDF=Neutral Detergent Fibre; P=Phosphorus; Ca=Calcium

Based on our results, both the gibbons and the douc langurs were able to ferment structural carbohydrates with the gibbons having a slightly higher apparent digestibility for both ADF and NDF. Keeping in mind that the douc langurs ingested more fibre by weight, they therefore digested a much larger amount when compared to the gibbons. Colobine primates are expected to have an apparent digestibility of NDF of at least 60% (Edwards & Ullrey 1999; Nijboer et al. 2006). Our results indicate a mean apparent digestibility of 89.15% for the douc langurs which is consistent with their fibre degrading bacteria housed in their digestive system (Clayton et al. 2016). A mean apparent digestive efficiency of 92.58% for gibbons is much higher than anticipated and may highlight how adapted gibbons may be to fibre in their diet.

Lastly, the protein to NDF intake ratio is different between douc langurs (Fig. 1) and gibbons (Fig. 2). Douc langurs were very specific and stringent in their selection of protein to fibre, choosing 2.7g of fibre to every gram of protein. Gibbons were less restrictive in their selection and the line of best fit generated had a low R value (0.68), which means the values are correlated but only barely. What was surprising, however, is that the gibbons definitely ingested more fibre than was thought necessary for this apparent frugivorous species (National Research Council 2003). Perhaps captive care for them should focus more on fibrous browse and vegetables and less on highly succulent fruits since this appears to be what they are intently selecting. Higher fibre diets also come with a host of health benefits for primates under human care (Clayton et al. 2016). With the surprisingly high apparent digestibility of fibre and the selection of fibrous foods, fibre may be more important in their diets than previously thought.

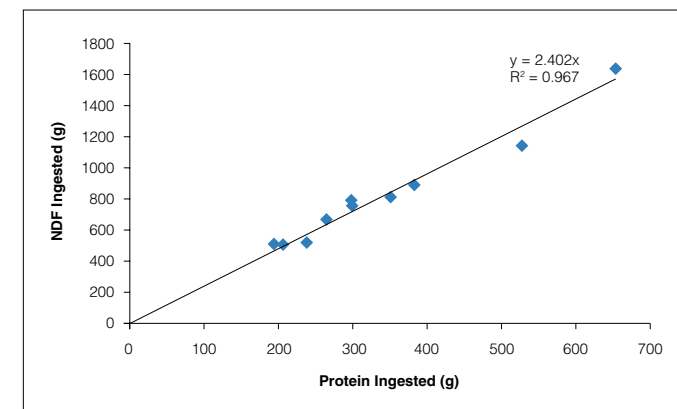


Fig.1. Protein to NDF intake ratio for douc langurs.

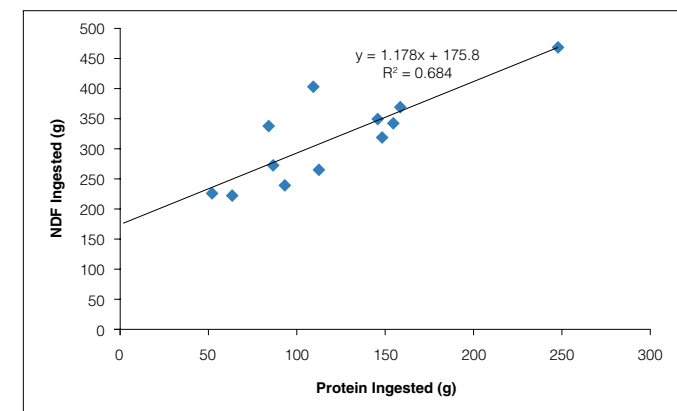


Fig.2. Protein to NDF intake ratio for gibbons.

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Preliminary study of an albino individual in a Francois langur group (*Trachypithecus francoisi*) with reference to *Trachypithecus* genus color variation

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Key words: albino, Francois langur, *Trachypithecus francoisi*, pelage color, behaviour

Summary

An albino female Francois langur was identified in a Francois langur group consisting of 12 individuals in Encheng National Nature Reserve, Daxin, China. Preliminary observation indicated that the albino was pure white from head to tail and clear contrast with other members. She exhibited foraging and cliff-climbing behaviors like other individuals. There were no cases of discrimination against her during our observation periods. Further study on both genetic differences amongst her parents and siblings and behaviors would be necessary to reveal the genetic mechanisms of albinism in langurs, which may provide more evidence to study the albinism mechanism among the *Trachypithecus* genus.

Kết quả nghiên cứu ban đầu về cá thể bạch tạng trong bầy Voọc đen má trắng (*Trachypithecus francoisi*) và liên hệ với sự đa dạng màu sắc của giống *Trachypithecus*

Tóm tắt

Một cá thể cái loài Voọc đen má trắng mắc bệnh bạch tạng được nhận diện trong bầy gồm 12 cá thể tại khu bảo tồn Encheng, Daxin, Trung Quốc. Những quan sát trực tiếp cho thấy cá thể này có màu sắc thân trắng toàn bộ từ đầu đến đuôi, và tương phản hoàn toàn với các cá thể khác trong bầy. Về tập tính từ kiếm ăn đến leo treo trên núi đá, cá thể này hoàn toàn giống các cá thể khác. Suốt thời gian nghiên cứu, chúng tôi không ghi nhận bất kỳ hành động kỳ thị nào từ các con khác trong bầy đối với cá thể này. Cần có thêm những nghiên cứu về di truyền đối với bố mẹ và các thành viên trong gia đình của cá thể này để có những kết luận về cơ chế di truyền đối với bệnh bạch tạng ở các loài Voọc. Những nghiên cứu này cũng có thể đưa ra những bằng chứng rõ ràng hơn về cơ chế gây bệnh bạch tạng trong giống *Trachypithecus*.

Introduction

Body color is important for camouflaging (Sun 2006) and most primates display black, black and white, or a dark coat (Fleagle 2013; Groves 2001; Mittermeier et al. 2013). The colobine genus *Trachypithecus*, includes 20 species. Of these, seven species are classified in the *francoisi* langur species group including the Francois langur (*T. francoisi*), the white-headed langur (*T. leucocephalus*) and the Cat Ba langur (*T. poliocephalus*) in the northern area of the distribution, the Delacour's langur (*T. delacouri*) in the central area and the Hatinh langur (*T. hatinhensis*), the black morph of the Hatinh langur (*T. hatinhensis* morph *ebenus*) and the Lao langur (*T. laotum*) in the South. Populations of all three clades are able to survive in karst habitats, landscapes underlain by limestone. Therefore they

are commonly referred to as karst langurs (Nadler & Brockman 2014; Mittermeier et al. 2013).

Karst langurs are distributed throughout southern Chongqing Municipality, Guizhou and Guangxi Provinces of China, northern and central Vietnam, and north Laos (Nadler & Brockman 2014; Mittermeier et al. 2013). These seven langur species are allopatric and occupy similar types of karst habitats. These species also share similar external features: adults are mainly black with white or gold patches on their heads or part of their bodies and infants differ from adults in being golden or bright yellow in color. All species have a narrow distribution and small populations; and all have excellent cliff-climbing abilities (Mittermeier et al. 2013; Huang et al. 2008b).

DNA analysis indicated that the seven karst langurs originated from a primitive *T. francoisi* during the expansion from Southeast Asia across Vietnam and north to South China (Roos et al. 2007; Roos et al. 2011). Two species of the northern clade (*T. poliocephalus* and *T. leucocephalus*) evolved into independent species 0.45-0.5 mya from *T. francoisi* (Liu et al. 2013).

Besides the allopatric distribution, the main feature of the seven karst langur species is the composition of hair color. In the northern clade, *T. francoisi* is completely black with a strip of white hair from the corner of the mouth to the ear and then around the ear. *T. poliocephalus* has golden hair on the head with the remainder of the body being dark brown. *T. leucocapthalus* is very similar to *T. poliocephalus* but with white hair replacing the golden hair and a distal part of the tail is white. In fact, these two species are so similar in morphological features that *T. leucocapthalus* was until recently considered a subspecies of *T. poliocephalus* (Groves 2001). Only *T. delacouri*, which has a large white pelage on the hip, belongs to the central clade. In the southern clade of the Francois' species group, *T. hatinhensis* is similar to the Francois langur in appearance, with additional white hair from the ears down to the neck. *T. laotum* also has similar pelage to the Francois langur except for a white head with a black crest on top. The black morph of the Hatinh langur (*T. hatinhensis* morph *ebenus*) has completely black pelage in the adult (Nadler & Brockman. 2014; Mittermeier et al. 2013). It appears then that the composition of white and black pelage differentiates the seven species, suggesting that the genes that control the pelage and its color may drive the speciation of the Francois species group, once the ancestral population became geographically isolated and the pelage change fixed.

It is possible that an examination of the albino individual and its behavior might contribute modestly to our understanding of the relationships between pelage variation and the mechanism of speciation.

Study site and methods

Encheng National Nature Reserve is located in Daxin County, Guangxi Province, China, (22°36'32"—22°49'53"N / E106°58'12"~107°15'45"), with a total area of 25,819 m². Close to the border of China and Vietnam, the reserve is an important passage for biological exchange between mainland Asia and the Indochinese Peninsula and is one of the hot spots of biodiversity. The reserve consists of important biological groups and unique species, including 1007 species of vascular plants and 261 species of terrestrial animals. The Francois langurs, other rare species of animals and plants, and their habitats, including the karst ecosystem of the northern part of tropical forest, are protected (Tan 2014).

The Francois langur group with an albino individual inhabits a hill belonging to the Bangtun Village. To the North, Northeast, and South is cultivated land. The land to the South is flat, is surrounded by hills (Fig. 1), and has less human activity so it is used more frequently by the Francois langur group.

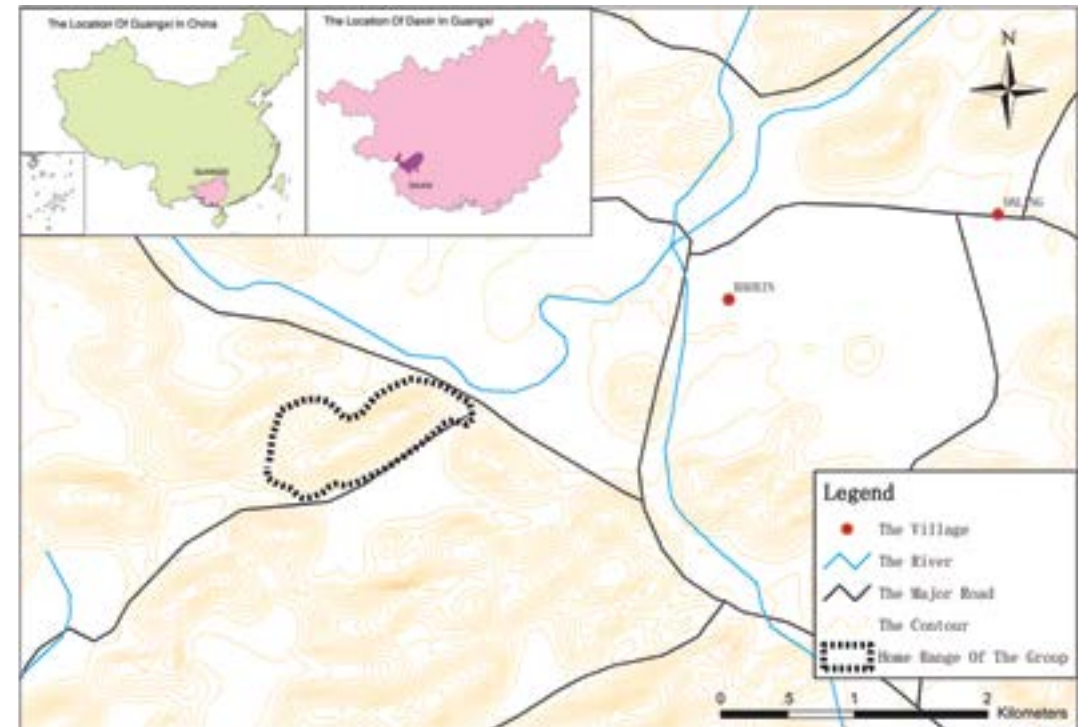


Fig.1. Location of an albino Francois' langur and it's group.

The study period lasted from November 2017 to January 2018.

Binoculars (Sky Hawk Pro 14x42) were used to observe the langurs during their day range and a Nikon AF-S 800mm lens was used to photograph.

All research was with formal permission from the Encheng National Nature Reserve Administration Bureau in Daxin and adhered to the legal requirements of China and the International Primatological Society (IPS Principles) for the ethical treatment of non-human primates during the study.

Results

Group composition

The Francois langur group is composed of 12 individuals, one adult male, four adult females, three subadults (female albino and two males), three immature individuals (one male and two females) and one infant. The albino individual is a three-year-old female. The adult male is the father of the albino, and one of the resident adult females is the mother (Fig. 2).

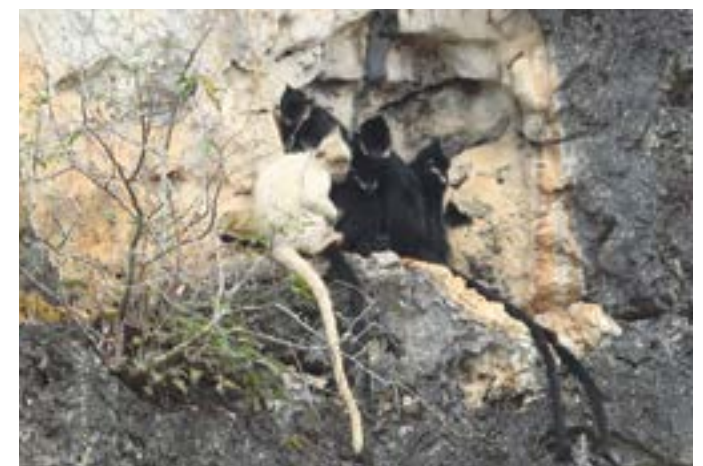


Fig.2. Albino individual and part of its family. Photo: Chengming Huang.

Color description of the albino individual

The pelage of the albino individual is purely white from head to tail. The skin of the face is light colored and similar to a one month old infant. The albino is striking in comparison to the normal individuals with black hair and faces (Fig. 3). When she moves against a black cliff, it is also striking (Fig. 4).



Fig.3. The pelage from head to tail of the albino is purely white with light facial skin color. Photo: Chengming Huang.



Fig.4. The striking contrast between the purely white pelage of albino and the cliff background. Photo: Chengming Huang.

Behavioral observation

Preliminary observation indicated that the albino individual exhibits normal foraging behavior (Fig. 5) and the distinctive cliff-climbing behavior (Fig. 4) as exhibited by her relatives in the group. During the day, she clustered with other members sometimes at the side of the group and other times at center of the group (Fig. 2, Fig. 3). Grooming behavior often reflects a close relationship between two individuals (Dunbar 1988; Goodall 1986), and the albino individual both groomed others and was groomed by others. It did not appear that the albino individual was discriminated against by other members of the group.



Fig.5. Albino individual exhibits foraging behavior similar to others. Photo: Chengming Huang.

Discussion

Albinism is often seen in rats, which have been well studied as important experimental animals (Butt et al. 2007; Khan et al. 2007; Aguech-Oueslati et al. 2018). Individuals of primate species of sometimes exhibit albinism as well including the Hamadryas baboon (Grigson et al. 2008), stump-tailed macaque (Maneechot et al. 2015), Western gorilla (Marquez et al. 2008; Prado-Martinez et al. 2013) and Rhesus macaque (Singh et al. 2009). The 40 years old gorilla also became albino (Marquez et al., 2008) due to iron deficiency, and inbreeding in the wild also results in albinism (Prado-Martinez et al. 2013). However, the exact mechanisms of albinism in different species are not yet well studied except for human being (Hassan et al. 2017).

An albino Francois langur individual was first seen in the Encheng National Nature Reserve in 1970-80 during a wildlife population survey, and the older local villagers said that they also found an albino individual in the 1950's (Chengming Huang pers. comm.). It is known that the survey team from the Forestry Design Department of Guangxi Province shot one albino individual and prepared the skin at that time, but the specimen is nowhere to be found at present. Another albino individual was said to be captured and displayed in Liuzhou Zoo of Guangxi Province, China. Li & Ma (1980) discovered the hybridization of white-headed langurs and Francois langurs. Liu & Wei (1995) also reported five albino Francois individuals and one stump-tailed macaque (*Macaca arctoides*) in their survey. Unfortunately, there is no further information or studies on Francois langur albinos. Thus far,

albino Francois langurs have only been reported in Encheng Nature Reserve.

The albino individual is a three-year-old female and will be of breeding age at four or five years. We expect the adult male in the group will be replaced in the next year or two, which is similar to the white-headed langur (Huang et al. 2008a; Huang et al. 2008b; Huang et al. 2015; Zhou et al. 2009; Zhou et al. 2013). So it is likely that the albino will copulate and breed with another adult male. We plan to observe the pelage color of her infant at that time.

It would be important for future studies to focus on the genetic differences between the albino individual's mother, father and herself. Since the Francois langur is a primitive species amongst the at least three karst langur species (Liu *et al.* 2013), the study on albino mechanism will benefit the understanding of the speciation of karst langurs.

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Groves CP (2001): *Primate Taxonomy*. Smithsonian Institution Press, Washington DC.

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Groves CP 2004: Taxonomy and Biogeography of Primates in Vietnam and Neighbouring Regions. In: Nadler T, Streicher U. & Ha Thang Long (eds.): *Conservation of Primates in Vietnam*; pp. 15-22. Frankfurt Zoological Society, Hanoi.

Dissertations

Otto C (2005): Food intake, nutrient intake, and food selection in captive and semi-free Douc langurs. PhD thesis, University Cologne, Germany.

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