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Cover: Red-shanked douc langur (*Pygathrix nemaeus*). Photo: T. Nadler.

Conference
< CONSERVATION OF PRIMATES IN INDOCHINA >

October 2013

Cuc Phuong National Park, Vietnam

The Endangered Primate Rescue Center and Cuc Phuong National Park are pleased to announce the third international conference 'CONSERVATION OF PRIMATES IN INDOCHINA', October 2013 in Cuc Phuong National Park, Vietnam.

The conference will be arranged under the patronage of the Administration of Forestry of Vietnam with additional support by Frankfurt Zoological Society and Leipzig Zoo, Germany.

In 2003 the first international primate conference in Vietnam 'CONSERVATION OF PRIMATES IN VIETNAM' took place in Cuc Phuong National Park, organized by Frankfurt Zoological Society. This first conference hosted 110 participants from 13 countries, and 29 presentations from 41 authors have been published in a book (Nadler et al., 2004, 174 pages). Due to the increasing number of primatologists working in South-east Asia, several presentations about primate taxa across the region and the increasing necessity of cooperation among primatologists, a second conference was organized with broader relevance.

In 2008 the second international primate conference 'CONSERVATION OF PRIMATES IN INDOCHINA' included 130 participants from 10 countries, and 30 presentations from 79 authors were published again in book format (Nadler et al., 2010, 288 pages).

One important outcome of the conference 'CONSERVATION OF PRIMATES IN INDOCHINA' was the organization and agreement among participants to submit Vietnams bid to the International Primatological Society to host the IPS Congress 2014. With support and engagement of the Administration of Forestry of Vietnam, hosting of this congress was awarded to Vietnam by the IPS Congress 2010 in Kyoto.

Keeping the five year quinquennial primatological conference in Cuc Phuong we would like to invite all interested primatologists and conservationists to attend the third conference 'CONSERVATION OF PRIMATES IN INDOCHINA'. This will permit the exchange of information about primate work in the region including the results of research and status of primates, and will aid preparation for the IPS Congress in August 2014.

Aside from scientific presentations the arrangement of field trips as pre and post conference tours are in planning. Integrated in the program is a field trip to Van Long Nature Reserve with the possibility to observe Delacour's langur (*Trachypithecus delacouri*) in their natural habitat.

Additional to the conference program we try to organize parallel field trips to Cat Ba Island in Ha Long Bay with the possibility to observe Cat Ba langurs (*Trachypithecus poliocephalus*), to Kon Ka Kinh National Park in the Central Highlands of Vietnam to observe grey-shanked douc langurs (*Pygathrix cinerea*), to Son Tra Nature Reserve, Danang to observe red-shanked douc langurs

(*Pygathrix nemaeus*), to Khau Ca Nature Reserve to observe Tonkin snub-nosed monkeys (*Rhinopithecus avunculus*), and to Trung Khan Nature Reserve with the possibility to see eastern black gibbons (*Nomascus nasutus*).

We hope to provide an attractive agenda with interesting presentations, field trips, and stay at Cuc Phuong National Park's nature with the possibility to visit the Endangered Primate Rescue Center housing many of Vietnams endangered primates.

Details about registration, costs, travel and presentations we will provided early next year on the EPRC website (www.primatecenter.org), currently being arranged, along with the next issue of the *Vietnamese Journal of Primatology*.

We look forward to seeing you soon.

Nadler T, **Streicher U** & **Ha Thang Long** (eds.) (2004): Conservation of Primates in Vietnam. Frankfurt Zoological Society, Hanoi.

Nadler T, **Rawson BM** & **Van Ngoc Thinh** (eds.) (2010): Conservation of Primates in Indochina. Frankfurt Zoological Society and Conservation International, Hanoi.

Why Sea Lions don't catch Zebras
– Thoughts about common names of Indochinese primates

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Key words: primates, common / vernacular names, *Pygathrix*, douc langurs

Summary

There are several common English names for Indochinese primate species in use. A consensus of names and usage will benefit conservation activities and protection work of policy makers and forest protection authorities by reducing confusion and enhancing understand in legal proceedings and in the public.

Tại sao Sư tử biển không bắt Ngựa vằn - Suy nghĩ về tên gọi thông thường của các loài thú linh trưởng vùng Đông Dương

Tóm tắt

Hiện nay, có nhiều tên gọi thông thường (tên tiếng Anh) đối với các loài thú linh trưởng vùng Đông Dương. Tuy nhiên vẫn chưa có sự thống nhất trong việc gọi tên ở một số loài. Sự thống nhất về tên gọi của một loài và việc sử dụng tên gọi hợp lý sẽ có lợi cho các hoạt động bảo tồn loài đó. Mặt khác, việc thống nhất tên gọi của một loài cũng giúp các nhà quản lý, các chính trị gia trong lĩnh vực bảo vệ rừng hiểu rõ hơn về đối tượng cũng như tăng cường hiệu quả của công tác quản lý bảo vệ.

Why sea lions don't catch zebras? Even in kindergarden you would likely have provided a plausible answer to this question. Explaining the reasoning in terms of morphology, ecology, phylogeny and geography for a flying fox, guinea pig, mouse deer or sea cow (not to mention a Tasmanian devil) is probably more difficult.

To reach a consensus about the common name for a primate species is sometimes a long process. For the species belonging to the Indochinese genera *Nomascus* and *Pygathrix* it is a Gordian knot and unresolved.

For the three recognized species of the genus *Pygathrix* the discussion involves the use of douc, douc langur or douc monkey. Unanimity exists in usage of the term "douc" for these primates with red (*P. nemaeus*), grey (*P. cinerea*) or black legs (*P. nigripes*). The etymology of the term remains unclear. Its been suggested the name derived from Vietnamese origin and was translated to French. However, this name even with an amended offbeat pronunciation is unknown in Vietnam. From the vocalization of the animals, which is sometimes suggested as a source, this animal must have been making uncharacteristic sounds when discovered.

Easier to trace is the origin of "langur". There exists a source in three languages with similar pronunciation: Hindi लंगूर, Urdu لنگور (lagur or langur) and Sanskrit लाङ्गूलिन् (langulin). The original use characterized the sacred Hanuman langur (*Semnopithecus entellus*) as a monkey with a long tail. In the 19th century this name was used for all long-tailed Colobinae in the region, including the genera *Semnopithecus*, *Trachypithecus*, *Presbytis*, *Pygathrix*, and mostly also for the two odd-nosed taxa *Rhinopithecus* and *Simias*. The use of "douc langur" for the three taxa which belonging to the genus *Pygathrix* should also convey the scientific placement of the genera to South-east Asian Colobinae. These are in general leaf-eating primates with a long tail. The term "douc langur" both recognizes the similarity and distinction with the other south and South-east Asian genera *Semnopithecus*, *Trachypithecus*, *Presbytis*, which are named as langurs. The three *Pygathrix*-species are not red-, grey-, or black-shanked langurs: they should be named as red-, grey- and black-shanked douc langurs.

The term "langur" should also be considered for the four South-east Asian *Rhinopithecus* species and for *Simias concolor* on the Mentawai Islands. Furthermore, "snub-nosed langur" and "douc langur" which is already a widely used term for these groups, is more accurate than "snub-nosed monkey" or "douc monkey" because of the biogeographical and phylogenetic significance of the term "langur".

South and South-east Asian "monkeys" in principal represent both Colobinae and Cercopithecinae (i.e. the genus *Macaca*). Macaques differ considerably in morphology, ecology and behavior from the Colobinae which should be referred to as langurs. The common term "monkey" is insufficient for use among Colobinae taxa.

Why do we need to discuss splitting hairs? Why can't scientists and authors use a name which satisfies their own view?

Conservation activities and conservationists have an increasing responsibility to preserve our natural environment. Many wild animal and plant species are highly threatened and need all efforts for their preservation. The goal should be to involve a maximum number of our human population to take part in conservation. Education and awareness is important but due to multifarious and increasing problems with the flood of information, we can not expect a broader public understanding in our field. To make matters more difficult there is the issue of creating several names for one animal. Few will realistically understand or know that the "douc", the "douc langur" and the "douc monkey" or the "yellow-cheeked gibbon", the "southern yellow-cheeked gibbon", the "yellow-cheeked crested gibbon", the "golden-cheeked gibbon", the "buff-cheeked gibbon", and the "Gabriella's gibbon" represent only two species. Occasionally decision makers are also confused and irritated with the use of names which hinder understanding and necessary conservation activities.

Even a use of scientific names, normally not in public use, does not simplify the issue. The system of biological systematics is not stable and changes depending on current knowledge and research. We are still far from a final definition and a general agreement of what a species actually is. Despite all the new genetic, cytogenetic, behavioural and additional findings, the wise words are still relevant: "a species is a group of individuals which a competent taxonomist identifies as such".

A consensus and use of common names would benefit the understanding and practice of protection and conservation of our field which has a high number endangered primate species (Table 1).

Table. 1. Recommended names for Vietnamese primate species.

Common name	Scientific name
Lorises	
Pygmy loris	*Nycticebus pygmaeus*
Northern slow loris	*Nycticebus bengalensis*
Macaques	
Long-tailed macaque	*Macaca fascicularis*
Stump-tailed macaque	*Macaca arctoides*
Rhesus macaque	*Macaca mulatta*
Assamese macaque	*Macaca assamensis*
Northern pig-tailed macaque	*Macaca leonina*
Langurs	
Annamese silvered langur	*Trachypithecus margarita*
Indochinese silvered langur	*Trachypithecus germaini*
Grey langur	*Trachypithecus crepusculus*
Francois' langur	*Trachypithecus francoisi*
Hatinh langur	*Trachypithecus hatinhensis*
Black langur	*Trachypithecus ebenus*
Cat Ba langur	*Trachypithecus poliocephalus*
Delacour's langur	*Trachypithecus delacouri*
Douc langurs	
Red-shanked douc langur	*Pygathrix nemaeus*
Grey-shanked douc langur	*Pygathrix cinerea*
Black-shanked douc langur	*Pygathrix nigripes*
Snub-nosed langurs	
Tonkin snub-nosed langur	*Rhinopithecus avunculus*
Gibbons	
Western black gibbon	*Nomascus concolor*
Eastern black gibbon	*Nomascus nasutus*
Northern white-cheeked gibbon	*Nomascus leucogenys*
Southern white-cheeked gibbon	*Nomascus siki*
Northern yellow-cheeked gibbon	*Nomascus annamensis*
Southern yellow-cheeked gibbon	*Nomascus gabriellae*

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Comparative cranial morphology of douc langurs (*Pygathrix cinerea*, *P. nemaeus*, *P. nigripes*)

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Key words: *Pygathrix*, cranial morphology, comparison

Summary

The study describes the cranial morphology of the three species of douc langurs, *Pygathrix cinerea*, *P. nemaeus* and *P. nigripes*. The variability of some features could be analysed on 24 skulls of *P. cinerea*, 18 skulls of *P. nemaeus*, and 4 skulls of *P. nigripes*.

28 linear measurements were taken on all skulls for statistical analyses. As the skulls clearly change with age, correlations between each measurement and age have to be eliminated from statistical analyses. Therefore, age-independent residuals were calculated from all linear measurements in linear regressions against the age class.

Morphologically the skulls of the three species of *Pygathrix* can not be clearly separated from each other by naked eye or simple measurements. Student's t-tests revealed only few statistically significant differences between the species but none in the age-independent residuals between *P. cinerea* and *P. nemaeus*. Discriminant analyses of the age-independent residuals indicated the possibility to separate the three species of *Pygathrix*.

So sánh đặc điểm giải phẫu hình thái sọ ở các loài vọoc chà vá (*Pygathrix cinerea*, *P. nemaeus*, *P. nigripes*)

Tóm tắt

Nghiên cứu này mô tả các đặc điểm giải phẫu hình thái sọ của ba loài chà vá tại Việt Nam gồm *Pygathrix cinerea*, *P. nemaeus* và *P. nigripes*. Sự biến thiên của các đặc điểm giải phẫu sọ được phân tích trên 24 mẫu sọ của loài *P. cinerea*, *P.nemaeus* (18 mẫu) và loài *P.nigripes* (4 mẫu). 28 thông số đã được đo và được phân tích thống kê. Khi xử lý số liệu thống kê, mối quan hệ giữa các số đo và độ tuổi của mẫu sọ phải được loại bỏ. Nhờ đó, các biệt số độc lập với độ tuổi được tính từ tất cả các phép đo trong thống kê hồi quy tuyến tính.

Hình thái của các mẫu sọ của ba loài thuộc giống *Pygathrix* không thể phân biệt rõ bằng mắt thường và các thông số đo đơn giản. Kiểm định thống kê T-test cho thấy chỉ có một vài sự sai khác một cách có ý nghĩa thống kê các số đo của mẫu sọ thuộc hai loài *P.cinerea* và *P.nemaeus*. Tuy nhiên, phân tích thống kê sự khác biệt của biệt số độc lập với độ tuổi cho thấy có thể phân loại 3 loài chà vá thuộc giống *Pygathrix* dựa trên đặc điểm hình thái sọ.

Introduction

Vietnam is considered a "Biodiversity Hotspot" (Mittermeier et al., 2004) and is characterized by a large number of endemic species (Stirling & Hurley, 2005, Sterling et al., 2006), including five of the world's 25 most endangered primates (Mittermeier et al., 2009). One of them is the grey-shanked douc langur, *Pygathrix cinerea*, which has only recently been described, first as subspecies of the red-shanked douc langur, *P. nemaeus*, on differences in coloration (Nadler, 1997) and later was considered a distinct species on the basis of molecular genetic data (Roos & Nadler, 2001; Roos, 2004). Thus currently three species of *Pygathrix* are distinguished.

Pygathrix cinerea is listed as a "Critically Endangered" species, *P. nemaeus* and *P. nigripes* as "Endangered" (IUCN, 2009). All three species are relatively poorly known.

P. nemaeus, occurs in central to south Laos, north-central Vietnam and in a small area in north-east Cambodia (Rawson & Roos, 2008). *P. cinerea* occurs in five provinces in central Vietnam: Quang Nam, Gia Lai, Kon Tum, Quang Ngai and Binh Dinh (Ha Thang Long, 2007; Nadler et al., 2003; 2007), and probably in restricted areas in Laos and Cambodia close to the Vietnamese border (Duckworth et al., 1999; Rawson & Roos, 2008). *P. nigripes* occurs in east Cambodia, east of the Mekong, and in southern Vietnam (Smith, 2001; Nadler et al., 2003; Pollard et al., 2007). The range of *P. cinerea* overlaps in small areas with *P. nemaeus* in central Vietnam and probably also in South-east Laos and north-east Cambodia (Ha Thang Long, 2004, Nadler et al., 2007, Rawson & Roos, 2008). Contact areas between *P. cinerea* and *P. nigripes* – if exist - are not clarified yet (Fig. 1).

Fig.1. Distribution of the three Pygathrix species according to Duckworth et al. (1999); Ha Thang Long (2004); Nadler et al. (2007); Pollard et al. (2007); Rawson & Roos (2008).

So far detailed data on the skull morphology and changes in craniometry during ontogeny are lacking besides of the comparison of cranial dimensions of *P. nemaeus* with *Rhinopithecus* (Pan & Oxnard, 2001). A first craniometric comparison of the three *Pygathrix* species is made by Harding (2003). The result of the study shows significant differences in size between the three taxa, but this is based on a very limited number of specimens (*P. nemaeus* 7 male, 5 female; *P. nigripes* 8 male, 2 female; *P. cinerea* 2 male, 2 female) and individual variation.

In this paper we describe the cranial morphology of the three species of douc langurs and assess ontogenetic changes with age. In this respect also the sequence of tooth replacement will be briefly considered.

It is aimed to check if cranial features could reliably be used to distinguish between the species now established on the basis of fur coloration and molecular genetic data. The morphological description is supplemented with a multivariate statistical analysis of linear cranial measurements and both are used to test if a separation of the three species of *Pygathrix* might be possible.

Material and Methods

The study is based on 24 skulls of *P. cinerea*, 18 skulls of *P. nemaeus*, and 4 skulls of *P. nigripes* from Endangered Primate Rescue Center (EPRC), the Zoological Museum at National University Hanoi (ZMNU), and Museum für Tierkunde Dresden (MTD) (Table 1).

Table. 1. Studied material of *Pygathrix* species at the Endangered Primate Rescue Center (EPRC), Zoological Museum National University Hanoi (ZMNU), and Museum für Tierkunde Dresden (MTD) with assigned age groups.(1 = juvenile; 2 = subadult; 3 = adult)

species	coll. No.	sex	age	age group
Pygathrix cinerea	EPRC 7-07	f		2
Pygathrix cinerea	EPRC 7-33	m	8 years	3
Pygathrix cinerea	EPRC 7-26	f		3
Pygathrix cinerea	EPRC 7-18	m	5 years	2
Pygathrix cinerea	EPRC 7-02	m		3
Pygathrix cinerea	EPRC 7-17	f		3
Pygathrix cinerea	EPRC 7-06	m	9 years	3
Pygathrix cinerea	EPRC 7-08	m	10 years	3
Pygathrix cinerea	EPRC 7-27	f		3
Pygathrix cinerea	EPRC 7-10	f		3
Pygathrix cinerea	EPRC 7-15	m		1
Pygathrix cinerea	EPRC 7-12	m	1 year	1
Pygathrix cinerea	EPRC 7-20	m	5 years	2
Pygathrix cinerea	EPRC 7-27	f		2
Pygathrix cinerea	ZMNU M870	m		3
Pygathrix cinerea	ZMNU M850	m		3
Pygathrix cinerea	ZMNU 877	m		3
Pygathrix cinerea	ZMNU M869	m		3
Pygathrix cinerea	ZMNU M867	m		3
Pygathrix cinerea	ZMNU M855	f		3
Pygathrix cinerea	ZMNU M732a	m		3
Pygathrix cinerea	ZMNU M849	f		3
Pygathrix cinerea	ZMNU M854	m		1
Pygathrix cinerea	ZMNU M853	m		1
Pygathrix nemaeus	MTD B19855	m		3
Pygathrix nemaeus	EPRC 6-40	f		3
Pygathrix nemaeus	EPRC 6-44	m		3
Pygathrix nemaeus	EPRC 6-17	f	10 years	3
Pygathrix nemaeus	EPRC 6-25	m	3,5 years	1
Pygathrix nemaeus	EPRC 6-22	m		1
Pygathrix nemaeus	EPRC 6-11	m	5 days	1
Pygathrix nemaeus	EPRC 6-43	m	8 months	1
Pygathrix nemaeus	EPRC 6-27	m	3 years	1
Pygathrix nemaeus	EPRC 6-18	f	3 years	1
Pygathrix nemaeus	EPRC 6-19	m	2 years	1
Pygathrix nemaeus	EPRC 6-X03	m		1
Pygathrix nemaeus	EPRC 6-20	f	1 year	1
Pygathrix nemaeus	EPRC 6-24	f	3,5 years	1
Pygathrix nemaeus	EPRC 6-08	m	5...6 years	2
Pygathrix nemaeus	MTD B19854	m		2
Pygathrix nemaeus	ZMNU M 101	m		2
Pygathrix nemaeus	ZMNU M 1038	?		2
Pygathrix nigripes	EPRC 13-04	f	2,5 years	1
Pygathrix nigripes	EPRC 13-06	f	2 years	1
Pygathrix nigripes	MTD B19857	f		3
Pygathrix nigripes	MTD B19856	f		2

The skulls of subadult and adult animals at the EPRC come from animals that were rescued but subsequently died though heavy injuries or fatal digestion disturbance. Skulls of newborn and very young animals are from animals born at the EPRC and did not survive. Skulls from other collections are mostly from hunted animals.

The ages of individuals which were born at the EPRC is exactly known. The age of confiscated subadult and adult animals are estimated in comparison to animals at the EPRC with known age.

28 linear measurements were taken on the skull and mandible, partially in accordance to Maryanto et al. (1997). They are explained in Table 2 and illustrated in Fig. 2. All measurements were taken with digital callipers to the nearest 0.01 mm.

The morphological description follows Whitehead et al. (2002).

Table. 2. Measurements taken on cranium and mandible (see also Fig. 2.)

cranium	
gsl	greatest skull length, measured parallel to the base of the skull, including incisor
ch	cranial height, measured as maximal height above auditory bullae and basioccipital
zw	zygomatic width, maximal width across zygomatic arches
iob	interorbital constriction, smallest distance between orbits
pob	postorbiral breath, measured at the narrowest point of the cranial constriction in the temporal fossa
orbw	orbital width
maxb	width across maxillas, or maximal rostral breadth, breadth across the maxillas
measure	d lingually, dorsal to M1 (about equal to palatal breadth plus teeth)
pmxb	width across premaxillae, breadth across praemaxillary bones measured frontally at alveoles of canines
nb	nasal breadth
nl	nasal length
dM3	distance between M3s
dC	distance between canines
mfw	width across mesopterygoid fossa
dcc	distance between carotid canals
linfm	distance posterior rim of incisor to anterior end of foramen magnum
lip	distance of posterior rim of incisor to posterior end of palatine
libasio	distance of posterior rim of incisor to anterior end of basoccipital
gcw	greatest cranial width at hindcranium
lvom	length of vomer visible in choana
mandible	
dl	dentary length, measured parallel to the long axis of the mandible
pcr	maximal height of mandible, measured in straight line from coronoid process to base of angular process
pcp	condylar height, measured from the top of condyle to the base of angular process
mcorb	maximal length of ascending mandibular ramus, measured parallel to long axis of mandible
mandh	mandible height, height of mandibular ramus from ventral rim to alveole level between m1 and m2
mandw	width of mandible, measured across the mandible below m2/m3
dcond	condylar distance, distance between the condyles of right and left dentary in straight line
lcm3	length of mandibular tooth row, measured occlusally
cbf	width across both canines, measured frontally

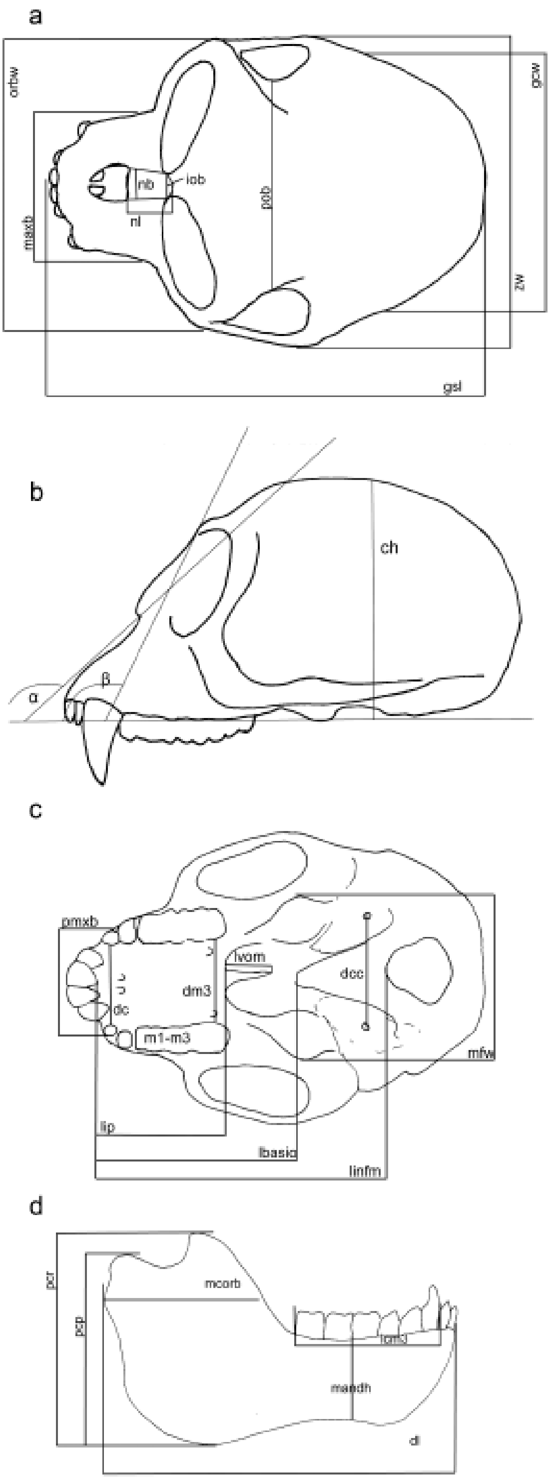

Fig.2. Schematic illustration of most of the measurements taken on the skull and mandible (Abbreviations see Table 2).
a. Skull in dorsal view; **b**. Skull in lateral view; **c**. Skull in ventral view (α: angle of snout and β: angle of orbital plane - not measured in each skull); **d**. Mandible in lateral view.

Aging and forming of age groups

Not many data on the life history of douc langurs are known to be used as a basis to form age groups suitable for statistical analysis. Tooth replacement, tooth wear and cementum apposition are often used to age mammals on the basis of cranial material. The most prominent example where teeth, and in particular tooth replacement and wear of the incisors, are used in age determination (e.g. Habermehl, 1961; Richardson et al., 1995; Muylle et al., 1997). Also for some economically important species age determinations on the basis of teeth have been given, e.g. for domestic cattle, *Capra hircus* or *Cervus elaphus* (Habermehl, 1961). In Japanese Macaques also cementum apposition was used for aging (Wada et al., 1978). The most thorough compendium on the ages of dental eruption in primates is given by Smith et al. (1994). An overview, based on Harvati (2000), Schultz (1935) and Smith et al. (1994) is provided by Swindler (2002).

The completion of dental development does not necessarily co-occur with sexual maturity and thus adulthood or full growth of the animal. For *Trachypithecus cristatus* males it has been stated that the dental development is concluded at the age of about 3.75 years (Harvati, 2000). In the slightly smaller males of *Macaca fascicularis* dental development is completed at the age of 5.5 years (Smith et al., 1994). Only few individuals of each species are of exactly known age, and only few of age <2 years which can be considered a very important time span for growth. For *P. cinerea* and *nemaeus* cranial growth reaches the adult level at about 50 months, about 4 years of age

Due to the difficulties of exact aging we established four age groups used in some of the statistical analysis: Table 1 gives the frequency of specimens in each age class for the species.

- 0 - newborns that died within a few days of birth (only 3 specimens),
- 1 - juveniles, young animals from about 8 months to 4 years of age,
- 2 - subadult about 4 to 5 years of age and
- 3 - adults from 6 years and more of age, definitely with a complete dentition.

Statistics

Reasonable statistical comparisons are only possible between *P. cinerea* and *P. nemaeus* as only four skulls of *P. nigripes* were available for analysis. They are included in the discriminant analysis, but the results concerning this species have to be treated with some caution.

All original data were checked for normal distribution using Q-Q Plots. As expected all measured parameters correlate strongly with age. Therefore, a method had to be found to eliminate the influence of age from the data. Here the same procedure as in Stefen & Rudolf (2007) is used. Linear regressions of all measured parameters against age – the four age groups – were performed, calculating the resulting unstandardized residuals of each variable against the independent age. These were saved as 'RES-variable' of the original measurement and used in further tests.

Two other ways to deal with the different ages of the specimens were used and finally all were compared. Analyses with the original data were done using specimens of age class 2 and 3 only. And the original data were log transformed and saved as 'Log variable' and these were used in different analyses.

Students t-tests (always at the 95 % significance level) were performed with the age-independent residuals a) to test for differences between females and males in each species and b) to test for differences between the species. In these tests *P. nigripes* was not used due to the low number of available specimens.

To see which variables are responsible for most of the variance in the overall sample a principal component analysis (PCA) was performed with the original data, the age-independent residuals and the log-transformed variables.

Discriminant analysis (DA) of the three species were also performed primarily with variables mainly influencing the first factor of the PCA and some different sets of the original data, the age-independent residuals or the log-transformed variables in order to see whether the species could be separated. The DAs were done using Wilk's lambda statistic, entry of all variables at once not stepwise, with equal prior probabilities of group membership, based on the pooled within-group covariance matrix. SPSS 16 was used for all statistical calculations.

Results

Description of juvenile skull of *Pygathrix*

Cranium

The description is mainly based on two skulls of *P. nemaeus* females (EPRC 6-18 and 6-20), but observations on other skulls are included.

In dorsal view the skulls are more or less oval to egg shaped being pointed at the interorbital constriction, with the orbital region forming a kind of base and a short snout attached (Fig. 3a). The frontoparietal suture is convex and in the sagittal plane the frontal extends over more than half of the skull length. The frontoparietal suture (*sutura coronalis*) might be neat and just curved or zigzagging irregularly especially in the middle of the skull. Distal and posterior to the orbital ridges, which are visible but not clearly separated from the rest of the frontals as in adult skulls, the frontal is well inflated, forming the highest point of the juvenile skull. The vault slightly curves ventrally to the posterior end of the skull. The parietooccipital suture (*sutura lambdoidea*) is just visible in the posterior end of the skull.

The postorbital constriction is shallow in these juvenile skulls and separates the orbital plane from the rest of the skull. The orbital width is smaller than the cranial width. The orbital plane is tilted in an angle β of 80° (see Fig. 2b) to the base of the skull toward posterior.

In frontal view the orbits dominate the impression of the skull and the cranium is well inflated. The nose opening is skewed oval, being more pointed ventrally, with the widest lateral extension more dorsal than the middle of its length and a nearly straight or levelled dorsal end at the nasals (Fig. 3b). Although the orbits appear well rounded, the orbital rims might be straightened in some skulls (e.g. MTD B19400) and the lateral side, formed by the jugal (*Os zygomaticum*). Two to three infraorbital foramina are visible ventral to the orbits and close to the maxillojugal suture (*sutura zygomaticomaxillaris*); they usually grow a bit more apart with increasing age. The premaxillomaxillar suture is kind of dome-shaped around the nasal opening, not extending as far dorsally as the nasals, leaving room for a short maxillanasal suture (*sutura nasomaxillaris*). The maxillafrontal suture (*sutura frontomaxillaris*) forms just dorsal to the nasals, often slightly zigzagging and extending ventrally into the orbits.

In lateral view in the juvenile skulls all the sutures between the visible bones are still unfused. The near 80°-orientation of the orbital plane (β) to the base of the skull is well visible in this view. The frontojugal suture (*sutura frontozygomatica*) is nearly straight at the orbital rim, but varies slightly in course in the postorbital constriction. In some skulls the frontal shows a sharply pointed triangular extension ventrally, just posterior to the orbital rim (MTD B19400), which is lacking in other skulls where the maxilla instead might show a small dorsal extension (Fig. 3c). Particularly variable is the form of the dorsal extension of the sphenoid, which might be a narrow band between the maxilla and squamosum (e.g. EPRC 6-07) or a broadened wing-like extension with a dorso-posterior extension (e.g. MTD B24004). The jugal foramen (*foramen zygomaticofaciale*) is very close to this suture.

The zygomatic arch is slim and ends anterior to the external auditory meatus. The squamosal bone dorsal to the external auditory meatus is slightly bulged laterally but does not show a rim or stronger bulging visible in adult skulls. The parietosquamosal suture shows a marked ventrally pointing projection postrior to the external auditory meatus.

The distal view shows an inflated skull, the parieto-occipital suture and a marked bend within the occipital between posterior and ventral part of the skull. This bend develops to a strong lamdoidal crest in adults and ends laterally at the parietosquamosal suture.

In ventral view (Fig. 3d) all sutures between the bones are unfused. The large foramen magnum is posterior to the middle of the skull. In the juvenile skulls the pterygoid wings extend as far lateral as the maximal width of the snout. The most prominent of the visible foramina are the carotic canals in the bullae, circular and large, and the distal palatine foramina (*foramen palatinum majus*), situated in the maxillopalatine suture (*sutura palatinum transversa*). The glenoid fossa appears large and flat, distally terminated by a narrow pointed squamosal projection.

Mandible

The mandible of the juvenile skulls is characterized by the large alveoli for the still forming molars and the lateral tilt of the coronoid processes in dorsal view. The articular surface of the condyles is nearly horizontal, skewed oval, and no marked neck separates it from the mandibular ramus. The angular process is well rounded and does not extend as far posterior as the condyle. On the lingual side no pterygoid protuberances are visible. In lateral view the coronoid process is well pointed posteriorly and the bone between the tip of the coronoid process and the condyle is well rounded. A mental foramen (sometimes there are more) is visible in the lower part of the mandibular ramus ventral to dp3/4. The ventral rim of the mandible is nearly straight horizontally, slightly concave (Fig. 3e, f, g).

Description of subadult skull of *Pygathrix*

Cranium

The description is based primarily on skulls of a female of *P. cinerea* (EPRC 7-07) and a male of *P. nemaeus* (MTD B19854).

Most skull sutures are still well visible; in ventral view the maxillopremaxilla suture is about level to the dC/P1 junction; in the midline the palatinum extends forward to the M1/M2 junction; the large, oval palatine foramen are about level to the anterior part of M3.

In dorsal view the changes with increasing age are the following: the overall oval shape becomes more egg-shaped, that is more pointed anteriorly at the interorbital constriction, and more flattened posteriorly; the overall inflation of the skull extends further posterior and then bends ventrally more sharply.

The orbital rims increase in size and in dorsal view and form a flattened ledge in the anterior part of the skull: The postorbital constriction becomes more pronounced and a frontal crest forms. The snout is enlarged compared to the juvenile skull and also in relation to the cranium. This seems to be mainly due to an increased length of the maxilla leading to a lower inclination of the nose and

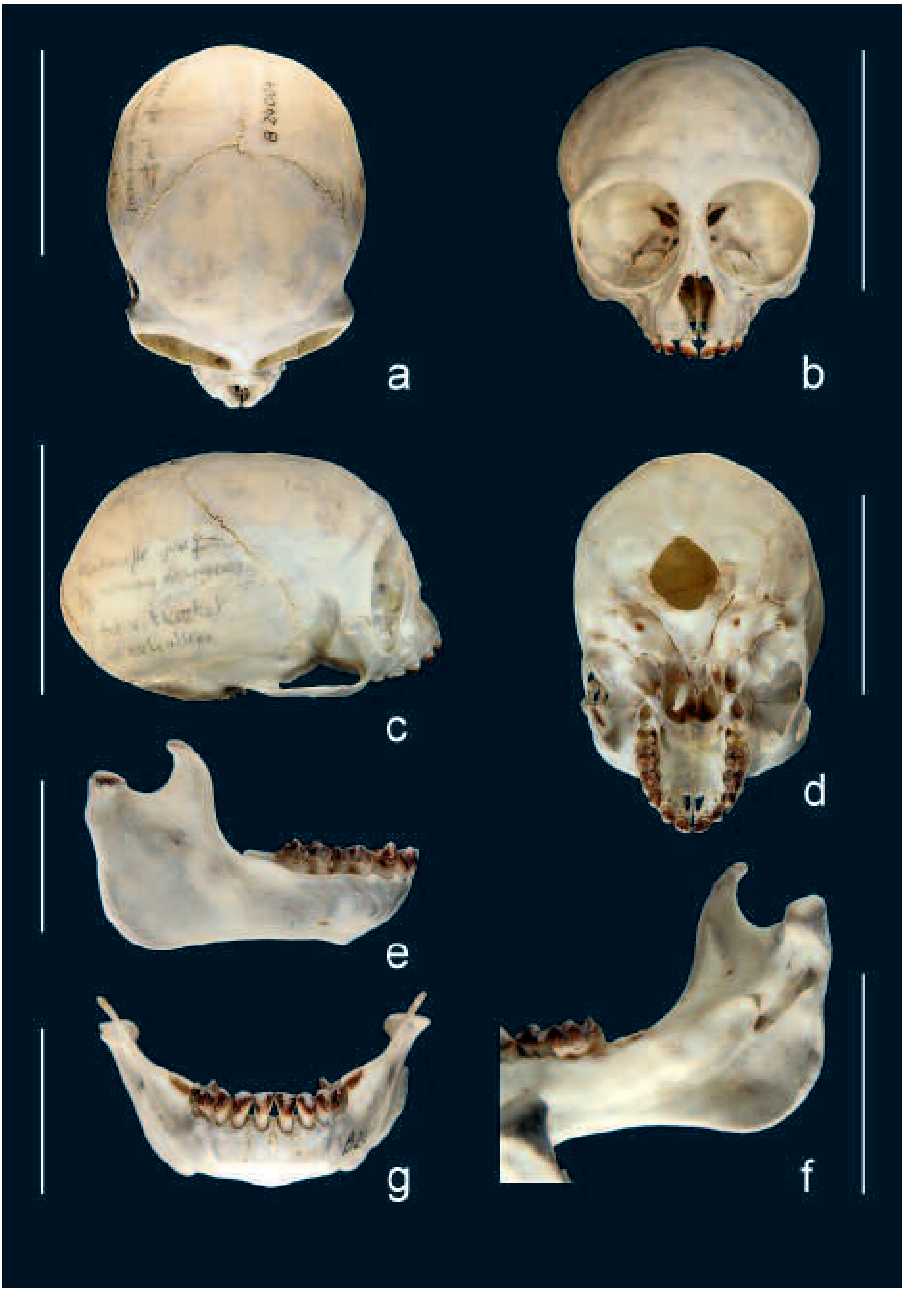

Fig.3. a. Skull of a juvenile female *Pygathrix nemaeus* (MTD B24004), dorsal view. Scale bar 5 cm; **b**. Dorso-frontal view; **c**. Lateral view; **d**. Ventral view; **e**. Mandible of a juvenile female *Pygathrix nemaeus* (MTD B24004), lateral view. Scale bar 2 cm; **f**. frontal view; **g**. lingual view. Photos: B. Bastian.

nasals (α about 70° in juveniles and about 55° in subadults), the same holds for the orbital plane (β 80° in juveniles and about 70° in subadults).

The orbits extend as far as, and with increasing age further lateral than the widest cranial width, thus dominate the frontal view. The zygomatic arch still ends anterior to the external auditory meatus but a tendency to form a crest or rim dorsal to the external auditory meatus is visible.

Mandible

The mandilbe is like in the juvenile skulls. But the pterygoid fossa on the medial side of the angular process is marked and structured in the very distal end with five slight grooves separated by well visible ridges (tuberositas pterygoidea); also at the angular process a crest develops at the ventral rim of the angular process. The coronoid process points distally, is slightly hook-shaped and shows a slight dorsal crest. There seems to be some variability in the form of the mandibular bone between the tip of the coronoid process and the condylar process: the distal pointing and thus strong appearance of a slim hook of the coronoid process of juvenile skulls is lost with increasing age and the coronoid process gets broader (with the broadening of the mandibular ramus as a whole), less pointed and ends blunt oriented dorsally.

Description of adult skull of *Pygathrix*

Cranium

The description is based primarily on skulls of a *P. nemaeus* male (EPRC 6-44) and a *P. nirgipes* female (MTD B19857).

In dorsal view with increasing age frontoparietal crests form that run parallel towards the nuchal crest (Fig. 4a). They seem to be stronger in males, but this is difficult to judge as the exact age might also play a role and that is not known for the animals grouped as "adults" here. The orbital rims become more pronounced and extend further posteriorly in the form of a flattened ledge. This as well as the elongation of the rostral part result in the postorbital constriction being more pronounced and more or less in the middle of the skull length in the adult skulls compared to the juveniles, where this is in the anterior third of the skull. In the elongated rostral part of the skull the nasal opening is more oval and not so skewed oval as in the juvenile skulls.

In frontal view the orbitals are clearly broader than the greatest extension of the cranium and the greatest skull width in adult skulls is at the zygomatic arches (Fig. 4b).

In lateral view (Fig. 4c) the zygomatic arch extends with age more and more in a crest continuing dorsal to the external auditory meatus. The nuchal crest, not at the parieto-occipital suture but more ventral, extends laterally into a more or less marked crest extending nearly to the external auditory meatus. This lateral extension of the nuchal crest, however, does not fuse with the posterior extension of the zygomatic arch. Very variable is the course of the larcimojugal suture in the orbita and the course of the maxiallojugal suture.

In ventral view (Fig. 4d) the carotid canals (in the bullae) are oriented more centrally and open nearly straight ventrally and not so much towards the sagittal plane as in the juvenile skulls. The incisive foramen are more or less pointed anteriorly, more rounded to straight at the posterior end, and terminate posteriorly level to the posterior end of the canines. This relation to the canines is the same in juveniles.

Mandible

The mandibel of the adult skull is more massive, but overall shows the same morphology as in subadults (Fig. 4e, f).

Age grouping and tooth eruption

The maxillary teeth present in juvenile and subadult skulls are listed in Table 3. The data suggest the sequence [M1 I1] [I2 M2] P4 P3 [M3 C] for the studied *Pygathrix* species. From the data it is

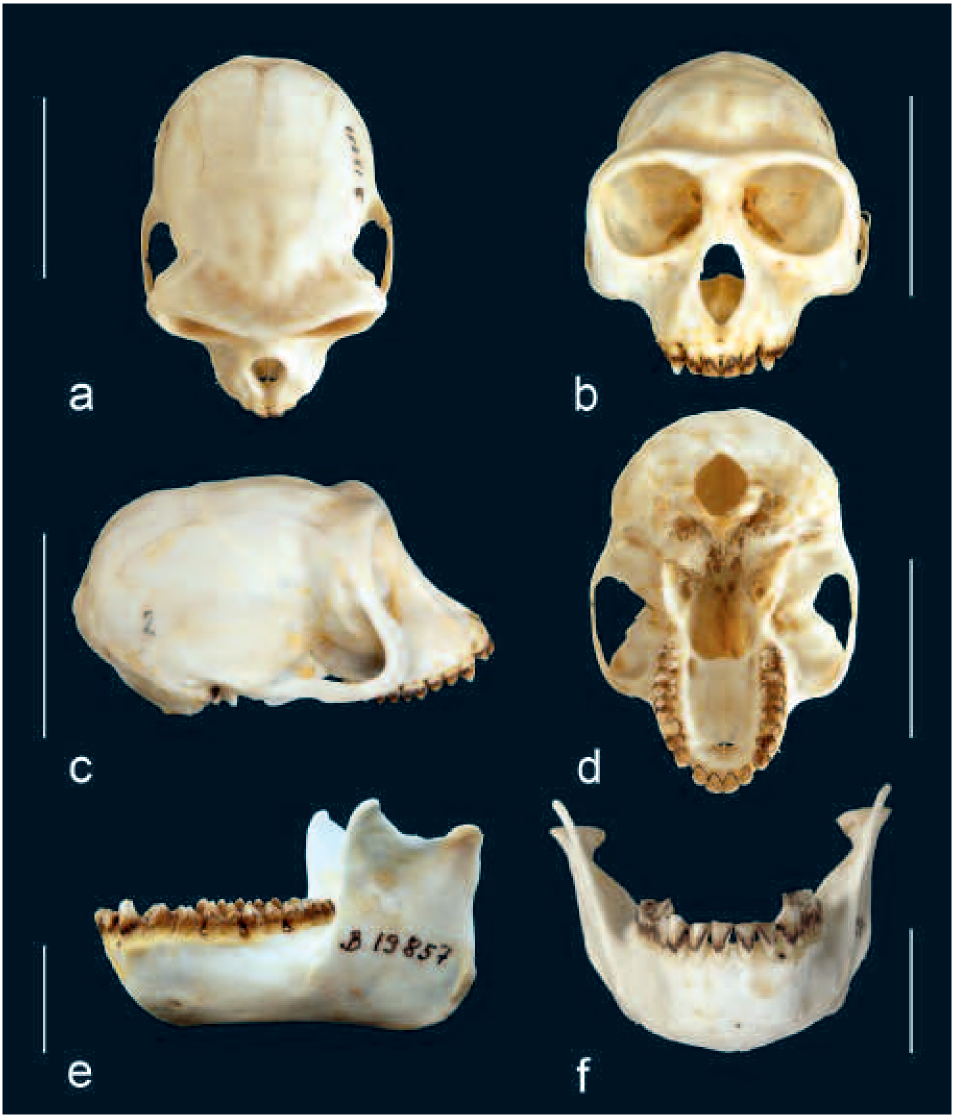

Fig.4. a. Skull of an adult female *Pygathrix nigripes* (MTD B19857), dorsal view. Scale bar 5 cm; **b**. frontal view; **c**. lateral view; **d**. ventral view; **e**. Mandibel of an adult female *Pygathrix nigripes* (MTD B19857), lateral view. Scale bar 2 cm; **f**. frontal view. Photos: B. Bastian.

very difficult to clearly determine the sequence of M1 and I1 as in some very young individuals the presence of M1 was not verifiable. It is equally difficult to clearly determine the sequence of I2 and M2 as both are emerging in the relevant specimen (EPRC 6-X3). P4 seems to erupt prior to P3 in EPRC 6-24 and 7-07. Similarly the sequence of C and M3 is difficult to determine, in one specimen (EPRC 7-26 both are emerging and in one (EPRC 7-20) M3 is erupted and C still emerging. As the first is a female and the second a male there might be sexual differences involved. In *Pygathrix nemaeus* one specimen lacks only the canine of the final dentition, whereas one specimen of *P. cinerea* at the age of 8 years still shows dC, DP3 and an emerging P4.

Table. 3. Teeth present in the maxillar dentition of some studied individuals. (Age* - indicates fairly exact age known. Teeth: d –deciduous tooth; em – emerging, not quite in occlusion yet; in alv – visible in alveole; x – present; ? status not known; n – not visible).

EPRC number	Sex	Age group	Age	I1	I2	C	P3	P4	M1	M2	M3
Pygathrix cinerea											
7-12	m	juv	1 year*	dI	dI	dC	dP	dP	in alv	n	n
7-20	m	subad	5 years	dI	dI	em	x	x	x	x	x
7-18	m	subad	5 years	x	x	x	x	x	x	x	x
7-33	m	ad	8 years	x	x	x	x	x	x	x	x
7-02	m	ad	11 years	x	x	x	x	x	x	x	x
7-07	f	subad	?	x	x	dC	dP	em	x	x	n
7-26	f	ad	?	x	x	em	x	x	x	x	em
Pygathrix nemaeus											
6-22	m	newborn	1 day*	dI	dI	dC	dP em	dP	in alv	n	n
6-11	m	newborn	5 days*	dI	dI	dC	dP	dP	?	n	n
6-43	m	juv	8 months*	dI	dI	dC	dP	dP	?	n	n
6-X3	m	juv	?	x	em	dC	dP	dP	x	em	n
6-19	m	juv	2 years	dI	dI	dC	dP	dP	x	em	n
6-27	m	juv	3 years*	I	dI?	dC	dP	dP	x	em	n
6-25	m	juv	3,5 years*	x	x	dC	dP	dP	x	x	em
6-08	m	subad	5..6 years	x	x	dC	x	x	x	x	x
6-44	m	ad	?	x	x	x	x	x	x	x	x
6-20	f	juv	1 year	dI	dI	dC	dP	dP	in alv	n	n
6-24	f	juv	3,5 years*	x	x	dC	dP	in alv	x	x	n
6-18	f	juv	3 years	dI	dI	dC	dP	dP	?	?	?
6-17	f	ad	10 years	x	x	x	x	x	x	x	x
6-40	f	ad	?	x	x	x	x	x	x	x	x
Pygathrix nigripes											
13-04	f	juv	2 years	dI	dI	dC	dP	dP	in alv	n	n
13-06	f	juv	2 years	dI	dI	dC	dP	dP	in alv	n	n
MTD B19857	f	ad	?	x	x	x	x	x	x	x	x

Craniometry and Statistics

The cranial morphology of the three species of douc langurs is very similar and so are the measurements (Fig. 5). In overall skull geometrics as illustrated by a scatter diagramm of zygomatic width against greates skull length, no difference between the species can be observed (Fig. 6). Most of the original measurements show a normal or near normal distribution for the studied species (except of *P. nigripes* where the sample was considered too small for these tests). Only cbf and nb showed no normal distribution in *P. cinerea* and were not used in further analyses.

A sexual dimorphism can be seen in *P cinerea* and *P. nemaeus* but seems to be markedly stronger in *P. cinerea*. In this species 17 original measurements differed significantly between the sexes in age class 2 and 3, 19 age- independent residuals and 2 log transformed variables.

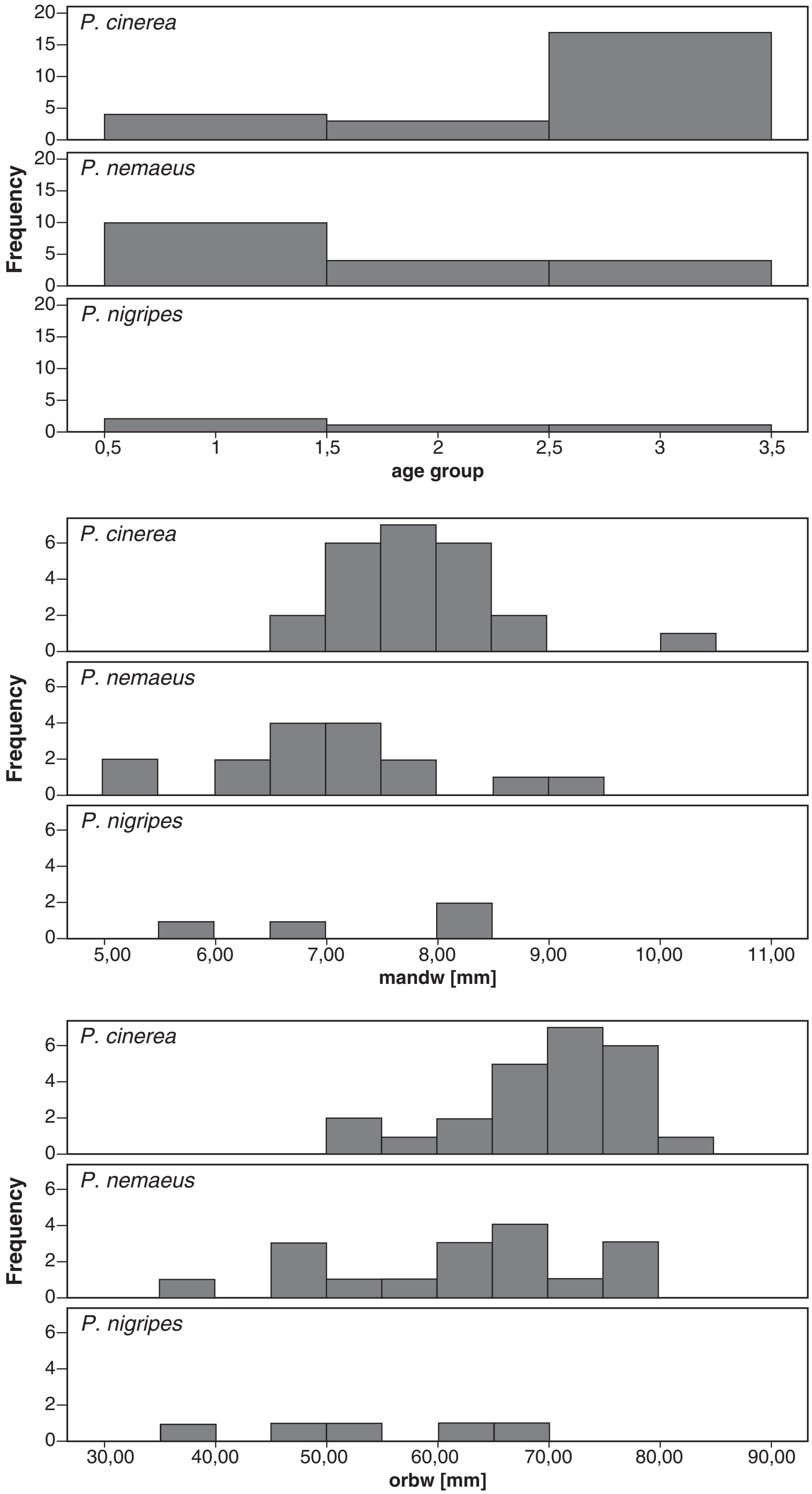

Fig.5. Frequency of age groups, orbital width (orbw) and mandibular width (mandw).

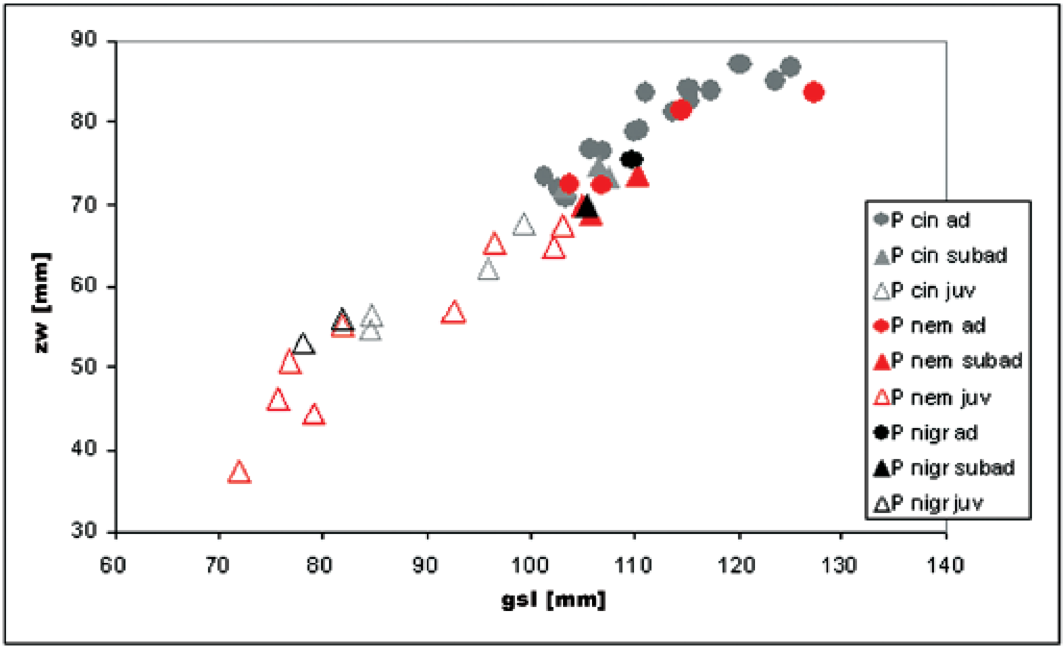

Fig.6. Scatter diagramm of zygomatic width against greatest skull length for *Pygathrix cinerea* (P cin), *P. nemaeus* (P nem) and *P. nigripes* (P nigr) separated for age groups: ad – adult, subad – subadult, juv – juvenile.

In *Pygathrix nemaeus* the sexual dimorphism seems to be weaker, only in one age-independent residual (RES-cm3) a statistically significant difference between males and females was observed.

The PCAs resulted in several factors, the first four explaining > 90% of the total variance for the original data in age classes 2 and 3 as well as for the age-independent residuals and log-transformed data. In all cases maxb, zw, pcp, gsl, orb, libasio, lifm, cbf and lip contributed most to the first factor. Also important were dm3, and pmaxb.

The DAs show some degree of separation of the three studied species of *Pygathrix*. Using the variables mainly associated with PCA factor 1 and specimens of age class 2 and 3, the species show a clear separation with the original data but *P. nigripes* is not well represented. (Fig. 7A). The distinction of *P. nemaeus* and *P. cinerea* is weaker and *P. nigripes* again not well represented with the age-independent residuals important in the first factor of the PCA (Fig. 7B). Using the log transformed data which explain most of the variance in PCA factor 1 does not give a separation of the species. Using some random age-independent residuals in a DA indicates a slightly better separation of the three species without ungrouped cases (Fig. 7C). But still there is some overlap between *P. cinerea* and *P. nemaeus* and *P. nigripes* well separated from the others. Reducing the number of residuals used in the DA did not increase the possibility to separate between the species. Using a number of random log transformed variables a separation of *P. nigripes* from the others but no clear separation of *P. cinerea* and *P. nemaeus* is possible (not shown).

Discussion

So far only Harding (2003) provided some craniometric data of *Pygathrix*. Her sample consisted of 12 *P. nemaeus*, 10 *P. nigripes* and 4 *P. cinerea*, thus the number of specimens of the species differed from this study. Here we give a more detailed description of cranial morphology and

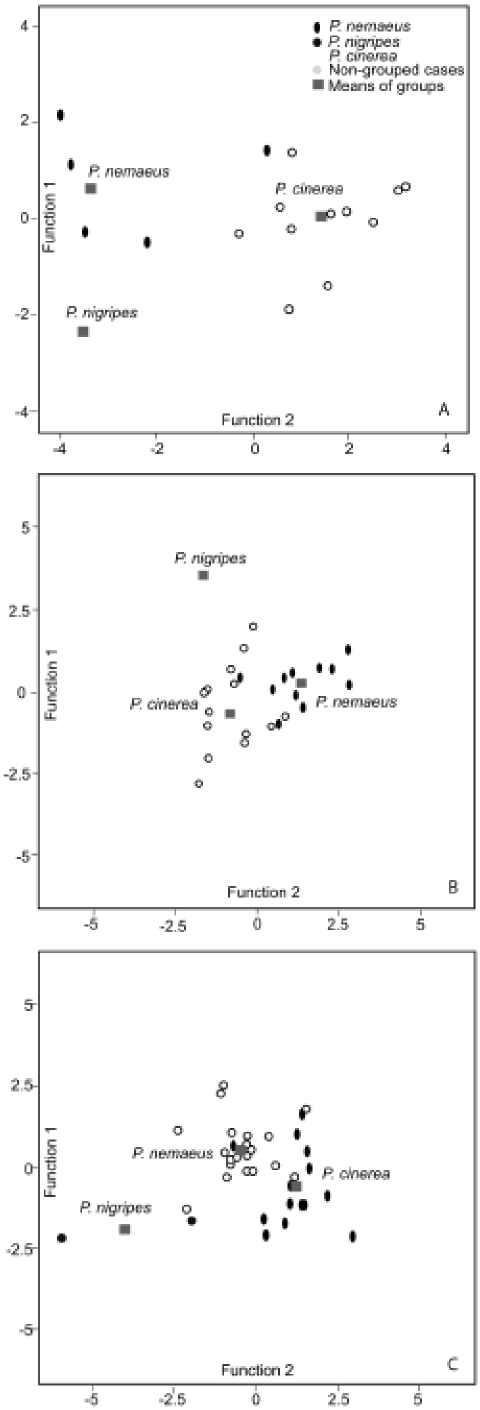

Fig.7. Discriminant analyses of the three species of *Pygathrix* with different sets of data. **A**: with original measurements as given in the structure matrix and specimens of age class 2 and 3 only; **B**: with age-independent residuals of some variables as given in the structure matrix and all specimens; **C**: with a set of random age-independent residuals of some variables as given in the structure matrix and all specimens.

ontogenetic changes as well as more data on skull morphometrics. The three species of *Pygathrix*, can be separated on the basis of coat color, few morphological features and molecular genetics (Nadler, 1997; Roos & Nadler, 2001; Harding, 2003; Roos, 2004). The cranial morphology of the three species, however, is very similar, so that in gross or overall morphology no diagnostic features were found to allow for a species differentiation. For statistical analysis the studied samples are not ideal as the specimens are of different and often unknown ages and the three species are not represented in sufficient and similar numbers which could not be helped during the course of the study. Results can nevertheless be compared to Harding (2003) who studied samples of similar unequal sizes. The linear measurements of cranial parameters are hardly distinguishable but boxplots of some measurements indicate that *P. cinerea* is the largest and *P. nigripes* a smaller species with *P. nemaeus* having the largest range (Fig. 6). This is in accordance to Harding (2003).

The principal component analyses with the original data, age-independent residuals and log-transformed variables pointed to the main importance of the same variables to explain most of the overall variability in the sample. These include length and width measurements of the skull and the height and width of the mandibular ramus thus variables influencing overall geometry.

Discriminant analyses using the variables which mainly influenced the PCA factor 1 gave different results in the DAs. The log transformed data did not reveal a clear separation of the species at all. Using original data and specimens of the age classes 2 and 3, thus adult specimens only or age independent residuals indicated a separation of the three species to a different degree. In all cases (Fig. 7) *P. nigripes* was further separated than the other two species. Due to the small sample size studied here this has to be treated with great care but is in accordance to Harding (2003) who stated that "*P. nigripes* appears to be the most distinctive species" on the base of external differences though.

One aspect that might influence the

differentiating power of the DAs with the selected variables is the difference in sexual dimorphism in the samples of *P. cinerea* and *P. nemaeus*.

The DA's indicate that there might be the possibility for a separation of the three species on the base of cranial measurements but only with larger and similar sized samples of all species and possibly also including methodology of geometric morphometrics which might be more suitable to pick up differentiating signals between the species. That was not feasible in the study presented here but might be future approach.

The statistical tests yielded a strong sexual dimorphism in *P. cinerea* but a weak one in *P. nemaeus*. As both species are closely related these results are surprising and hard to explain. As the sample of *P. nemaeus* contained more juvenile specimens sexual dimorphism might be more pronounced in older specimens than were available. Pan & Oxnard (2001) indicated some sexual dimorphism for *P. nemaeus* but their measurements are difficult to compare to those used in the present study. These authors also stated (for *P. nemaeus* and several species of *Rhinopithecus*) that sexual dimorphism is often related to width variables, species separation rather to length variables. This cannot be verified in the present study as there were several sexual differences in *P. nemaeus* and hardly any between species. In the DAs the functions separating the species are influenced by length and width variables likewise.

A problem of the presented study is the material of different ages which had been addressed in different ways. Using age groups 2 and 3 only had the disadvantage of having even less specimens but an at least more even size range, as "adult" size is reached at about 4 years. The DAs indicated differentiation of the species of these age groups. The other approach was to use age-independent residuals of a linear regression to age groups. This approach had the problem that the age classes are not all equal. The residuals however showed some power of differentiation of the species. The last approach was the use of log transformed data which did not show a differentiation of species in the DAs. It seems that larger samples of adult specimens would probably be best for a future study on species differentiation.

Overall the results of the presented study show that the skulls of the three species of *Pygathrix* are hardly distinguishable on the basis of morphology alone, but that cranial measurements reveal some potential to separate the species in DAs.

The dental eruption sequence of permanent maxillar teeth has been given as M1 [I1 M2] I2 P3? P4 C M3 by Harvati et al. (2000) and Swindler (2002). Harvati et al. (2000) indicate that the eruption sequence was not determinable at the P3/P4 position. In one individual studied here it is indicated that P4 emerges prior to P3. Another specimen indicates that M3 emerges prior to C. Harvati et al. (2000) state that *Trachypithecus cristatus* completes dental development at the age of about 3.75 years and *Macaca fasciularis* at about 5.5 years, thus later. With the specimens studied here it is still difficult to determine the age when dental development ends in *Pygathrix*: one specimen of *P. cinerea* shows complete adult dentition at the age of about 5 years, a specimen of *P. nemaeus* still has a dC at the age of about 6 years, a *P. cinerea* of 5 years shows dI1, dI2 and dC. An even larger sample of immature specimens that demonstrate various stages of dental eruption is still needed to further clarify the normal eruption sequence, or to better understand the variability that is indicated.

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References

Duckworth JW, **Salter RE** & **Khounboline K** (compilers)(1999): Wildlife in Lao PDR. 1999 Status Report. IUCN, WCS and CPAWM, Vientiane.

Habermehl KH (1961): Altersbestimmung bei Haustieren, Pelztieren und beim jagdbaren Wild. Paul Parey, Berlin.

Ha Thang Long (2004): Distribution and status of the grey-shanked douc langur (*Pygathrix cinerea*) in Vietnam. In: Nadler T, Streicher U & Ha Thang Long (eds.) Conservation of Primates in Vietnam. Frankfurt Zoological Society, Hanoi.

Ha Thang Long (2007): Distribution, population and conservation status of the grey-shanked douc (*Pygathrix cinerea*) in Gia Lai Province, Central Highlands of Vietnam. Vietnamese J. Primatol. 1 (1), 55-60.

Harding JL (2003): Wildlife Conservation in the Central Highlands of Vietnam. Master thesis. Australian National University, Canberra.

Harvati K (2000): Dental Eruption Sequence Among Colobine Primates. American J. Phys. Anthropol. 112, 69–85.

IUCN (2009): IUCN Red List of Threatened Species <www.iucnredlist.org>.

Maryanto I, **Mansjoer I**, **Sajuthi D** & **Supriatna J** (1997): Morphological variation in the ebony and silver leaf monkeys [*Trachypithecus auratus* (E. Geoffroy, 1812) and *Trachypithecus cristatus* (Raffles 1821)] from Southeast Asia. Treubia 31(2), 113-131.

Mittermeier RA, **Robles GP**, **Hoffmann M**, **Pilgrim J**, **Brooks T**, **Mittermeier CG**, **Lamoreaux J** & **Fonseca GAB** (eds.) (2004): Hotspots revisited: Earth Biologically Richest and Most Endangered Terrestrial Ecosystems. Cemex, Agrupacion Serra Madre, Mexico.

Mittermeier RA, **Wallis J**, **Rylands AB**, **Ganzhorn JU**, **Oates JF**, **Williamson EA**, **Palacios E**, **Heymann EW**, **Kierulff MCM**, **Long Yongchen**, **Supriatna J**, **Roos C**, **Walker S**, **Cortes-Ortiz L** & **Schwitzer C** (2009): Primates in Peril: The World's 25 Most Endangered Primates 2008-2010. Primate Conservation 24, 1-57.

Muylle S, **Simoens P**, **Lauwers H** & **Van Loon G** (1997): Ageing draft and trotter horses by their dentition. The Veterinary Record 141, 17-20.

Nadler T (1997): A new subspecies of Douc Langur, *Pygathrix nemaeus cinereus* ssp. nov. Zool. Garten (N.F.) 67, 165–176.

Nadler T, **Momberg F**, **Nguyen Xuan Dang** & **Lormee N** (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler T, **Vu Ngoc Thanh** & **Streicher U** (2007): Conservation status of Vietnamese primates. Vietnamese J. Primatol. 1 (1), 7-26.

Pan R & **Oxnard C** (2001): Cranial Morphology of the Golden Monkey (*Rhinopithecus*) and Douc Langur (*Pygathrix nemaeus*). Human Evolution 16(3-4), 199-223.

Pollard E, **Clements T**, **Nut Meng Hor**, **Sok Ko** & **Rawson B** (2007): Status and conservation of globally threatened primates in the Seima Biodiversity Conservation Area, Cambodia. WCS-Cambodia Program, Forestry Administration Cambodia, Australian National University. (Unpubl. report).

Rawson B & **Roos C** (2008): A new primate species record for Cambodia: *Pygathrix nemaeus*. Cambodian J. Nat. Hist. 1, 7-11.

Richardson JD, **Cripps PJ** & **Lane JG** (1995): An evaluation of the accuracy of ageing horses by their dentition: changes of dental morphology with age. Veterinary Record 137, 117-121.

Roos C (2004) Molecular evolution and systematics of Vietnamese primates. In: Nadler T, Streicher U & Ha Thang Long (eds.): Conservation of Primates in Vietnam. Frankfurt Zoological Society, Hanoi.

Roos C & **Nadler T** (2001): Molecular evolution of douc langurs. Zool. Garten (N.F.) 71, 1-6.

Schultz AH (1935): Eruption and decay of the permanent teeth in primates. Am. J. Phys. Anthropol. 19, 489-581.

Smith BH, **Crummet TL** & **Brandt KL** (1994): Age of eruption of primate teeth: a compendium for aging individuals and comparing life history. Yrbk. Phys. Anthropol 37, 177–231.

Smith JD (ed.)(2001): Biodiversity, the life of Cambodia – Cambodian Biodiversity Status Report 2001. Cambodia Biodiversity Enabling Activity. Phnom Penh, Cambodia.

Stefen C & **Rudolf M** (2007): Contribution to the taxonomic status of *Niviventer confucianus* and *N. fulvescens*. Mammalian Biology 72(4), 213-223.

Sterling EJ & **Hurley MM** (2005): Conserving Biodiversity in Vietnam: Applying Biogeography to Conservation Research. Proceedings of the California Academy of Sciences, Suppl. 1, 56 (9), 98–118.

Sterling EJ, **Hurley MM** & **Le Duc Minh** (2006): Vietnam: a Natural History. Yale University Press, New Haven and London.

Swindler DR (2002): Primate Dentition: An Introduction to the Teeth of Non-human Primates. Cambridge University Press, Cambridge.

Wada K, **Ohtaishi N** & **Hachiya N** (1978): Determination of age in the Japanese monkey from growth layers in the dental cementum. Primates 19(4), 775-784.

Whitehead PF, **Sacco WK** & **Hochgraf SB** (2002): A photographic Atlas for Physical Anthropology. Morton Publishing Company, Englewood, Colorado.

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The feeding behaviour and phytochemical food content of grey-shanked douc langurs (*Pygathrix cinerea*) at Kon Ka Kinh National Park, Vietnam

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Key words: *Pygathrix cinerea*, grey-shanked douc langur, feeding behaviour, diet, nutrition, Kon Ka Kinh National Park

Summary

The grey-shanked douc langur[1] is a critically endangered and endemic leaf-eating primate to Vietnam. The population of the species is decreasing and highly fragmented due to hunting pressure and loss of habitat. The species is restricted to several provinces in the Central Highlands. Kon Ka Kinh National Park is home of less than 250 individuals. Currently, there is insufficient understanding about the feeding behaviour and phytochemical content in food selection among the species. This study was conducted in Kon Ka Kinh National Park from February 2009 to June 2010. We collected 212 hours of feeding behaviour data. Grey schanked douc langurs ate 135 plant species of 44 plant families during the study period. The plant species *Pometia pinnata* is the most preferred item. We collected 33 plant samples from eaten species for phytochemical analysis which revealed that protein comprised of 11.4% of dry matter, lipids 2.6%, minerals 5.0%, sugar 4.9%, starch 12.8%, and Neutral Detergent Fiber (NDF) 40.8%. Protein in leaves is higher than in whole fruits: 12.8% and 8.3% respectively. However, protein in young leaves and mature leaves was not significantly different; 14.1% and 11.5% respectively.

Thành phần hóa dinh dưỡng và tập tính ăn của loài voọc chà vá chân xám (*Pygathrix cinerea*) tại Vườn Quốc Gia Kon Ka Kinh, Việt Nam

Tóm tắt

Voọc chà vá chân xám là loài khỉ ăn lá đặc hữu và cực kỳ nguy cấp của Việt Nam. Quần thể của loài trong tự nhiên đang bị suy giảm do tình trạng săn bắt và mất môi trường sống. Hiện nay, loài chỉ phân bố tại một số tỉnh miền Trung và Tây Nguyên, Việt Nam. Vườn Quốc gia Kon Ka Kinh là nơi sinh sống của gần 250 cá thể voọc chà vá chân xám. Những dẫn liệu khoa học về tập tính sinh thái dinh dưỡng của loài hiện vẫn còn rất hạn chế. Nghiên cứu này được tiến hành từ tháng 2 năm 2009 đến tháng 6 năm 2012. Khoảng 212 giờ quan sát trực tiếp tập tính ăn của loài ngoài tự nhiên đã được thu thập. Kết quả cho thấy, loài voọc chà vá chân xám ăn 135 loài thực vật thuộc 44 họ. Trong đó loài

[1] There remains some scholarly debate about the common names for the *Pygathrix* species, although this does not affect systematic placement. For the purpose of consistency within the Vietnamese Journal of Primatology, douc langur is used for all *Pygathrix* species. Please refer to the article in this issue for a discussion of vernacular names [Nadler (2012): Why Sea Lions don't catch Zebras–Thoughts about common names of Indochinese primates. Vietnamese J. Primatol. 1(2), 3-5].

Pometia pinnata là loài thực vật được ưa thích nhất của loài tại khu vực nghiên cứu. 33 mẫu thức ăn của loài voọc chà vá chân xám đã được thu thập để phân tích thành phần hóa dinh dưỡng. Kết quả cho thấy, các mẫu thức ăn chứa 11,4% là protein, 2,6% chất béo, 5,0% chất khoáng, 4,9% đường, 12,8% tinh bột, và 40,8% chất xơ. Hàm lượng protein trong lá nhiều hơn trong quả với 12,8% và 8,3% hàm lượng chất khô. Hàm lượng protein trong lá non (14,1%) nhiều hơn trong lá già (11,5%), tuy nhiên sự sai khác không có ý nghĩa thống kê.

Introduction

Food components of colobines consist of leaves, fruits (including seeds), flowers, lichen, bark and partly animals (insects). According to Yeager & Kool (1997), colobines select foods of high nutritional value, and young leaves are preferred over mature leaves. Milton (1998) argued that young leaves contain more protein than mature leaves, and that young leaves contain less fiber. Therefore, young leaves tend to be consumed more than mature leaves.

Colobines are folivorous primates, but in some species their diets also contain large proportions of unripe fruits and seeds. For example, Davies (1991) found that *Presbytis rubicunda* eat over 80% seeds in some months. In Africa, other colobines also feed heavily on fruits such as *Colobus satanas* in Cameroon and Gabon (McKey, 1978; McKey et al., 1991; Harrison, 1986) or *Colobus polykomos* in Sierra Leone (Dasilva, 1992).

Diet and feeding behaviour of the genus *Rhinopithecus*, *Pygathrix* and *Nasalis* have been studied by Yeager (1989), Boonratana & Le Xuan Canh (1993), Kirkpatrick (1998), Lippold (1998), Otto (2005), Hoang Minh Duc (2007), Ha Thang Long (2009), and Grüter (2009).

Black-shanked douc langurs in Nui Chua National Park and Binh Chau Phuoc Buu National Park eat leaves, flowers, fruits and seeds from at least 152 plant species of 37 plant families (Hoang Minh Duc, 2007). Red-shanked douc langurs eat leaves and fruits of 50 plant species (Pham Nhat, 1993). Otto (2005) provided a list of 87 species from 36 families consumed by the red-shanked douc langurs, but the list of feeding species was collected in captivity, containing many species of limestone areas around Cuc Phuong National Park. Feeding behaviour of the grey-shanked douc langurs was first studied by Ha Thang Long (2009) in Kon Ka Kinh National Park and the author found that the species fed on 166 plant species belonging to 40 plant families. In terms of food items, the grey-shanked douc langurs ate 49.5% young leaves, 21.9% ripe fruits, 19.1% unripe fruits and only 9.3% mature leaves. This study aims to provide further understanding of grey-shanked douc langurs feeding behaviour as well as the phytochemical contents of their food items.

Material and methods

Study site

Kon Ka Kinh National Park is located in north-east Gia Lai Province (14^0 09' – 14^0 30'N and 108^0 16' – 108^0 28'E) with an area of 41,710 ha (Fig.1). The park belongs to Kon Pne, Dak Roong and Kroong Communes, K'Bang District, and Ha Dong and Ayun Communes, Mang Yang District, Gia Lai Province. Altitude ranges from 570 m along Ba River to 1,748 m at Mount Kon Ka Kinh (Le Trong Trai et al., 2000). The rainy season lasts from May to November. Average annual rainfall is 1,700 mm; the peak is in July or August with 400-450 mm/month. The dry season starts in December and ends in April. The peak of the dry season is in January or February with zero rainfall. Eighty percent of Kon Ka Kinh National Park is montane and lowland forest (33,565 ha).

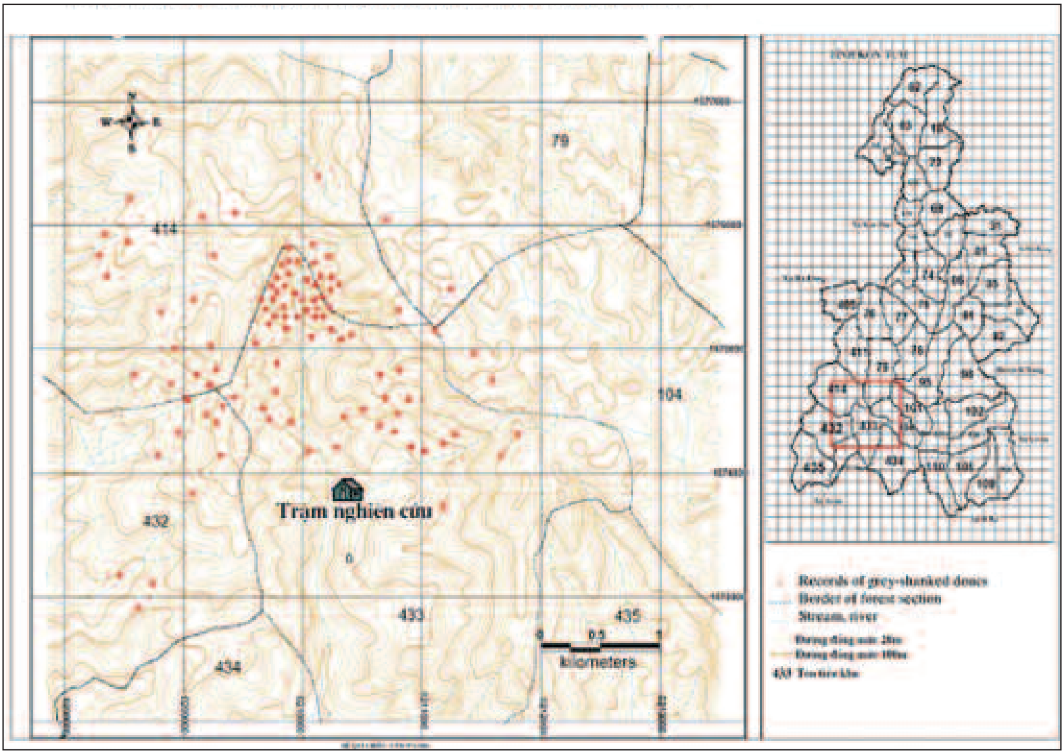

Fig.1. Study area in Kon Ka Kinh National Park.

There are seven species of primates recorded in Kon Ka Kinh National Park, including the northern yellow-cheeked gibbon (*Nomascus annamensis*), grey-shanked douc langur (*Pygathrix cinerea*), stump-tailed macaque (*Macaca arctoides*), pig-tailed macaque (*M. leonina*), rhesus *macaque (M. mulatta*), pygmy loris (*Nycticebus pygmaeus*), and northern slow loris (*N. bengalensis*). The population of grey-shanked douc langurs in the national park is less than 250 individuals (Ha Thang Long, 2009), which represents the largest known population.

Behavioural observation

Behavioural observations were made on different family units of a super-troop of 88 individuals. The observations were made from dawn to dusk 7 days every month from June 2009 to July 2010. Approximately 212 hours of observation were made. The observations were focused on adult males and females. Instantaneous focal animal sampling method (Altmann, 1974) was used to record feeding behaviour. If the animal was feeding, the species and plant parts (e.g. young leaf, mature leaf, fruits, seeds, and flowers) were recorded (Fig. 2).

Herbarium specimen collecting and classification

Herbarium specimens were collected and identified. Feeding trees were tagged with a number and located by GPS. The herbarium specimens of the feeding tree were collected within the month that observations were conducted.

Fig.2. Grey-shanked douc langurs (*Pygathrix cinerea*) eating at the study site. Photo: Nguyen Thi Tinh.

Nutritional Analyses

Every month 2 plant samples frequently eaten and 1 plant sample occasionally eaten were collected. In total 34 plant samples were collected (14 young leaves, 8 mature leaves, 9 seeds, 2 fruits, and 1 flower), but one fruit sample was not analyzed. The samples represent 32 plant species of which 12 species were on the top 20 most selected plants. The samples were dried by sunshine. They were stored in airtight plastic bags until analysis. Samples were sent to the biochemistry lab in Hue University. In the laboratory, samples were re-dried in an oven (60°C) to a constant weight to determine total dry matter (DM). Samples were ashed at 550°C from 3 to 6 hours to determine the percentage of inorganic constituents (total ash content). Total nitrogen content was determined using a macro-Kjeldahl procedure with the machine Kjeltex-2200. Crude protein (CP) was determined using the standard formula: N × 6.25 (Williams, 1984).

Neutral Detergent Fiber (NDF) (cellulose+hemicellulose+lignin), Acid Detergent Fiber (ADF) (cellulose + lignin), and Acid Detergent Lignin (ADL) were sequentially analyzed along with the sulfuric acid lignin fraction, using the methods described in Van Soest, (1991).

Sugars were determined from a phenol-sulfuric acid colorimetric assay (Dubois et al., 1956) as modified by Strickland and Parsons (1972) with sucrose used as a standard. Data was reported on 100% of dry matter (DM). The nutrient value of the plant samples was analyzed by several methods (Table 1).

Table. 1. Methods for nutrient analysis.

Parameter	Test method
Crude protein	Kjeldahl test (TCVN 4328-01)
Crude fat	Soxhlet (TCVN 4331-01)
Sugar	Dubois et al. (1956)
Starch	Hovencamp & Hermelink (1988)
NDF, ADF, ADL	Van Soest (TCVN 4329-93)
Minerals	Atomic absorption spectrometry AAS(AOAC–2000)

Statistical Analyses

Nutrient and fiber content of young and mature leaves were compared. The difference was determined using independent sample T-Test. Levene's Test was used to check the equality of variances before T-Tests were conducted. The same procedure was applied to nutrient and fiber contents in leaves and fruits. All tests set the significant value α=0.05, 2-tailed.

Results

Plant species eaten by the grey-shanked douc langurs

In this study, 135 plant species of 44 plant families were recorded as foods of the grey-shanked douc langurs. 81 species were observed directly and 54 species identified from food remains. The top 10 most eaten plant families contain 54.8% of all eaten species. The 10 families were Myrtaceae, Sapindaceae, Moraceae, Lauraceae, Euphorbiaceae, Meliaceae, Elaeocarpaceae, Fagaceae, Papilionoideae and Flacourtiaceae. The family Moraceae contained the most selected foods with 14 species, including 12 species for young leaves and two species for fruit. The family Euphorbiaceae contained the second most selected foods with 13 species, including 12 species for young leaves and flowers of one plant species.

In terms of time spent feeding, 10 different families occupied 64.4% of total feeding time. The 10 families were Sapindaceae, Myrtaceae, Lauraceae, Guttiferae, Moraceae, Flacourtiaceae, Burseraceae, Theaceae, Loganiaceae and Betulaceae (Table 2). The family Sapindaceae was eaten most extensively with 28.5% of total feeding time. The family Myrtaceae was second with 7.13% of total feeding time. Five plant families (Myrtaceae, Sapindaceae, Moraceae, Lauraceae, and Flacourtiaceae) were very important food sources for grey-shanked douc langurs. Three families (Moraceae, Theaceae, Loganiaceae) were important sources of leaves while four families (Burseraceae, Sapindaceae, Myrtaceae, and Guttiferae) were important sources of seeds and fruits.

Table. 2. The top 10 most eaten plant species.

TT	Species	Family	Young leaves	Mature leaves	Fruit	Seed	Flower	Time spent (%)
1	*Pometia pinnata*	Sapindaceae	1.18	0.77	.	21.53	0.71	24.19
2	*Syzygium tramnion*	Myrtaceae	.	1.35	0.20	1.42	.	2.97
3	*Garcinia merguensis*	Guttiferae	.	.	.	2.86	.	2.86
4	*Canarium bengalense*	Burseraceae	0.14	.	0.91	1.76	.	2.81
5	*Strychnos ovata*	Loganiaceae	2.35	.	.	.	.	2.35
6	*Syzygium oblatum*	Myrtaceae	.	.	0.69	1.47	.	2.15
7	*Nephelium lappaceum*	Sapindaceae	.	.	.	2.09	.	2.09
8	*Betula alnoides*	Betulaceae	1.94	.	.	.	.	1.94
9	*Homalium ceylanicaum*	Flacourtiaceae	0.97	0.81	.	.	.	1.78
10	*Camellia fleuryi*	Theaceae	1.73	0.04	.	.	.	1.77

The species *Pometia pinnata* and *Nephelium lappaceum* were the most eaten foods. The douc langurs spent nearly a quarter of their feeding time (24.1%) on *Pometia pinnata* (Fig. 3). For this plant species, all type of food items were eaten including young leaves, mature leaves, flowers and seeds. The seeds of *Pometia pinnata* were available in peak from June to July and young leaves were available at peak in February. *Syzygium tramnion* and *Syzygium oblatum* were also important for the douc langurs since they feed on young leaves and seeds of the both species through-out the year. The species *Homalium ceylanicaum* was an important source of young leaves and mature leaves from January to April.

Fig.3. Plant species *Pometia pinnata* eaten by the grey-shanked douc langurs (*Pygathrix cinerea*). Photo: Nguyen Thi Tinh.

Among the most important food sources to the douc langurs were 3 families (Sapindaceae, Myrtaceae and Flacourtiaceae) and 5 species (*Nephelium lappaceum*, *Pometia pinnata*, *Syzygium tramnion*, *Syzygium oblatum* and *Homalium ceylanicaum*).

Phytochemical content of food items

Leaves vs. fruits

The fiber content of leaves was greater than of fruits including NDF (t=4.188; P<0,001), ADF (t=4.379; P<0.001), and ADL (t=2.976; P=0.006) (Table 3). Protein in leaves is greater than in fruits (t=2.257; P=0.031). However, sugars and starches in fruits were greater than in leaves (t=-2.989; P=0.012) and (t=-3.184; P=0.007). Lipid content in leaves and fruits was similar.

Table. 3. Nutrient and fiber content between leaves and fruits.

Parameter	Leaves (n=22)		Fruits (n=11)		T-Test		
	Mean (g/kg DM)	sd	Mean (g/kg DM)	sd	t	df	P (2-tailed)
Protein	127.68	46.37	83.30	65.40	2.257	31	0.031
Sugar	37.47	16.19	75.52	40.63	-2.989	31	0.012
Starch	83.96	73.23	222.66	134.90	-3.184	31	0.007
Lipids	20.88	12.73	40.13	74.98	-0.845	31	0.417
Ash	58.87	33.00	32.44	16.40	2.493	31	0.018
NDF	466.38	97.33	280.07	158.43	4.188	31	0.001
ADF	324.65	107.14	155.97	98.08	4.379	31	0.001
ADL	163.15	75.66	84.92	60.76	2.976	31	0.006

Young vs. mature leaves

Nutrients (protein, sugar, lipid, and starch) in young leaves were almost identical to mature leaves. Protein in young leaves was generally higher than in mature leaves, but the difference was not statistically significant (t=1.46; P=0.16). Fiber content (NDF, ADF and ADL) in young leaves and mature leaves was similar (Table 4).

Table. 4. Nutrient and fiber contents in young leaves and mature leaves.

Parameter	**Young leaves** (n=14)		**Mature leaves** (n=8)		**T-Test**		
	Mean (g/kg DM)	**sd**	**Mean** (g/kg DM)	**sd**	**t**	**df**	**P** (2-tailed)
Protein	141.27	41.47	115.23	37.93	1.46	20	0.160
Protein/ADF	0.44	0.21	0.42	0.15	0.32	20	0.750
Sugar	35.47	16.11	39.01	9.59	-0.56	20	0.579
Starch	75.37	30.96	65.00	15.83	0.88	20	0.390
Lipids	16.96	8.19	27.16	16.88	-1.92	20	0.069
Ash	66.90	37.03	46.08	17.82	1.48	20	0.153
NDF	487.26	104.98	462.78	92.13	0.55	20	0.589
ADF	350.88	111.36	291.21	82.13	1.32	20	0.202
ADL	185.32	77.63	127.71	58.70	1.82	20	0.084

Nutrient and fiber content in selected plant species

The greatest amount of protein was found in seeds of *Canarium bengalense* with 210.7 g/kg DM. Protein in young leaves of *Strychnos ovata* and *Antidesma veluntinosums* was also high with 201.4 g/kg DM. The greatest amount of lipids was found in seeds of *Nephelium lappaceum* with 208.6 g/kg DM. The greatest amount of sugar was found in fruits of *Syzygium oblatum* with 178.1 g/kg DM. The greatest amount of starch was found in seeds of *Lithocarpus ceriferus* with 428.9 g/kg DM. The species *Antidesma velutinasum* contains the greatest amount of NDF (622.2 g/kg DM), ADF (560.1 g/kg DM) and ADL (351.8 g/kg DM) of the young leaves that were eaten (Table 5).

Discussion

Diversity of plant species in diets of grey-shanked douc langurs

Ha Thang Long (2009) reported that the grey-shanked douc langurs fed on 166 species of 40 families in Kon Ka Kinh National Park. In this study, 135 species of 44 families were identified. There are only 25 food species overlapping between this study and the study of Ha Thang Long (2009). Difference in location of feeding observations and trees combined with high diversity of plant species in Kon Ka Kinh National Park may constitute to the low overlap of consumed plant species. In total, the grey-shanked douc langurs ate 251 identified plant species in Kon Ka Kinh National

Table. 5. Mean for nutrient and fiber content in all food items.

Nutrient and fiber contents	Mean (g/kg DM) (n= 33)	sd	Min	Max	Top 3 species with the highest nutrient and fibers
Protein	114.99	57.03	25.2	210.7	*Canarium bengalense, Strychnos ovata, Antidesma velutinosums*
Lipid	26.83	43.55	0.7	208.6	*Nephelium lappaceum, Canarium bengalense, Tetradium glabrifolium*
Sugar	49.59	31.61	12.5	178.1	*Syzygium oblatum, Syzygium zimmermannii, Syzygium tramnion*
Starch	128.02	115.60	19.8	428.9	*Lithocarpus ceriferus, Syzygium tramnion, Garcinia merguensis*
NDF	408.75	148.42	98.3	622.2	*Antidesma velutinosum, Betula alnoides, Wightia speciosissima*
ADF	272.84	131.17	29.8	560.1	*Antidesma velutinosum, Garcinia oligantha, Maesa parvifolia*
ADL	141.86	83.07	4.1	351.8	*Antidesma velutinosum, Maesa parvifolia, Garcinia oligantha*

Park, 109 additional plant species were identified in this study. Among *Pygathrix*, the grey-shanked douc langur shows the highest recorded diversity in plant species consumed. Black-shanked douc langurs consumed 152 plant species of 37 families (Hoang Ming Duc, 2009), and red-shanked douc langurs 87 species from 36 families (Otto, 2005). Among odd-nosed monkeys, the grey-shanked douc langurs also show very high diversity of plant species in their diets. For example, the proboscis monkey (*Nasalis larvatus*) ate 188 plant species (Matsuda et al., 2009) while *Rhinopithecus roxellana* ate 84 plant species (Guo et al., 2007). Food resources in Kon Ka Kinh National Park are likely more diverse and dense than other sites due to greater plant density and diversity.

Nutrition in the diet of grey-shanked douc langurs

In this study, we found that the grey-shanked douc langurs met the adaquate 7-11% protein of dry matter required for growth and maintenance as suggested by Oftedal (1991). Among *Pygathrix*, the diets of the red-shanked douc langurs contained the highest amount of protein (173 g/kg dry matter) in young leaves, followed by the amount of protein in the diets of the grey-shanked and black-shanked douc langurs. The study of red-shanked douc langurs was conducted in captivity at Cuc Phuong National Park which is located in limestone forest of northern Vietnam outside of the known range of *Pygathrix* (Otto, 2005), while the studies on grey-shanked and black-shanked douc langurs were conducted in southern Vietnam in the wild. Difference in vegetation and habitat may affect the amount of protein in their diets.

The nutrition contained in eaten plant parts was analyzed in the Delacour's langur (*Trachypithecus delacouri*) also showing that protein in young leaves is higher than in mature leaves (Workman & Le Van Dung, 2009) (Table 6).

Table. 6. Comparing nutritional value in the diets of all douc langur species and the Delacour's langur (*Trachypithecus. delacouri*).

Species	Study site	Nutrition Value (g/kg dry matter)		Plant parts	Reference
		Protein	**NDF**		
Pygathrix cinerea	Kon Ka Kinh NP, Gia Lai	141.2	487	Young leaves	This study
		115.2	462	Mature leaves	
		83.3	280	Fruits	
Pygathrix nemaeus	Cuc Phuong NP, Ninh Binh	173	365	Young leaves	Otto (2005)
		128	384	Mature leaves	
Pygathrix nigripes	Bu Gia Map NP, Binh Phuoc Nui Chua NP, Ninh Thuan	123	466	Mixed leaves	Hoang Minh Duc (2007)
		75.7	442	Fruits	
Trachypithecus delacouri	Van Long Nature Reserve, Ninh Binh	122	380	Young leaves	Workman & Le Van Dung (2009)
		104	334	Mature leaves	

Important food sources for the grey-shanked douc langurs in Kon Ka Kinh National Park

Dietary studies that identify the important food in a primate diet are important for conservation. In this study, we determined 3 species which are the most important foods including *Pometia pinnata*, *Syzygium tramnion*, and *Canarium bengalense* (Fig. 4). Among those, *Pometia pinnata* was the most vital since up to 24.9% of time spent feeding was on this species, which corroborates an earlier study that grey-shanked douc langurs spent the greatest amount of time (14,3%) feeding on *Pometia pinnata* (Ha Thanh Long, 2009). Grey-shanked douc langurs ate several plant parts of these species including young leaves, mature leaves, fruits, seeds and flowers. During the peak of fruiting (June, July, and August) the grey-shanked douc langurs spent significant time harvesting fruits and seeds. They also intensively ate young leaves of this plant during 4 months of the dry season (January to April). Following

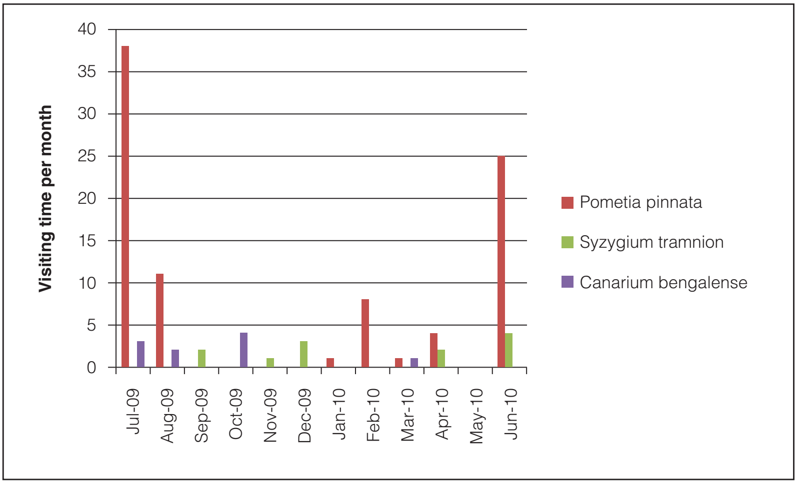

Fig.4. The three plant species most visited by the grey-shanked douc langurs (*Pygathrix cinerea*).

Marshall & Wrangham's (2007) definition of 'preferred food' there is sufficient evidence to conclude that *Pometia pinnata* is the 'preferred food' of grey-shanked douc langurs, because the density of the plant species in the study site is only 1.4 trees/ha, so the availability is low. Further, the usage of the plant species by the grey-shanked douc langurs is very high. *Pometia pinnata* is an important agro forest tree in the Pacific Island (Thomson & Thaman, 2006), where it has commercial value and ecological value in Samoa. In Kon Ka Kinh National Park, however, local people did not harvest this plant species for any purpose, and does not seem to be in high local demand currently.

Conclusions

The diet of grey-shanked douc langurs is highly diverse in terms of plant species. There were 135 species of 44 plant families eaten by the douc langurs in this study. Combined with previous studies, there are 251 plant species recorded as foods for the grey-shanked douc langurs in the Kon Ka Kinh National Park. The nutritional component in selected food consists of protein at 11.4% of dry matter, lipids at 2.6%, minerals at 5.0%, sugars at 4.9%, starchs at 12.8%, and NDF at 40.8%. The consumption of protein is similar to that of red-shanked and black-shanked douc langurs. At the study site, the plant species *Pometia pinnata* is the preferred food.

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References

Altmann J (1974): Observational study of behavior: sampling methods. Behaviour 49, 227-267.

Boonratana R & **Le Xuan Canh** (1998): Preliminary observations of the ecology and behavior of the Tonkin snub-nosed monkey (*Rhinopithecus* [*Presbytiscus*] *avunculus*) in Northern Vietnam. In: Jablonski (eds.): The Natural History of the Doucs and Snubnosed Monkeys; p 207-215. World Scientific Publishing, Singapore.

Davies AG (1991): Seed-eating by red leaf monkeys (*Presbytis rubicunda*) in dipterocarp forest of northern Borneo. Int. J. Primatol.. 12,19-144.

Dasilva LG (1992): The western black-and-white colobus as a low-energy strategist: activity budgets, energy expenditure and energy intake. Journal of Animal Ecology 61, 79-91.

Dubois M, **Gilles KA**, **Hamilton JK**, **Rebers PA**, & **Smith F** (1956): Colorimetric methods for determination of sugars and related substances. Anal Chem 28, 350–356.

Grüter CC (2009): Determinants of Modular Societies in Snub-nosed Monkeys (*Rhinopithecus bieti*) and other Asian Colobines. PhD Dissertation, Universität Zürich, Zürich.

Guo S, **Li Band** & **Watanabe K** (2007): Diet and activity budget of *Rhinopithecus roxellana* in the Qinling Mountains, China. Primates 48, 268-276.

Ha Thang Long (2009): Behavioural ecology of grey-shanked douc monkeys (*Pygathrix cinerea*) in Vietnam. PhD Dissertation, University of Cambridge, Cambridge.

Harrison MJS (1986): Feeding ecology of the black colobus (*Colobus satanas*) in central Gabon. In: Else & Lee (eds.): Primate Ecology and Conservation; p 31-38. Cambridge University Press, Cambridge.

Hoang Minh Duc (2007): Ecology and Conservation Status of the black-shanked douc (*Pygathrix nigripes*) in Nui Chua and Phuoc Binh National Parks, Ninh Thuan Province, Vietnam. PhD Dissertation, School of Natural and Rural Systems Management. University of Queensland, Queensland

Hovenkamp-Hermelink, **De Vries**, **Adamse**, **Jacobsen**, **Witholt** & **Feenstra** (1988): Rapid estimation of the amylose/amylopectin ratio in small amounts of tuber and leaf tissue of the potato. Potato Research 31, 241-246.

Kirkpatrick RC (1998): Ecology and behavior of the snub-nosed and douc monkeys. In: Jablonski (eds.): The Natural history of the doucs and snub-nosed monkeys; p155-190. World Scientific Publishing, Singapore.

Le Trong Trai, **Le Van Cham**, **Tran Quang Ngoc** & **Tran Hieu Minh** (2000): An investment plan for Kon Ka Kinh Nature Reserve, Gia Lai Province: a contribution to the management plan. Birdlife International Vietnam Programme & the Forest Inventory and Planning Institute, Hanoi.

Lippold LK (1998): Natural history of douc langurs. In: Jablonski (eds): The Natural history of the douc and snub-nosed monkeys; p191-206. World Scientific Publishing, Singapore.

Marshall AJ & **Wrangham RW** (2007): Evolutionary consequences of fallback foods. Int. J. Primatol. 28, 1219–1235.

Matsuda I, **Tuuga A** & **Higashi S** (2009): The Feeding Ecology and Activity Budget of Proboscis Monkeys. Am. J. Primatol. 71, 1-15.

McKey DB (1978): Soil vegetation, and seed eating by black colobus monkeys. In: Montgomery (eds.): The ecology of arboreal folivores; pp. 423-438. Smithsonian Institution Press, Washington D.C.

McKey DB, **Gartlan JS**, **Waterman PG** & **Choo GM** (1981): Food selection by black colobus monkeys (*Colobus satanas*) in relation to plant chemistry. Biological J. of the Linnean Society 16, 115-146.

Milton K (1998): Physiological ecology of howlers (*Alouatta*): Energetic and digestive considerations and comparison with the Colobinae. Int. J. Primatol. 19(3), 513-548.

Oftedal OT (1991): The nutritional consequences of foraging in primates: The relationship of nutrient intakes to nutrient requirements. Philosophical Transactions: Biological Sciences 334, 161-170.

Otto C (2005): Food Intake, Nutrient Intake, and Food Selection in Captive and Semi-free Douc Langurs. PhD Dissertation, University Cologne, Cologne.

Pham Nhat (1993): First results on the diet of the red-shanked douc monkeys (*Pygathrix nemaeus*). Australian Primatology 8, 5-6.

Thomson LAJ & **Thaman RR** (2006): *Pometia pinnata* (Tava) Species profile for Pacific Island Agroforestry; pp. 1-17. http://www.traditionaltree.org. Retrieved at 28. August 2012.

Strickland JDH & **Parsons TR** (1972): A practical handbook of seawater analysis. Fisheries Board of Canada. Ottawa.

Van Soest PJ, **Robertson JB** & **Lewis BA** (1991): Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci. 74, 3583–3597.

Workman C & **Le Van Dung** (2009): The chemistry of eaten and uneaten leaves by Delacour's langurs (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. Vietnamese J. Primat. 1 (3), 29-36.

Williams S (1984): Official methods of analysis of the association of official analytical chemists. VA: Association of Official Analytical Chemists, Inc. Arlington

Yeager CP (1989): Feeding ecology of the probosis monkey (*Nasalis larvatus*). Int. J. Primatol. 10, 497-530.

Yeager CP, **Silver SC** & **Dierenfeld ES** (1997): Mineral and phytochemical influences on foliage selection by the proboscis monkey (*Nasalis larvatus*). Am. J.. Primatol. 41(2), 117-128.

Yeager CP & **Kool K** (2000): The behavioural ecology of Asian colobines. In: Whitehead & Jolly (eds.): Old World Monkeys; p 496-528. Cambridge University Press, Cambridge.

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The "Son Tra Douc langur Research and Conservation Project" of Frankfurt Zoological Society

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Summary

Research activities of Frankfurt Zoological Society (FZS) on Son Tra Nature Reserve, Danang City began in 2006. This evolved into the 'Son Tra Douc langur Research and Conservation Project' in 2010, focusing on the conservation of red-shanked douc langurs (*Pygathrix nemaeus*). This project gathers information about douc langurs social behavior, feeding ecology, ranging and forest phenology. The project worked primarily with one group of douc langurs. Son Tra's douc langurs live in multi-male/multi-female groups. Groups consist of multiple families with a sex ratio of adult females to adult males typically 2:1. Sixty-three different feeding plant species were identified. The douc langurs feed on a variety of plants, mainly trees but also vines and climbers. Nutritional analysis of select food items was conducted. Langurs select higher quality foods when available, suggesting dental and gut morphology is an adaptation to tough fall-back foods. During the entire study we also monitored threats to the biodiversity on Son Tra including poaching, fishing, and extraction of timber and non-timber forest products. Development of several tourist resorts and roads have serious negative impacts on biodiversity. Threats were reported regularly to Da Nang City administration.

Dự án nghiên cứu và bảo tồn loài voọc chà vá chân đỏ của Hội Động vật học Frankfurt tại bán đảo Sơn Trà

Tóm tắt

Hoạt động nghiên cứu của Hội Động vật học Frankfurt, thành phố Đà Nẵng bắt đầu từ năm 2006. Đến năm 2010, dự án nghiên cứu và bảo tồn loài voọc chà vá chân đỏ được thực hiện. Mục tiêu của dự án là thu thập số liệu về tập tính xã hội, sinh thái dinh dưỡng, tập tính di chuyển và sự phát triển của rừng. Chương trình nghiên cứu được thực hiện trên một bầy voọc chà vá chân đỏ tại bán đảo Sơn Trà. Kết quả cho thấy, loài voọc chà vá chân đỏ sống thành bầy với nhiều con đực và con cái trưởng thành. Bầy lớn được hình thành từ nhiều gia đình nhỏ với tỷ lệ giới tính ở con trưởng thành là 2 cái:1 đực. Có 63 loài thực vật là thức ăn chính của loài voọc chà vá chân đỏ đã được xác định. Thức ăn của loài đa dạng với phần lớn là cây thân gỗ, một số dây leo và cây thân thảo. Đặc điểm dinh dưỡng của thức ăn cũng được phân tích. Kết quả cho thấy loài lựa chọn những thức ăn có hàm lượng dinh dưỡng cao. Mặt khác cấu trúc răng và dạ dạy của loài cũng thích nghi với việc ăn các loại thức ăn kém chất dinh dưỡng trong những thời điểm nhất định. Trong quá trình nghiên cứu những tác động đến sự tồn tại của loài cũng được ghi nhận và giám sát. Các tác động bao gồm săn bắt, đánh cá, khai thác gỗ và lâm sản ngoài gỗ. Sự phát triển của các khu du lịch và đường sá cũng tác động nghiêm trọng đến đa dạng sinh học ở bán đảo Sơn Trà. Những tác động đã được báo cáo thường xuyên lên nhà chức trách của thành phố Đà Nẵng.

Introduction

One of the most colorful primates in the world, the red-shanked douc langur[1] (*Pygathrix nemaeus*) is endemic to Indochina. They inhabit a diversity of tropical forests in north and central Vietnam, east-central Laos and the northeastern tip of Cambodia (Fooden, 1996; Timmins & Duckworth, 1999; Nadler et al., 2003; Rawson & Roos, 2008). Unfortunately, an absence of basic survey data throughout their range confounds exact population estimates. Red-shanked douc langurs are listed as Endangered on the IUCN Red List of Threatened Species (IUCN, 2012) and the Red Data Book of Vietnam (Ministry of Science and Technology & Vietnamese Academy of Science and Technology, 2007). Despite legal protection in Vietnam, Laos and Cambodia populations are declining rapidly all over the distributions range mainly due to hunting for medicinal purposes. Law enforcement is lacking. Douc langurs are further threatened by habitat loss and fragmentation as result of logging, agricultural and infrastructure development.

They have dental and gut adaptations allowing them to process low quality foods, such as mature leaves (Kay, 1978; Chivers & Hladik, 1980; Davies & Oates, 1994). Although they have unique folivorous adaptations their diet is diverse, consisting of fruits, nuts, seeds, flowers, and bark in addition to young and mature leaves (Lippold, 1977; Pham Nhat, 1994).

Material and Methods

Son Tra Nature Reserve

Son Tra Nature Reserve is located on Son Tra Peninsula only 8 km from the center of Danang City. The peninsula comprises a total landmass of about 6000 ha with several peaks of which the highest is 696 m (Tordoff et al., 2004). Son Tra comprises a patchwork of different habitats including forests, plantations and shrub lands. Son Tra forest is home to a large variety of plants and animals. Surveys conducted by Danang University confirmed 985 plant species, 36 mammal species, 106 bird species, 23 reptile species, 9 amphibian species and 113 insect species (Dinh Thi Phuong Anh, 1997). Observations made during this project have confirmed even greater diversity then the numbers reported in 1997. Regardless, many of the species remaining on Son Tra are listed in the Red Data Book of Vietnam and the IUCN Red List of Threatened Species and some of them are critically endangered.

Son Tra played an important role in Danang's legends and its recent history. Initially the entire peninsula was protected under military jurisdiction. In 1977 4.439 ha of the peninsula were protected as a cultural and historical site (Tordoff et al., 2004). The protection status was upgraded to a nature reserve in 1992 and forest protection rangers were appointed to stop illegal activities. In 2008, the size of the reserve was reduced by nearly half, to 2.670 ha and many areas important for biodiversity are now being developed (Vietnam Conservation Fund, Central Region TA, 2009). The entire coastline of Son Tra is no longer protected and numerous large resorts are being built.

Many roads have been constructed crossing Son Tra and have created wide gaps in the forests, which are impossible for douc langurs and other wildlife to cross. An invasive vine which has been brought in with the road construction spreads over the peninsula, covering and destroying large areas of the forest. Nature on Son Tra is on the decline and protection measures are urgently required.

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[1] There remains some scholarly debate about the common names for the *Pygathrix* species, although this does not affect systematic placement. For the purpose of consistency within the Vietnamese Journal of Primatology, douc langur is used for all *Pygathrix* species. Please refer to the article in this issue for a discussion of vernacular names [Nadler (2012): Why Sea Lions don't catch Zebras–Thoughts about common names of Indochinese primates. Vietnamese J. Primatol. 1(2), 3-5].

Son Tra reflects the threats to biodiversity in the entire country and also the problems conservation face trying to address them (Lippold & Vu Ngoc Thanh, 2008). There is rampant hunting and cutting, severe habitat loss and fragmentation, uncontrolled tourism and development, and a lack of awareness of the douc langurs and biodiversity conservation and an entire absence of law enforcement activities.

First reports of red-shanked douc langurs at Son Tra were published in 1969 and 1971, from a survey that took place from 1966-69 during the Vietnam-American War (Van Peenen, 1969; Van Peenen et al., 1971). A brief survey in 1974 estimated only 11-28 individuals (Lippold, 1977). A survey conducted in 1988 reported one group of 10 individuals remaining in the area (Pham Nhat, 1994). In 1995, the population estimate was 30-40 individuals remaining on the peninsula (Lippold, 1995). Until the beginning of 2007, it appeared the population of douc langurs at Son Tra was very small if not extirpated (Nadler et al., 2003). In 2007, a survey recorded 171 individuals, and a population estimate of 198 red-shanked douc langurs (Vu Ngoc Thanh et al., 2007), suggesting that nearly 60% of the red-shanked douc langur population in Vietnam may be located on Son Tra (Lippold & Vu Ngoc Thanh, 2008). Son Tra is therefore home to an important population of red-shanked douc langurs, probably one of the largest populations remaining in Vietnam. Here the species managed to survive relatively undisturbed due to military presence and restricted access to the peninsula.

Research component

Phenology transects

Three transects were established, measuring 8 x 300 m (2 transects), and 8 x 500 m (1 transect). Transect locations were chosen randomly using a number generator for coordinates. All trees with 10 cm diameter at breast height (DBH) or greater were marked. Measurements of DBH, tree height, crown width, percentage of young to old leaves, living to dead leaves, and proportion of fruits and flowers were recorded. Measures on the leaves, fruits and flowers were recorded twice each month for 14 months. There are 512 trees with at least 10 cm DBH along the transects. Transect trees have all been identified to at least family level.

Feeding ecology

Feeding observations used focal sampling, and rotated between adult males and adult females, but also included sub-adults, juveniles, and infants where possible. Records were made of time, weather, individual, feeding behavior, tree(s) species, tree characteristics, canopy height and distance to nearest douc langur.

Nutritional quality

Select feeding plants were collected for testing. Within 48 hours of the observed feeding bout, 300 g of wet matter were collected from the same feeding tree, and weighed on location. Plants matter was then stored in open plastic containers with silica gel in an open air room, then in an air conditioned room for drying. Samples were weighed for consecutive months until a dry weight was reached, then stored in sealed plastic containers until tested. Based on dry weight, 22 were selected for testing including 18 plants selected for by the douc langurs and 4 plants readily available but not selected as food. Tests include crude protein, neutral detergent fiber, acid detergent fiber, ash, water content, and condensed tannins. Tests were conducted at the Center for Environmental Management Laboratory of Nong Lam University, Ho Chi Minh City. Water content is based on wet and dry matter weights. Other tests are conducted using the following methods: AOAC 987.04-1997 (crude protein), AOAC & TC 2000 (ash), AOAC & TC 2000 (tannins), AOAC 973.18 (fibers).

Behavioral observations

Behavioral observations are also based on focal sampling, rotating between adult males and adult females, and opportunistically on subadults, juveniles and infants (Fig. 1).

Fig.1. An adult male, female and young in the habituation group. Photo: Larry Ulibarri.

Preliminary results

Tree compositions and characteristics between the 3 transects are different. Transect 1 has the highest percentage of trees taller than 15 m (13%), and is the only transect which contains trees higher than 20 m. It has the highest diversity of tree families. Douc langurs were most often seen around transect 1 compared to the other transects. Transect 2 has the next highest percentage of tall trees (8% with a height 15 m or greater) and the next highest diversity of tree families. Transect 3 has the lowest diversity of tree families and the lowest percentage of trees 15 m height or greater (2%). Douc langurs were seen infrequently along Transect 2, and only observed twice along Transect 3. This pattern suggests a habitat preference towards good secondary or primary forests in which there is a greater percentage of trees 15 m height or greater.

The douc langurs were observed feeding at all canopy levels, including the ground. Young leaves comprise a majority of their diet, followed by mature leaves, fruits, flowers, seeds and bark. As observations are predominantly on one group of douc langurs, the total number of food species is likely low compared to the probable diversity of feed species on Son Tra. However, 63 different plant species were selected and have been identified, and the list is growing. Among the most important food resources, including its young and mature leaves, its flowers and seeds, is the IUCN classified critically endangered tree – White Seraya (*Parashorea stellata* Kutz) (IUCN, 2012) (Fig. 2). This is the same tree that the douc langurs were seen in most frequently during observations, positively correlating with the frequency of douc langur observations.

Fig.2. A White Seraya tree (*Parashorea stellata* Kutz) with flowers. Flowering season is short and was only observed once in 2.5 years.
Photo: Larry Ulibarri.

Selection of fruits and flowers increases with availability. However, the douc langurs do not actively seek out fruiting or flowering trees, and were never observed to deplete a food resource on an individual tree. This implies that the douc langurs folivorous adaptations (dentition and gut morphology) are for fall-back resources in a seasonal and fluctuating environment. Results of the nutritional analysis are still pending.

During the first year of this project the semi-habituated douc langur group consisted of 17 individuals, the following year a new infant was born into the group. This group comprises three families. Two of these families have a single adult male, the 3rd family has two adult males. The sex ratio is 2:1; adult females to adult males. The families come together to form a group, and are often seen together at all times of the year, especially during the spring (February – May) and autumn (August – October) months. During other times of the year, they frequently sleep together, then split into their respective families in the morning, travel and feed as separate families, then join again in the late afternoon. This daily fission-fusion behavior was frequently observed in several groups, not just among the habituation group. Adult males tolerate other adult males intragroup. Both friendly and aggressive intergroup interactions were observed.

Two separate groups comprising only adult and subadult males were observed. These bachelor groups appear to be seasonally formed in the spring and autumn. However, these males also roam the forest as solitary males, often shadowing douc langur groups and coming as close as 100 m before a douc langur family becomes agitated.

Douc langur groups were often observed together with a troop of rhesus macaques (*Macaca mulatta*). During all such observations, the macaques tended to stay below 15 m and the douc langurs above, although overlap in substrate use and encounters of 1 m distance between species were not uncommon. Such associations between the two species appear to be unstable chance encounters. However a few prolonged occasions of half-day feeding and traveling associations were recorded. Also, adult male red muntjacs (*Muntiacus muntjac*) were infrequently observed to travel under the douc langur group (and macaque troops) for extended periods, presumably feeding on seeds dropped by the primates. These associations also appear to be chance encounters.

Conservation component

Threats to biodiversity

Hunting and Non-timber-forest-products (NTFP) collection

Based on the number douc langurs confiscated by local authorities in 2010, we predict that about one adult per month was hunted from Son Tra during that year. No reported confiscations occurred in 2011 and 2012. Snare fences stretching 500 to 1000 m were found during the research and numerous snares are removed from Son Tra by the rangers each month (Fig. 3). Hunting activities are not only conducted by hunters but to a large degree by construction workers living in the forest during road construction. At times there were about 1000 construction staff living in tents and sheds on Son Tra. Some of the construction workers have been living on the site for the last 7 years. Wildlife has been found in the construction camps (Fig. 4).

Bird hunting is rampant and is done by hunters but also young men and students to earn extra money during the weekends. Although most are aware that catching birds is illegal, few are concerned about repercussions. Based on records made during 2010 - 2011, it was estimated that 30 birds are hunted each day leading to a massive reduction of the bird populations of Son Tra (Fig. 5).

Trees, rattan, Cycadaceae plants and orchids are taken from Son Tra daily (Fig. 6). Tree scraping of White Seraya is also frequent and is done for the resin which is used as boat sealant.

Fig.3. Snare fences and single snares are an ongoing problem. Photo: Larry Ulibarri.

Fig.4. Wildlife of all sorts has been observed in construction camps. This adult male has been injured with a machete probably by construction workers. Photo: Larry .Ulibarri.

Fig.5. On an average day at least 30 birds are estimated to be hunted on Son Tra. Photo: Ulrike.Streicher.

Fig.6. The cutting of leaves from cycad species has nearly eradicated these plants on Son Tra. Photo: Larry Ulibarri.

Habitat destruction and fragmentation

A road surrounding Son Tra Peninsula was approved by Danang City in 2001 (Decision No. 113, 2001). Construction of the road was initially very slow. In July 2012, the road is still under construction. All forests below the road and along the coast not longer belong to the nature reserve and are designated for development. In some locations, the areas designated for development include several hundred ha of good secondary forest and is home to douc langur groups.

Road construction is done with little concern to the forest. In many areas forest is cleared simply for access to soil which is then used in the road construction. Steep slopes are blasted into the hill side and the nearly vertical slopes are left exposed. This results in heavy landslides during the raining season and large patches of forest slide down with the mud. The gaps in the forest created by the roads are in some places over 100 m wide (Fig. 7). Roads and the slopes are significant barriers for all arboreal species. Smaller forested areas and arboreal species are more susceptible to the negative effects of habitat fragmentation, which is a double-strike against the douc langurs on Son Tra Nature Reserve. In at least two locations, douc groups are currently separated by the roads; one family on the 'protected' side of the road, the other on the 'unprotected' side. All observation of such split groups indicate they stay close to each other and thus to the road, and are maximally exposed to hunting.

Fig.7. Roads create large gaps in the forest, which in some places are over 100 m wide. Photo: Ulrike Streicher.

Conservation activities

Raising awareness

Education activities involved the cooperation of several organizations and people including the Department of Education, Department of Science and Technology, Danang City consultant Dr. Ulrike

Streicher, Frankfurt Zoological Society, and Danang University. We have conducted and continue to work on several activities to raise public awareness about the red-shanked douc langurs, Son Tra Nature Reserve, and the threats they face (Fig. 8).

Fig.8. Several activities to raise public awareness have been conducted, including a photo exhibition in Danang City, which attracted nearly 8000 visitors. Photo: Ulrike Streicher.

Canopy bridges

Based on these threats this project proposed a tree bridge project to link the habitat patches which are fragmented by the newly developed tourist roads. This includes planting and maintaining trees to encourage natural canopy bridges. This has been approved by the People's Committee of Danang City, but the implementation of the tree bridge project is slowed due to administrative reasons.

Continued activities

The project is on-going, although the primary activity during 2012 focused on conservation awareness activities and analysis of data obtained so far. With the relative success of habituating a red-shanked douc langur group, the ability to locate the group consistently, follow the group at close range for full days, and identify each individual within the group, plans to continue research and contact with the douc langur group are important. It is not currently possible anywhere else in Vietnam to gather data of the same quality on red-shanked douc langurs.

Outputs and conclusions

This project is expanding our knowledge on the ecology of the red-shanked douc langurs. Data on nutrition will be immediately useful for the care of douc langurs in zoos and rescue centers, where adequate diet is often a problem (Edwards & Killmar, 2004).

This study also gathered data immediately useful for the protection of the douc langurs on Son Tra as we gather information on home ranges, important plant species, movement patterns, and threats and provide this directly to the relevant protection authorities. It has continued to raise the issue of threats to various departments of the city government and the People’s Committee.

Conservation activities on Son Tra need to be intensified and must focus on law enforcement and protection of the douc langurs and the nature reserve.

Decisive measures are needed if the red-shanked douc langurs should be given the chance to survive.

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References

Chivers DJ & **Hladik CM** (1980): Morphology of the gastrointestinal tract in primates: comparisons with other.mammals in relation to diet. J. of Morphology 166, 337-86.

Davies AG & **Oates JF** (1994): Colobine monkeys: their ecology, behavior, and evolution. University Press, Cambridge.

Decision No. 113 (2001): QD-TTg, July 30. Approving the overall plan for socio-economic development of Da Nang City in the period 2001-2010. The Prime Minister of Government. Socialist Republic of Viet Nam, Ha Noi.

Dinh Thi Phuong Anh (1997): Studies on fauna, flora, and impact factors in Son Tra Nature Reserve with recommendation of rational conservaton solutions. Final Project Report, Da Nang University of Pedagogy, Da Nang University, Da Nang.

Edwards MS & **Killmar KS** (2004): Nutrition and captive feeding of red-shanked douc langurs (*Pygathrix nemaeus*) at the San Diego Zoo. In: Nadler T, Streicher U, Ha Thang Long (eds): Conservation of Primates in Vietnam; pp. 169-171. Frankfurt Zoological Society, Hanoi.

Fooden J (1996): Zoogeography of Vietnamese primates. Int. J. Primatol. 67, 845-899.

IUCN (2012): IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 26 July, 2012.

Kay RF (1978): Molar structure and diet of extant Cercopithecidae. In: Butler PM, Joyse KA (eds): Development, function, and evolution of teeth; pp. 309-339. Academic Press, New York.

Lippold LK (1977): The douc langur: a time for conservation. In: Prince Rainier III. HSH, Bourne GH (eds): Primate conservation; pp. 513-538. Academic Press, New York.

Lippold LK (1995); Distribution and conservation status of douc langurs in Vietnam. Asian Primates 4, 4-6.

Lippold LK & **Vu Ngoc Thanh** (2008): The time is now: survival of the douc langurs of Son Tra, Vietnam. Primate Conservation 23, 1-5.

Ministry of Science and Technology & **Vietnamese Academy of Science and Technology** (2007): Vietnam Red Data Book, part 1 Animals. Science and Technics Publishing House, Hanoi.(In Vietnamese).

Nadler T, **Momberg F**, **Nguyen Xuan Dang** & **Lormee N** (2003): Vietnam Primate Conservation Status Review 2002, part 2: Leaf monkeys. Frankfurt Zoological Society & Fauna and Flora International-Indochina Programme, Hanoi.

Pham Nhat (1994): Preliminary results on the diet of the red-shanked douc langur (*Pygathrix nemaeus*). Asian Primates 4, 9-11.

Rawson B & **Roos C** (2008): A new primate species record for Cambodia: *Pygathrix nemaeus*. Cambodian J. of Natural History 1, 7-11.

Timmins RJ & **Duckworth JW** (1999): Status and conservation of Douc langurs (*Pygathrix nemaeus*) in Laos. Int. J. of Primatol. 20, 469-489.

Tordoff AW, **Tran Quoc Bao**, **Nguyen Duc Tu** & **Le Manh Hung** (eds.) (2004): Sourcebook of existing and proposed protected areas in Vietnam. Vol. 2. Second edition. BirdLife International in Indochina and the Ministry of Agriculture and Rural Development, Hanoi.

Van Peenen PFD (1969): Preliminary Identification Manual for Mammals of South Vietnam. US National Museum Smithsonian Institution, Washington.

Van Peenen PFD, **Light RH** & **Duncan JF** (1969): Observations on mammals of Mt. Son Tra, South Vietnam. Mammalia 35, 126-143.

Vietnam Conservation Fund (VCF) Central Region TA (2009): Conservation needs assessment Son Tra Nature Reserve, Danang City. Technical Report. Danang City. Vietnam Conservation Fund. (Unpubl.).

Vu Ngoc Thanh, **Le Vu Khoi**, **Le Khac Quyet**, **Ngo Van Tri**, **Thran Huu Vy** & **Le Phuoc Bay** (2007): Survey results for red-shanked douc langur (*Pygathrix nemaeus nemaeus*) in Son Tra Nature Reserve, Da Nang City, Central Vietnam. Technical Report. Vietnam National University, Hanoi. (Unpubl.).

Vietnamese Journal of Primatology (2012) vol. 2 (1), 47-54

A note on phenotypical and genetic differences of silvered langurs in Indochina (*Trachypithecus germaini* and *T. margarita*)

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Key words: Silvered langurs, *Trachypithecus germaini*, *Trachypithecus margarita*, fur coloration, DNA, mitochondrial cytochrome b gene, taxonomy

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Summary

A genetic study using mitochondrial DNA sequences supports a separation of the silvered langurs from the South-east Asian mainland from the Sundaland species and further a species-level division of mainland silvered langurs into *T. germaini* (Indochinese silvered langur) and *T. margarita* (Annamese silvered langur). The exact distribution areas of the mainland silvered langur species are still unknown but the Mekong River is considered as zoogeographical barrier. Both species possess high phenotypical variability due to individual variation, which makes it difficult to diagnose species. However, the arrangement of the hair on the head shows a clear difference. In *T. germaini* the hairs on the head form a central occipital crest whereas in *T. margarita* a crest is missing and the hairs on the head form a cap or hood. Moreover, the skin of the face is completely black in *T. germaini*, whereas in *T. margarita* the space around the eyes is paler and forms a ring, sometimes in flesh colour. Further investigations are required and should include additional samples, in particular from populations along the Mekong.

Ghi nhận về sự khác biệt về kiểu hình và kiểu gen của những loài vọoc bạc ở Đông Dương (*Trachypithecus germaini* và *T. margarita*)

Tóm tắt

Nghiên cứu về trình tự ADN ty thể cho thấy sự phân tách về phân loại học của các loài vọoc bạc ở khu vực Đông Nam Á gồm hai nhóm, nhóm lục địa và nhóm đa đảo. Đồng thời, hai loài ở nhóm lục địa cũng đã được khẳng định gồm vọoc bạc Đông Dương (*T. germaini*) và vọoc bạc Annam (*T. margarita*). Hiện tại, vùng phân bố của các loài vọoc bạc lục địa vẫn cần phải làm sáng tỏ, tuy nhiên sông Mê Kông được xem như là ranh giới địa động vật quan trọng. Cả hai loài vọoc bạc lục địa đều có sự biến thiên về kiểu hình rất đa dạng. Do đó việc nhận dạng loài vọoc bạc qua hình thái trở nên khó khăn. Nghiên cứu này cho thấy sự sắp xếp của chỏm lông trên đầu của hai loài vọoc bạc có sự khác biệt. Ở loài vọoc bạc Đông Dương, phần lông ở chỏm đầu dựng lên ở đỉnh đầu tạo nên chóp mào, trong khi đó loài vọoc Annam không có chóp mào mà tạo nên hình dáng giống chiếc mũ. Ngoài ra, ở loài vọoc bạc Đông Dương vùng da trên mặt hoàn toàn màu đen trong khi đó vùng da này ở loài vọoc Annam lại có màu đen nhạt vòng quanh mắt đôi khi giống màu da. Nghiên cứu cũng chỉ ra cần có thêm những dẫn liệu mới về đặc điểm hình thái từ các quần thể ở dọc sông Mê Kông.

Introduction

Langurs of the *Trachypithecus cristatus* species group (Napier & Napier, 1970; Groves, 2001; Nadler et al., 2005; Osterholz et al., 2008; Roos et al., 2008) are distributed over a large area of southeast Asia, from Borneo through Java to Sumatra, islands of the Riau and Natuna Archipelago, the west coast of the Malayan Peninsula, to Thailand and southern Indochina. All taxa of this species group closely resemble one another in external characters. While the six currently recognized species (Zinner et al., in press) are clearly distinguished from one another in mitochondrial DNA (Roos et al., 2008) there is variation in fur coloration and hair structure, in particularly on the head, within these species. For example, Elliot (1912) mentioned the conspicuous differences in the hair structure on the head for two silvered langurs from Thailand.

Brandon-Jones et al. (2004) divided the silvered langurs on the South-east Asian mainland into two subspecies (*T. villosus germaini* and *T. v. margarita*), along with a third subspecies from Sundaland (*T. v. villosus*). According to Brandon-Jones et al. (2004), *T. v. germaini* occurs in south Thailand, Cambodia and southwest Vietnam, and *T. v. margarita* in south Laos, northeast Thailand and south Vietnam. In contrast, Groves (2001) recognized villosus as a synonym of *cristatus* and separated silvered langurs from the mainland from all other members of the species group as *T. germaini*. Within *T. germaini*, he recognized two subspecies, *T. g. germaini* and *T. g. caudalis*, with the latter from unknown origin, and *margarita* as synonym of *T. g. germaini*. Based on a small number of individuals it was argued that the two mainland forms differ phenotypically (Nadler et al., 2005). A genetic study using mitochondrial DNA sequences further supported a separation of the silvered langurs from the mainland from the Sundaland species and further a species-level division of mainland silvered langurs into *T. germaini* (Indochinese silvered langur) and *T. margarita* (Annamese silvered langur) (Roos et al., 2008).

However, the exact distribution areas of the mainland silvered langur species and the zoogeographical barrier separating them is still unknown. Nadler et al. (2005) and Roos et al. (2008) considered the Mekong River, a well-known barrier for many primate species, as possible limit for both species, but highlighted the importance of further investigations. Moody et al. (2011) and Timmins et al. (2011) doubted the Mekong as barrier for silvered langurs, because species of this species group occur naturally in coastal and riverine forests throughout their range and are even found on islands in the Mekong in northern Cambodia (Bezuijen et al., 2007; Timmins et al., 2011), thus, suggesting that they might be able to cross the Mekong.

Due to these uncertainties concerning taxonomy and distribution, further investigations are urgently required. Hence, to further shed light on the phenotypic and genetic variation in silvered langurs form the Asian mainland, we collected information on phenotypic features from field observations and photos, and by analysing a fragment of the mitochondrial cytochrome b gene of an expanded silvered langur data set.

Materials and Methods

Phenotypical features

There exists only a limited number of museum specimen for comparison of the silvered langurs, in particular from the mainland species. Moreover, museum specimens are not very useful for the comparison of skin colour and the arrangement of hairs on the head. Thus, to study phenotypical features of silvered langurs from eastern and western parts of the Mekong we used field observations and photos taken primarily from individuals of known locations.

Molecular analysis

To expand our previous study on silvered langurs (Roos et al., 2008), we analysed faecal samples from nine additional silvered langurs. Samples were collected either during field surveys or from confiscated individuals from known origin (Table 1, Fig. 1) and stored in 80% ethanol before further processing. DNA was extracted with the QiAamp DNA Stool Mini Kit from Qiagen following protocols of the company. A 573bp fragment of the mitochondrial cytochrome b gene was amplified and sequenced according to methods outlined in Geissmann et al. (2004) and Roos et al. (2008). To prevent cross-sample contamination, laboratory procedures followed described protocols (Osterholz et al., 2008; Roos et al., 2008). PCR products were checked on 1% agarose gels and purified with a standard silica extraction method (Sambrook et al., 1989). Sequencing was performed on an ABI 3130xL sequencer using both amplification primers and the BigDye Terminator Cycle Sequencing Kit (Applied Biosystems).

Table. 1. Origin of samples used for the genetic analysis, respective numbers and detected haplotypes. Samples and haplotypes in italic are taken from Roos et al. (2008).

Species	Origin	Number in Fig. 1	Number of samples	Haplotypes
T. germaini	*Kien Luong, Vietnam (10°19'N; 104°38'E)*	*1*	*7*	*gA, gB, gC, gG, gH*
	Cambodia	-	2	*gB*
	Thailand	-	2	*gB, gD*
	unknown	-	*6*	*gB, gE, gF*
	Southern Cardamoms, Cambodia	2	1	gK
	Battambang, Cambodia	3	2	gG, gJ
	Siem Reap, Cambodia	4	1	gJ
	Preah Vihear, Cambodia	5	1	gE
T. margarita	*Kontum, Vietnam*	*6*	*1*	*mC*
	Veal Thom, Cambodia (14°02'N; 106°45'E)	7	2	mC, mD
	Gia Lai, Vietnam	*8*	*3*	*mA, mC*
	Koh Nhek, Cambodia (13°02'N; 107°10'E)	*9*	*1*	*mA*
	Dak Mil, Vietnam (12°22'N; 107°40'E)	*10*	*1*	*mA*
	Keo Seima, Cambodia (12°30'N; 106°50'E)	*11*	*1*	*mB*
	Cat Tien, Vietnam (11°31'N; 107°19'E)	12	1	mA
	Lo Go Sa Mat, Vietnam (11°35'N; 105°54'E)	13	1	mA

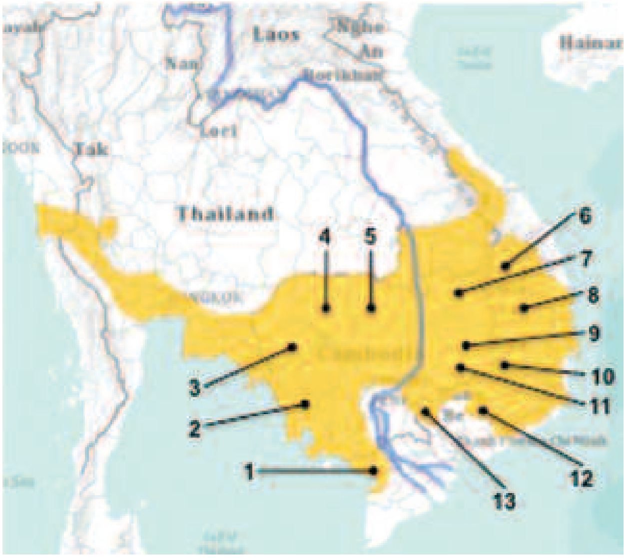

Fig.1. Map showing the proposed distribution of silvered langurs on the South-east Asian mainland. Sampling sites for genetic analysis are indicated by dots; respective numbers are presented in Table 1. The Mekong is indicated as blue line.

Sequences were aligned in SeaView 4 (Gouy et al., 2010) and correct by eye. For statistical analysis, we added further orthologous sequences from *T. germaini* and *T. margarita* published earlier (Roos et al., 2008). The final dataset comprised 34 sequences including 22 *T. germaini* individuals, 11 *T. margarita* individuals and one *T. cristatus* individual, with the latter used as an outgroup. Phylogenetic trees were constructed with a Bayesian algorithm in MrBayes 3.1.2 (Huelsenbeck et al., 2001; Ronquist & Huelsenbeck, 2003). For the reconstruction, the HKY nucleotide substitution model was chosen as the best-fit model under the Bayesian information criterion (BIC) as implemented in jModeltest 0.1 (Posada, 2009). Four independent Markov Chain Monte Carlo (MCMC) runs with the default temperature of 0.2 were used. Four repetitions were run for 10 million generations with tree and parameter sampling occurring every 100 generations. Acceptance rates were in the optimal range of 10 - 70%. The first 25% of samples were discarded as burn-in, leaving 75,001 trees per run. The adequacy of this burn-in and convergence of all parameters was assessed by examining the uncorrected potential scale reduction factor (PSRF) (Gelman & Rubin, 1992) as calculated by MrBayes, which should approach 1 as runs converge and by visual inspection of the trace of the parameters across generations using the software TRACER 1.5 (Rambaut & Drummond, 2007). Posterior probabilities for each split and a phylogram with mean branch lengths were calculated from the posterior density of trees.

Results and Discussion

In contrast to the clear phenotypical differences between *T. germaini* and *T. margarita* presented by Nadler et al. (2005), the analysis of additional individuals revealed that both species possess high phenotypical variability due to individual variation (see also Timmins et al. (2011)). A century ago Elliot (1912) mention for *T. margarita*: ”The colouring varies greatly according to the light which at certain times casts shadows on the gray that are almost black in their intensity”. Such variation occurs also in *T. germaini* (Fig 2, 3, 4, 5). The general colour of both species is silvery grey. Forearms, hands and feet are black. Chin, throat, under parts of the body, and inner side of arms and legs sparsely covered with white hairs. Flanks are paler silvery grey than the upper parts. The tail is above black, beneath silvery grey. The head is grey, the forehead covered by erect black hairs. However, the arrangement of the hair on the head shows a clear difference: in *T. germaini* the hairs on the head form a central occipital crest (Fig. 6, 7), whereas in *T. margarita* a crest is missing and the hairs on the head form a cap or hood, resembling *T. auratus* (Fig. 8, 9, 10). Moreover, the skin of the face is completely black in *T. germaini*, whereas in *T. margarita*, as noted by Elliot (1912) the space around the eyes is paler and forms a ring, sometimes in flesh colour. The eye rings appear very prominent if a flash is used to take photos, which is not the case in *T. germaini* (Fig. 11).

Fig.2. The coloration of Annamese silvered langurs (*T. margarita*) shows individual variation (Zoo Saigon – origin of animals Dong Nai Province, Vietnam). Photo: Tilo Nadler.

Fig.3. The Indochinese silvered langur (*T. germaini*) varies also in fur coloration, animal from southeast Cambodia. Photo: Tilo Nadler.

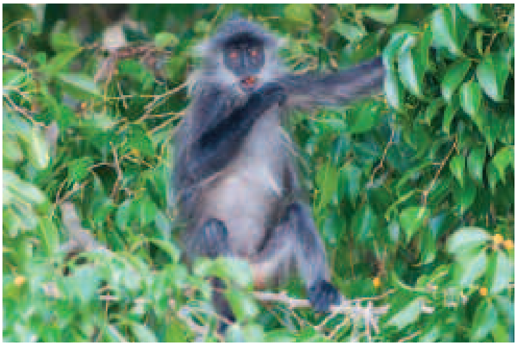

Fig.4. Indochinese silvered langur (*T. germaini*) from Kien Giang Province, Vietnam. Photo: Hoang Minh Duc.

Fig.5. Indochinese silvered langur (*T. germaini*) from Kien Giang Province, Vietnam. Photo: Hoang Minh Duc.

Fig.6. Hair arrangement on the head of Indochinese silvered langur (*T. germaini*) shows the typical crest (animal from southeast Cambodia). Photos: Tilo Nadler.

Fig.7. The extension of the black band on the forehead varies, and the hair of the cheeks is very long. Indochinese silvered langur (*T. germaini*) from southeast Cambodia. Photo: Tilo Nadler.

Fig.8. Hair arrangement on the head of Annamese silvered langurs (*T. margarita*) often shows a cape without a prominent crest. Animal from Dong Nai Province, Vietnam. Photo: Tilo Nadler.

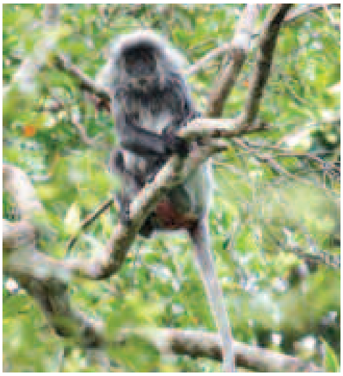

Fig.9. Annamese silvered langurs (*T. margarita*) from Ta Kou National Park, Binh Thuan Province, Vietnam. Photo: Photo: Tran Van Bang.

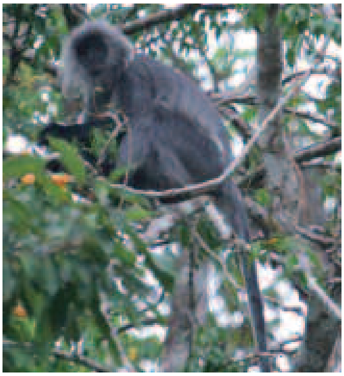

Fig.10. Annamese silvered langurs (*T. margarita*) from Ta Kou National Park, Binh Thuan Province, Vietnam. Photo: Hoang Minh Duc.

Fig.11. Annamese silvered langurs (*T. margarita*) show occasionally pale or fleshy colored eye rings. They are prominent if the photo is taken with a flash. Bu Gia Map National Park, Binh Phuoc Province, Vietnam. Photo: Hoang Minh Duc.

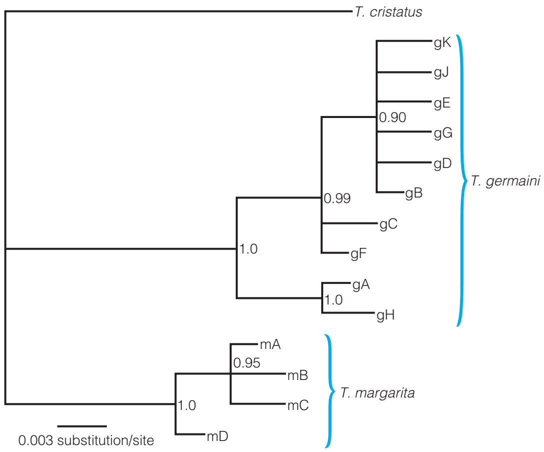

Fig.12. Phylogenetic relationships based on partial cytochrome b gene sequences among *T. margarita* and *T. germaini* haplotypes. *T. cristatus* was used as an outgroup. Details on haplotypes see Table 1.

In contrast to phenotypic features, the extended genetic data set provides additional support for a clear distinction between these species and further suggests the Mekong as natural barrier (Fig. 12). It has to be noted here that in the extended genetic data set, samples from both *T. germaini* and *T. margarita* were included which derived from silvered langur populations closer to the Mekong than in the original data set (Roos et al., 2008). Thus, the Mekong might be indeed the zoogeographic barrier between both species, despite inconclusive phenotypic features. Since we analysed only mitochondrial DNA which is only maternally inherited (Melnick & Hoelzer, 1993) and most primate species show female philopatry (Pusey & Packer, 1987; but see Koenig & Borries (2012) for male philopatry in *Trachypithecus*), nuclear markers need to be studied as well. From the limited nuclear data available to date (Roos, unpublished), all silvered langur species, including *T. germaini* and *T. margarita*, can be distinguished, but confirmation of species-specificity of polymorphisms on a population level is required. Moreover, future studies should include additional samples, in particular from populations along the Mekong. Limited gene flow between both forms on either or both sides of the Mekong cannot be excluded, but is most probably locally restricted and will not lead to panmixia of the whole South-east Asian mainland silvered langur population.

The validity of *T. margarita* and the status of taxa in the silvered langur species group in general was recently questioned (Tan et al., 2008; Moody et al., 2011; Timmins et al., 2011). However, in the silvered langur species group, all species are clearly diagnosable by mitochondrial DNA and to a lesser degree by phenotype, and thus, distinct species status for all taxa, including *T. germaini* and *T. margarita*, is supported by the Phylogenetic Species Concept (Cracraft, 1983, 1989), which is widely applied in primate systematics today (Groves, 2012).

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References

Bezuijen MR, **Timmins R** & **Seng T** (2007): Biological Surveys of the Mekong River Kratie and Stung Treng towns, Northeast Cambodia, 2006-2007. WWF Greater Mekong-Cambodia Country Programme, Phnom Penh.

Brandon-Jones D, **Eudey AA**, **Geissmann T**, **Groves CP**, **Melnick DJ**, **Morales JC**, **Shekelle M** & **Stewart C-B** (2004): Asian primate classification. Int. J. Primatol. 25(1), 97-164.

Cracraft J (1983): Species concepts and speciation analysis. Curr. Ornithol. 1, 159-187.

Cracraft J (1989): Speciation and its ontology: the empirical consequences of alternative species concepts for understanding patterns and processes of differentiation. In: Otte D & Endler JA (eds.): Speciation and its consequences; pp 28-59. Sinauer Associates, Sunderland.

Elliot DG (1912): A review of primates, vol. III. Am. Mus. Nat. Hist., New York.

Geissmann T, **Groves CP** & **Roos C** (2004): The Tenasserim lutung, *Trachypithecus barbei* (Blyth, 1847) (Primates: Cercopithecidae): description, of a live specimen, and a reassessment of phylogenetic affinities, taxonomic history, and distribution. Contrib. Zool. 73, 271-282.

Gelman A & **Rubin D** (1992): Inference from iterative simulation using multiple sequences. Stat. Sci. 7, 457-511.

Gouy M, **Guindon S** & **Gascuel O** (2010): SeaView version 4: a multiplatform graphical user interface for sequence alignment and phylogenetic tree building. Mol. Biol. Evol. 27, 221-224.

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

Groves C (2012): Species concepts in primates. Am. J. Primatol. 74, 687-691.

Huelsenbeck JP, **Ronquist F**, **Nielsen R** & **Bollback JP** (2001): Bayesian inference of phylogeny and its impact on evolutionary biology. Science 294, 2310-2314.

Koenig A & **Borries C** (2012): Chapter 10: Social organization and male residence pattern in Phayre's leaf monkeys. In: Kappeler PM & Watts DP (eds.): Long-term field studies in primates; pp 215-236. Springer, Berlin, Heidelberg.

Melnick DJ & **Hoelzer GA** (1993): What is mtDNA good for in the study of primate evolution? Evol. Anthropol. 2, 2-10.

Moody JE, **An Dara**, **Coudrat CNZ**, **Evans T**, **Gray T**, **Maltby M**, **Soriyun M**, **Nut Meng Hor**, **O'Kelly H**, **Bunnat P**, **Channa P**, **Pollard E**, **Rainey HJ**, **Rawson BM**, **Vann R**, **Chansocheat S**, **Setha T** & **Sokha T** (2011): A summary of the conservation status, taxonomic assignment, and distribution of the Indochinese silvered langur, *Trachypithecus germaini* (sensu lato), in Cambodia. Asian Primates J. 1(3), 17-24.

Nadler T, **Walter L** & **Roos C** (2005): Molecular evolution, systematics and distribution of the taxa within the silvered langur species group (*Trachypithecus* [*cristatus*]) in Southeast Asia. Zool. Garten (N.F.) 75, 238-247.

Napier JR & **Napier PH** (1970): Old World monkeys. Academic Press, New York.

Osterholz M, **Walter L** & **Roos C** (2008): Phylogenetic position of the langur genera *Semnopithecus* and *Trachypithecus* among Asian colobines, and affiliations of their species groups. BMC Evol. Biol. 8, 58.

Posada D (2009): Selection of models of DNA evolution with jModelTest. Methods Mol. Biol. 537, 93-112.

Pusey AE & **Packer C** (1987): Dispersal and philopatry. In: Smuts BB, Cheney DL, Seyfarth RM, Wrangham RW & Struhsaker TT (eds.): Primate societies; pp 250-266. Chicago University Press, Chicago.

Rambaut A & **Drummond AJ** (2007): Tracer: MCMC trace analysis tool, version 1.5. http://tree.bio.ed.ac.uk/sofware/tracer/.

Ronquist F & **Huelsenbeck JP** (2003): MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19, 1572-1574.

Roos C, **Vu Ngoc Thanh**, **Walter L** & **Nadler T** (2007): Molecular systematics of Indochinese primates. Vietnamese J. Primatol. 1(1), 41-53.

Roos C, **Nadler T** & **Walter L** (2008): Mitochondrial phylogeny, taxonomy and biogeography of the silvered langur species group (*Trachypithecus cristatus*). Mol. Phylogenet. Evol. 47, 629-636.

Sambrook J, **Fritsch EF** & **Maniatis T** (1989): Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor.

Tan, **SHD**, **Ali F**, **Kutty AN** & **Meier R** (2008): The need for specifying species concepts: How many species of silvered langurs (*Trachypithecus cristatus* group) should be recognized? Molecular Phylogenetics and Evolution 49, 688-689.

Timmins RJ, **Steinmetz R**, **Poulsen MK**, **Evans TD**, **Duckworth JW** & **Boonratana R** (2011): The Indochinese silvered leaf monkey *Trachypithecus germaini* (*sensu lato*) in Lao PDR. Primate Conserv. 26, 1-12.

Zinner D, **Fickenscher G**, **Anandam M**, **Bennett EL**, **Davenport TRB**, **Davies N**, **Detwiler KM**, **Engelhardt A**, **Eudey AA**, **Gadsby EL**, **Groves CP**, **Healy A**, **Karanth KP**, **Molur S**, **Nadler T**, **Richardson M**, **Riley EP**, **Rylands AB**, **Ting N**, **Sheeran LK**, **Wallis J**, **Waters SS**, **Whittaker D** & **Roos C** (in press): Old World monkeys (Cercopithecidae). In: Mittermeier RA & Wilson DE (eds.): Handbook of the mammals of the world. Vol. 3. Primates. Lynx Edicions, Barcelona.

A comparative study of activity budgets in captive and semi-free ranging Hatinh and Delacour's langurs (*Trachypithecus hatinhensis* and *T. delacouri*)

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Key words: Delacour's langur, Hatinh langur, *Trachypithecus delacouri*, *Trachypithecus hatinhensis*, activity budget

Summary

Captive reintroductions have become a popular tool for increasing viable populations of endangered primates. Comparisons of primate behavior in captive and wild settings provide critical insight to improve the success of reintroduction efforts. To better understand how captive vs. wild settings influence time budgets of Delacour's langurs and Hatinh langurs (*Trachypithecus delacouri* and *T. hatinhensis*), a study was conducted at the Endangered Primate Rescue Center in Cuc Phuong National Park, Vietnam. Study objectives included exploring differences in time budgets between the two study species and understanding influences of housing conditions on time budgets of caged vs. semi-wild groups. During the observation period (July 3rd-August 31st, 2011), each group was observed on rotating days using scan sampling at three-minute intervals. Results indicate that dominant behaviours include resting and feeding in all species-enclosure combinations. Yet significant changes in time budgets were observed for each species between the enclosure types, with particularly marked differences among age/sex classes. Juveniles and infants of both sexes typically engaged in play behaviour more than did adults in all settings.

So sánh quỹ thời gian hoạt động của loài vọoc Hà Tĩnh và vọoc mông trắng (*Trachypithecus hatinhensis* và *T. delacouri*) trong điều kiện nuôi nhốt và bán hoang dã

Tóm tắt

Giải pháp tái hòa nhập các cá thể được sinh sản trong điều kiện nuôi nhốt về môi trường tự nhiên nhằm tăng viện số lượng quần thể trở nên phổ biến đối với các loài linh trưởng nguy cấp. Những nghiên cứu nhằm so sánh tập tính giữa các cá thể nuôi nhốt và ngoài tự nhiên rất cần thiết để hoạt động tái hòa nhập thành công. Nghiên cứu về sự ảnh hưởng của điều kiện sống lên quỹ thời gian hoạt động của hai loài vọoc Hà Tĩnh và vọoc mông trắng được tiến hành tại Trung tâm Cứu hộ Linh trưởng Nguy cấp, Vườn Quốc gia Cúc Phương, Việt Nam. Những mục tiêu của nghiên cứu bao gồm việc tìm hiểu sự khác nhau về quỹ thời gian hoạt động của hai loài linh trưởng này cũng như sự ảnh hưởng của điều kiện chuồng trại lên quỹ thời gian hoạt động của mỗi loài. Thời gian nghiên cứu tiến hành từ ngày 3 tháng 7 năm 2011 đến ngày 31 tháng 8 năm 2011. Phương pháp quan sát scan-sampling với khoảng cách đều là 3 phút. Kết quả cho thấy tập tính nghỉ ngơi và ăn chiếm phần lớn quỹ thời gian hoạt động ở cả hai loài và điều kiện sống khác nhau. Có sự thay đổi đáng kể về quỹ thời gian hoạt động giữa hai loài và điều kiện sống. Đặc biệt có sự sai khác về quỹ thời gian hoạt động của các cá thể có độ tuổi và giới tính khác nhau. Cá thể bán trưởng thành và con non ở cả hai giới tính đều có nhiều thời gian dành cho tập tính chơi đùa hơn những cá thể trưởng thành.

Introduction

Captive reintroductions reflect a strategy to increase viable populations of endangered species in the wild (e.g. Baker, 2002). Captive propagation of primates is one way of increasing the number of individuals in species suffering low population numbers due to hunting pressures and/or habitat fragmentation generated by anthropogenic activities and environmental change. But reintroduction efforts require more than pools of captive-bred individuals ready for release into the wild. Success in these endeavours requires understanding of how reintroduced species utilize natural environments, affording thoughtful consideration of the habitat characteristics required for their survival (Stoinski et al., 2002; Keith-Lucas et al., 1999; Baker, 2002). In this way, conservation of flagship species can be leveraged to conserve complex natural environments that are important for biodiversity conservation more generally.

The "limestone langurs" (several species of the genus *Trachypithecus*) (Groves, 2007) are examples of flagship primates that promise to play a pivotal role in preserving the future of biodiversity hotspots within Vietnam. They naturally inhabit dense forests situated on steep limestone karst formations (Vogt et al., 2008). These biodiversity-rich habitats contain thousands of species of flora and fauna that are greatly threatened by rapid human-induced environmental change (Nadler, 2008). Although interest has grown in the diet and locomotor behaviour of limestone langurs in recent years (e.g., Workman & Covert, 2005; Stevens et al., 2008; Workman, 2010), relatively little information has been published to date on activity budgets for many *Trachypithecus* species in the wild. This paucity of data limits our understanding of how such primates adapt to their surroundings in and out of captivity, hampering reintroduction efforts. In particular the Delacour's langur is both critically endangered and endemic to Vietnam, so conservation efforts aimed at elevating this species as a symbol of national pride may be particularly fruitful in the long term survival of karst forest ecosystems throughout the region.

Material and Methods

Study setting and subjects

Established in 1993, the Endangered Primate Rescue Center (EPRC) is located within Cuc Phuong National Park, Vietnam, and strives to augment dwindling numbers of Vietnamese primate species in the wild through its internationally recognized captive breeding program (Nadler, 2008). The EPRC works vigorously to care for the influx of primates confiscated from markets and from the illegal pet trade throughout the country. Moreover, the EPRC has become a model for captive breeding of some of the world's most endangered primates including Delacour's and Hatinh langurs (Nadler, 2007). The EPRC's success in breeding these rare primates in captivity makes it a leader in primate reintroduction projects.

In particular, Delacour's and Hatinh langurs are ideal priorities for addressing how captive-bred animals respond to reintroduction into natural habitats. Both langurs are represented at the EPRC and have bred successfully in captivity. Moreover, both are currently housed in both semi-natural and caged enclosures, and individuals residing in the semi-natural setting are soon slated for reintroduction into the wild. Importantly, these congeners inhabit similar conditions in the wild, making them interesting candidates for exploring time budget patterns among closely related animals. Finally, both species are endemic or near endemic to Vietnam and have been listed as either endangered (Hatinh langur) or critically endangered (Delacour's langur), hence information about their biology is a priority for informing the conservation effort. This study is the first to compare activity budgets of these two species in captive and semi-wild enclosures at the EPRC.

Specific aims

Our first goal is to explore whether and how the time budgets of two limestone langur species differ, using comparisons made between Hatinh and Delacour's langurs in both the caged and semi-wild settings at the EPRC. No extensive time budget studies have to date been published on Delacour's langurs in their natural habitat, and little is known about activity budgets in the Hatinh langur. The species are similar in body size and proportions, are closely related, and live in limestone karst forested habitat, relying heavily on leaves as their main food source (Nadler et al., 2003; Nadler et al., 2007; Workman, 2010). Hence appreciable differences would not be expected in the time budgets of the two study species housed in similar enclosure types. Both study species are highly folivorous, so as for other folivores, activity budgets are expected to emphasize resting in order to digest the cellulose and toxins present in the leaves (Nadler et al., 2003; Zhaoyuan Li & Rogers, 2004; Chengming Huang et al., 2003; Matsuda et al., 2009;).

The second study goal is to examine how time budgets differ for each study species in the caged vs. semi-wild housing conditions. Greater variety of locomotor substrates and higher habitat heterogeneity has both been shown to alter primate time budgets (Zhaoyuan Li & Rogers, 2004; Jaman & Huffman, 2008). In the present study, langurs occupying the semi-wild enclosures have access to a larger habitat area, providing a richer environment than do smaller and more uniform cages. Accordingly animals occupying semi-wild enclosures are expected to allocate more time foraging/feeding, more time traveling, and less time engaging in social activities (Jaman & Huffman, 2008).

Study site

This study was conducted in the Endangered Primate Rescue Center. The two caged enclosures used for this study share the same dimensions (10.1m x 5.1m x 3.2m) and are labelled 6B and 10B. Cage 6B housed 4 Delacour's langurs (1 adult male, 1 adult female, 1 juvenile female and an infant male). Cage 10B housed 6 Hatinh langurs (1 adult male, 2 adult females, 2 juvenile males and 1 infant male). The two semi-wild enclosures (Hill 1 and Hill 2) comprise 2 ha and 5 ha respectively. The hills consist of fairly undisturbed karst limestone forest and are each enclosed by a solar powered electric fence. During the study period, Hill 1 housed two muntjacs (*Muntiacus muntjak*), five Delacour's langurs (1 adult male, 2 adult females, 1 juvenile male and an infant female) and 1 female northern white-cheeked gibbon (*Nomascus leucogenys*). Hill 2 housed 8 Hatinh langurs (2 adult males, 2 adult females, 2 juvenile males, 1 infant male and 1 infant female).

Data collection and analyses

Between July 3rd and August 31st, 2011 behavioural observations were conducted on study subjects housed in semi-wild and caged conditions (Table 1). Caged groups were selected to match group compositions available in the semi-wild enclosures. Observations of the animals

Table. 1. Behavioural category definitions.

Behaviour	Description
Feeding	Handling, processing or consuming plant material or insects.
Foraging	Manipulating plant material in search of favored food items, moving to another branch or bundle of leaves to feed or looking intently around for a certain leaf species before moving to gather it.
Moving	Changing position or location on bamboo poles, on the cage wires, on the ground or in the trees.
Resting	Inactivity, where the animal is sitting or lying down that is not associated with eating, foraging or social activity.
Social	Activity Interacting with another group member or species whether aggressively, allo-grooming or play. Mothers with infants riding ventrally were not considered to be in the realm of social activity, but the activity in which the mother was otherwise involved was the other activity. The infant was then categorized as “resting” or “feeding” appropriately.
Anti-Predator Behavior	Looking vigilant into the sky at large birds, on the ground for snakes and/or making alarm calls.
Playing	Acting in a playful manner with inanimate objects. Jumping, swinging, or bounding playfully from substrates or other group members without them being engaged.

alternated daily between caged and semi-wild enclosures, with each enclosure type observed for a total period of 12 days throughout the study period at the EPRC (Table 2). Animals of different age/sex classes can easily be discerned using perigenital coloration, body size, pelage colour and other features specific to the individual (specific characteristics/features provided by E. Schwierz). Adults were defined by having reached reproductive maturity: >age five in males and >age four in females (Nadler et al., 2003). Juveniles were defined as animals under the age of sexual maturity but not still dependent on their mothers for feeding. Infants were defined as animals still dependent on mothers for all or part of their dietary intake.

Observations began between 05:30 and 07:00 (depending on weather conditions) and ended at 18:00 each day. Scan sampling was conducted every 3 minutes (Altmann, 1974; Di Fore & Rodman, 2001). Animals housed in the semi-wild enclosures were not seen in every scan and therefore the total amount of data collected varied for those individuals. Total number of observations for cages 6B, 10B, Hill 2, and Hill 1 were 10021, 13984, 3362 and 2585 respectively. The following behaviours were recorded for each scan; feeding, foraging, moving, resting, social behaviour, play and anti-predator behaviours.

All observations were recorded in a water-resistant notebook. Each evening, data were transcribed into a spreadsheet (Microsoft Excel for Mac, version 12.3.2). A total of 29,952 individual activity observations were made. Each individual observation is treated as a separate data point when used in succeeding analyses in order to reduce the potential biases introduced by the scan sampling technique (Clutton-Brock, 1977). Time budgets were calculated as the percentage of all observations occupied by each of the seven behavioural categories (Ha Thang Long et. al, 2010). Pearson’s chi-squared test was used to assess interspecific patterns within a given habitat type, and intraspecific patterns for different habitat types.

Table. 2. Vital statistics of individual observed in the study. Animals born outside the center do not have exact birthdates, but age was approximated to the best of the center's ability. Names are given to the animals at the center as a way of record keeping and distinguishing them apart.

Name	Species	Cage number	Sex	Age class	Birth date
Tilo	*T. hatinhensis*	10B	Male	Adult	06.02.96
Heinrich	*T. hatinhensis*	10B	Male	Adult	20.10.06
2-74	*T. hatinhensis*	10B	Male	Infant	06.04.11
2-60	*T. hatinhensis*	10B	Male	Juvenile	01.04.09
Cuc	*T. hatinhensis*	10B	Female	Adult	07.01.01
Hanh	*T. hatinhensis*	10B	Female	Adult	04.04.02
Kurt	*T. hatinhensis*	Hill 2	Male	Adult	1995
2-75	*T. hatinhensis*	Hill 2	Male	Infant	??.05.11
2-59	*T. hatinhensis*	Hill 2	Male	Juvenile	29.12.08
2-56	*T. hatinhensis*	Hill 2	Male	Juvenile	??.09.07
2-62	*T. hatinhensis*	Hill 2	Male	Juvenile	??.05.09
Erna	*T. hatinhensis*	Hill 2	Female	Adult	1993
Minni	*T. hatinhensis*	Hill 2	Female	Adult	1994
2-76	*T. hatinhensis*	Hill 2	Female	Infant	??.05.11
Jonathan	*T. delacouri*	6B	Male	Adult	21.02.98
1-25	*T. delacouri*	6B	Male	Infant	20.03.11
Johanna	*T. delacouri*	6B	Female	Adult	09.07.03
Jojo	*T. delacouri*	6B	Female	Juvenile	29.07.08
Longtail	*T. delacouri*	Hill 1	Male	Adult	1990
Gil	*T. delacouri*	Hill 1	Male	Juvenile	08.01.08
Manu	*T. delacouri*	Hill 1	Female	Adult	28.07.96
Buschi	*T. delacouri*	Hill 1	Female	Adult	27.10.05
1-23	*T. delacouri*	Hill 1	Female	Infant	20.05.10

Results

Time budgets of all species-housing combinations are summarized (Table 3).

Table. 3. Summary of activity budgets for Hatinh and Delacour's langurs occupying caged and semi-wild enclosures.

	Cage 10B Hatinh langurs	Hill 2 Hatinh langurs	Cage 6B Delacour's langurs	Hill 1 Delacour's langurs
Resting	53.51%	56.96%	51.10%	44.80%
Feeding	31.94%	16.83%	34.54%	28.02%
Moving	5.63%	8.88%	7.21%	11.36%
Social	4.85%	6.85%	3.02%	13.49%
Playing	3.43%	10.04%	3.88%	1.70%
Foraging	0.54%	0.03%	0.56%	0.58%
Anti-predator	0.10%	0.42%	0.20%	0.04%

The interspecific time budgets of the langurs are compared for caged settings (Fig. 1) and semi-wild settings (Fig. 2). The intraspecific differences for langurs occupying different enclosure types are compared (Fig. 4).

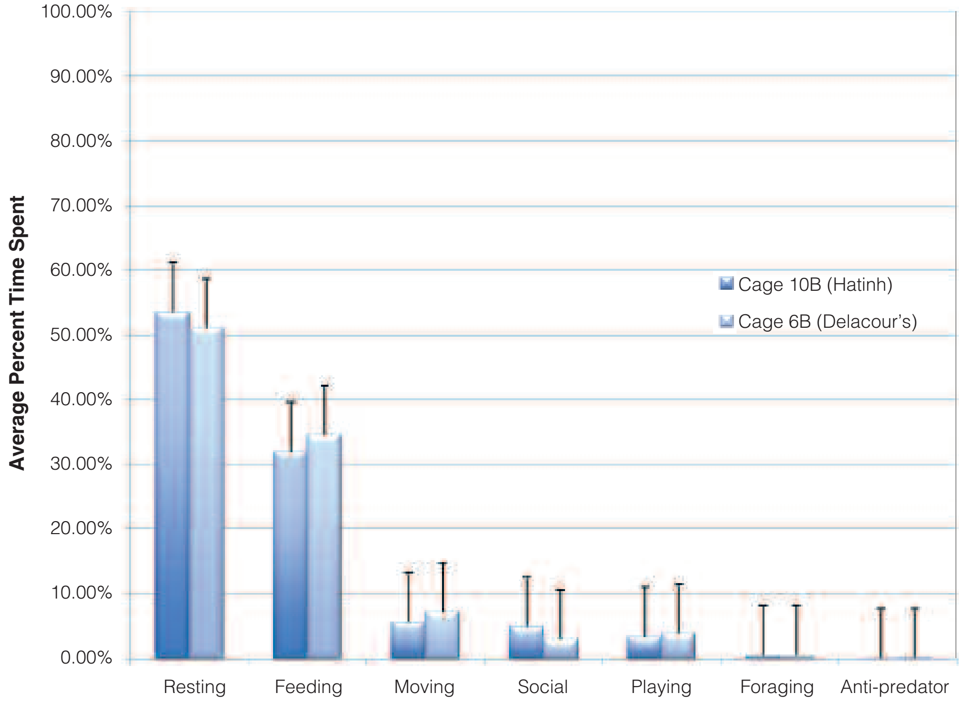

Fig.1. Bar graph depicting interspecific comparisons of time budgets of Hatinh and Delacour's langurs in caged environments.

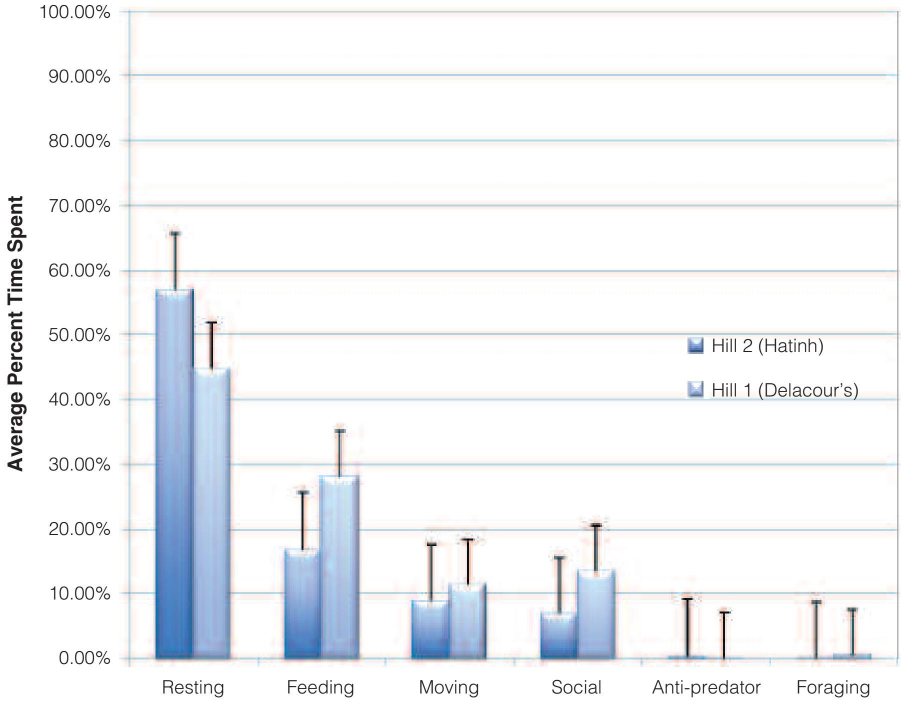

Fig.2. Bar graph showing interspecific comparisons of time budgets of Hatinh and Delacour's langurs in semi-wild environments.

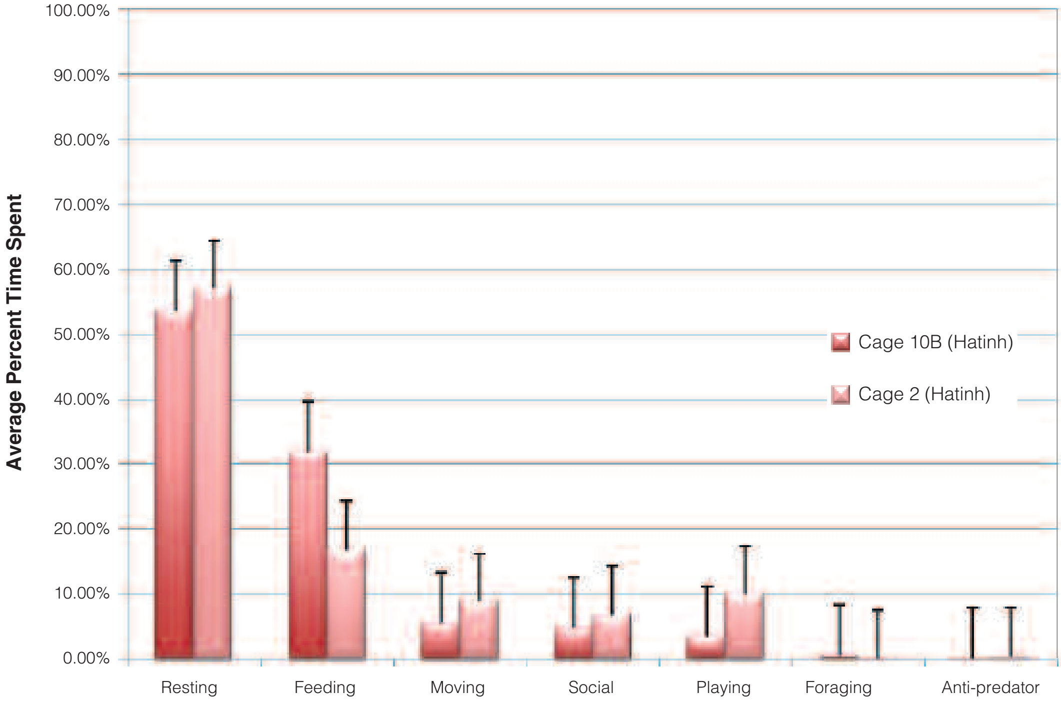

Fig.3. Bar graph depicting intraspecific comparisons of time budgets of Hatinh langurs occupying caged and semi-wild environments.

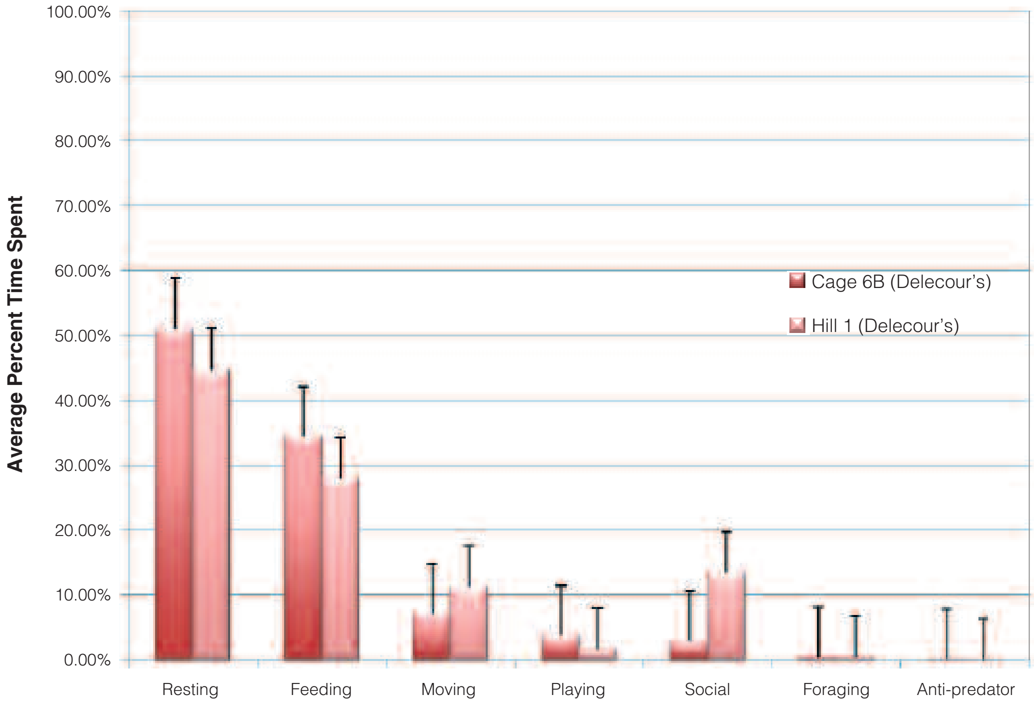

Fig.4. Bar graph depicting intraspecific comparisons of time budgets of Delacour's langurs occupying caged and semi-wild environments.

Interspecific comparisons in similar enclosure types

Chi-squared analyses of Delacour's and Hatinh langurs housed in caged settings were found to differ significantly in time spent feeding, moving, resting and engaging in social behavior ($p<0.05$ for each comparison). Study species in caged setting exhibited no significant differences in foraging, anti-predator and playing behaviors (Fig. 1).

Delacour's langurs and Hatinh langurs housed in semi-wild enclosures on Hill 1 and 2 exhibited significant differences in the following behaviours; feeding, foraging, resting, social, anti-predator and playing behaviours ($p<0.05$ for each comparison). Species did not differ in their time spent travelling (moving) in the semi-wild setting. Specific chi-squared and p-values for the comparisons between the two species in each enclosure type are summarized (Table 4).

Table. 4. Statistical results for interspecific comparisons in cages and semi-wild enclosures, and intraspecific comparisons for Hatinh and Delacour's langurs in both enclosure types.

Chi-squared values for time budget comparisons: Interspecific in the same enclosure types and itraspecific in different enclosure types

	Feeding		Foraging		Moving		Resting		Social		Anti-Predator		Playing	
Comparisons between	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value
Interspecific														
Cage 10B and Cage 6B	40.22	<0.001	0.67	0.41	3.90	<0.05	48.28	<0.001	120.95	<0.001	1.48	0.22	0.02	0.88
Hill 1 and Hill 2	20.11	<0.001	10.29	<0.001	0.04	0.84	185.06	<0.001	23.12	<0.001	11.27	<0.001	226.27	<0.001
Intraspecific														
Cage 10B and Hill 2	2580.22	<0.001	62.06	<0.001	127.42	<0.001	1975.47	<0.001	188.32	<0.001	0.04	0.85	23.71	<0.001
Cage 6B and Hill 1	1775.08	<0.001	26.80	<0.001	178.31	<0.001	2478.01	<0.001	3.54	<0.001	17.19	<0.001	267.22	<0.001

Intraspecific comparisons in different enclosure types

Chi square analyses of Hatinh langur time budgets in different enclosure types (Cage 10B and Hill2) revealed significant differences in the amount of time spent feeding, foraging, moving, resting, and engaging in social and playing behaviours ($p<0.05$ for each comparison). No significant differences were observed in anti-predator behaviour (Fig. 3).

Similar comparisons among Delacour's langurs housed in different enclosure types (Cage 6B and Hill 1) revealed significant differences in the amount of time spent feeding, foraging, moving, resting, and engaging in anti-predator and playing behaviours ($p<0.05$ for each comparison). Differences in time spent engaging in social behaviors did not reach significance (Fig. 4).

Discussion

Time budget comparisons to other langur species

Delacour's and Hatinh langurs in this study spent most of their time resting (44.80% - 56.96%) and feeding (16.83% - 34.54%) in both caged and semi-wild environments. A similarly large percentage of time spent resting has also been observed in many other species of langurs (grey-shanked douc langur *Pygathrix cinerea*: Ha Thang Long et. al, 2010; Francois' langur *Trachypithecus francoisi*: Qihai Zhou et. al, 2007; white-headed langur *Trachypithecus leucocephalus*: Chengminh Huang et. al, 2003; Zhaoyuan Li & Rogers, 2004; Cat Ba langur *Trachypithecus poliocephalus*: Schneider et. al, 2010). This emphasis on time allocated to resting is likely related to their folivorous diets. Longer resting periods allow for microbial digestion to break down the cellulose in plant cell walls (Oates & Davies, 1994; Nadler et. al, 2003). The process by which these monkeys digest leafy material is somewhat similar to that of a ruminant animal (Oates & Davies, 1994). Many of the microbes found in the rumen of artiodactyls are also found in the saccus gastricus of langurs in the genus *Trachypithecus* (Oates & Davies, 1994).

Importantly, in addition to the large amount of time spent resting and digesting, a high proportion of time was also allocated to feeding. Likely more initial processing of plant matter is conducted orally because *Trachypithecus* species do not possess a presaccus like that of colobines in the genera *Procolobus*, *Rhinopithecus*, *Pygathrix* and *Nasalis* (Oates & Davies, 1994). Indeed, they have been observed to masticate longer than those species possessing a presaccus and they may depend even more heavily upon enzymes produced by their large salivary glands to facilitate the breakdown of cell walls in their food (Wright et. al, 2008). *Trachypithecus* also exhibit deeper mandibular corpora than *Pygathrix*, perhaps related to longer chewing durations exhibited by *Trachypithecus* (Wright et. al, 2008). Since the behavioural category 'feeding' included mastication of foodstuffs, a large amount of time (16.83% - 34.54% of total time budget) was allocated to feeding in both species regardless of enclosure type. The necessary time required to both orally process and digest the leafy material reduces the remaining activity budget for participation in other behaviours (e.g., playing, social interactions, moving). A more complex digestive system, deeper mandibular corpora, high cusped bilophodont dentition and enlarged salivary glands likely serve as specializations for feeding on hard-to-digest plant materials, underscoring limestone langur uniqueness relative to feeding generalists in the Order Primates.

Interspecific comparisons in similar enclosure types

Since the *Trachypithecus* species examined herein are close in body size, and they inhabit similar habitats in the wild, it was hypothesized that they would not exhibit significantly different time budgets in a given enclosure type. Interestingly Hatinh and Delacour's langurs exhibited significant differences in time spent feeding, moving, resting and engaging in social interactions within the caged setting ($p < 0.05$ for each). The null hypothesis was also rejected for the two species inhabiting semi-wild enclosures in amount of time spent feeding, foraging, resting and engaging in social interactions and anti-predator behaviours ($p < 0.05$ for each). Hatinh langurs generally rested more of the time, and fed less than did Delacour's langurs (Fig. 1 and 2).

Differences documented between caged Hatinh and Delacour's langurs in this study may reflect true differences in the activity patterns of these species. Alternatively, the pattern might be attributed to differences in sampling intensity in different weather conditions during the study period. Observations of both species in semi-wild enclosures were also complicated by visibility and navigating high-relief karst terrain made slippery by rain, providing considerable challenges for obtaining the full 10-hour observation period each day. Animals were more easily visible was when they were feeding; hence observational data may reflect such practical limitations. Presumably such limitations might influence similar studies of limestone langurs. Nonetheless, the present study is valuable in the context of how little is known of the activity budgets of these closely related species, and these observed differences can serve as a baseline and contribute to hypotheses to be tested in future studies.

Intraspecific comparisons in different enclosure types

Cages at the EPRC differ in food placement and substrate availability from the nearby semi-wild living environments, hence it was hypothesized that there would be a significant difference in the behaviour of each langur species between the two housing environments. Because of increased opportunities to seek out preferred food items, langurs in semi-wild areas were expected to allocate more time to foraging, feeding and moving. Hatinh langurs in this study exhibited significant differences in six of the seven behaviours recorded (feeding, foraging, moving, resting, social and playing) when housed in different enclosures.

Surprisingly, observed differences were often in the opposite direction from expectations, with the Hatinh langurs in semi-wild conditions spending significantly less time foraging and feeding, but rather spending significantly more time resting, and engaging in play and other social behaviours ($p < 0.05$ for each). Hatinh langurs did, however, spend more time moving when housed in semi-wild conditions on Hill 2, following expectations that animals would travel more outside of the cages given opportunities to utilize the higher level of habitat heterogeneity.

Delacour's langurs housed in caged and semi-wild conditions also exhibited appreciable differences in their time budgets. Six of the seven recorded behaviours significantly differed by enclosure type. As for Hatinh langurs, and contra our predictions, significantly more time was spent feeding in the caged setting. Resting, and playing behaviours followed expectations and were significantly higher in the caged setting, whereas foraging, moving and anti-predator behaviours were higher in the semi-wild setting ($p < 0.05$ for all).

In general, animals in this study spent more of their time moving about semi-wild enclosures and more time feeding in the cages. Increased habitat size and heterogeneity in the semi-wild setting likely accounts for movement differences, with higher distances among food sources requiring greater time spent in travel. A greater amount of time spent socializing in semi-wild enclosures is most likely attributable to a greater number of juveniles and infants playing with one another in the semi-wild enclosures. For example, Hatinh langurs on Hill 2 and Delacour's langurs on Hill 1 showed a significant increase in play behaviour from those Hatinh langurs housed in Cage 10B and Delacour's langurs housed in Cage 6B ($p<0.05$). This group had more juvenile/infants than did the Hatinh group housed in Cage 10B. Moreover, animals chasing one another around the forest were considered to be engaging in "social behaviour" and animals took advantage of the different substrates available to them during their games of "chase". The larger areas for movement also allowed for longer periods of chasing from one tree to the next or from karst to karst, and indeed habitat heterogeneity has been observed to significantly alter time budgets in primates (Zhaoyuan Li & Rogers, 2004; Jaman & Huffman, 2008).

Conservation implications

Future propagation of the limestone langur group in Vietnam, and indeed throughout South-east Asia, may increasingly rely upon small rescue/conservation centres like the Endangered Primate Rescue Center (EPRC). Small remaining population size for many species in the wild renders each individual critical for the population's variability, such that further losses could be detrimental to the survival of the species as a whole. The EPRC has assumed a vital role in protecting Vietnam's biodiversity by providing a venue for expanding scientific understanding of primate biology and life history traits, and through efforts to protect wild populations and intercede in the illegal animal trade. Importantly, the EPRC has excelled not only in rescuing individuals of critically endangered species; it has also showed unparalleled success in captive breeding of these delicate animals. The next step for the conservation effort is to capitalize on this success via reintroductions of captive-bred animals back into suitable natural environments.

This observational study was conducted to help increase understanding of how time budgets vary in limestone langurs as a function of living conditions, and to develop baseline data that can inform soft-release techniques for captive reintroduction efforts. The IUCN recommends that animals housed in captivity first be transitioned into a semi-wild enclosure before release into a natural habitat. Significant activity budget differences in Hatinh and Delacour's langurs occupying caged and semi-wild settings suggests behavioural plasticity among the limestone langurs and supports the IUCN recommendation of soft-release to allow the animals time to adapt to larger ranges and different foraging requirements/opportunities. Practical considerations that also influence reintroduction efforts include budget, personnel time and space constraints.

Situation of the EPRC within the Cuc Phuong National Park offers advantages for future release endeavours. Coordination of efforts between the two entities may provide valuable opportunities to engage in and monitor captive releases with intensified protection efforts in place. A strong reintroduction project that increases primate density within the park is likely to bring an influx of revenue from visitors interested in flagship langur species. Managed well, an increase in park profits can further enhance protection efforts and contribute to the additional captive release efforts for these and other species.

Conclusions

This study, designed in collaboration with the EPRC's ongoing conservation, captive breeding and reintroduction efforts, provides important baseline behavioural data used to help understand habitat requirements for preserving biodiversity important to Vietnam's future. The nation's high number of critically endangered primates, as noted the IUCN's 25 Most Endangered List (Mittermeier et al., 2012), has focused international attention on limestone langur species on the brink of extinction. Future conservation initiatives will be augmented by intensified environmental education and recommendations for development of additional parks and protected areas.

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References

Altmann J (1974): Observational study of behavior: Sampling methods. Behaviour 48, 227-265.

Baker LR (ed.) (2002): Guidelines for Nonhuman Primate Re-introductions. Re-introduction News 21, 29-57.

Chengming Huang, **Fuwen Wei**, **Ming Li**, **Youbang Li** & **Ruyong Sun** (2003): Sleeping Cave Selection, Activity Pattern and Time Budget of White-headed Langurs. Int. J. Primatol. 24, 813-824.

Clutton-Brock TH (1977): Appendix 1: methodology and measurement. In: Clutton-Brock TH (ed.): Primate ecology: Studies of feeding and ranging behaviour in lemurs, monkeys, and apes; pp. 585-590. Academic Press, London.

Di Fiore A & **Rodman PS** (2001): Time Allocation Patterns of Lowland Woolly Monkeys (*Lagothrix lagotricha poeppigii*) in a Neotropical Terra Firma Forest. Int. J. Primatol. 22, 449-480.

Groves C (2007): Speciation and biogeography of Vietnam's primates. Vietnamese J. Primatol. 1(1), 27-40.

Ha Thang Long, **Nguyen Thi Tinh**, **Tran Huu Vy** & **Ho Tien Minh** (2010): Activity budget of grey-shanked douc langurs (*Pygathrix cinerea*) in Kon Ka Kinh National Park, Vietnam. Vietnamese J. Primatol. 1(4), 27-39.

Jaman MF & **Huffman MA** (2008): Enclosure Environment Affects the Activity Budgets of Captive Japanese Macaques (*Macaca fuscata*). Am. J. Primatol. 70, 1133-1144.

Keith-Lucas T, **White F**, **Keith-Lucas L** & **Vick L** (1999): Changes in Behavior in Free-Ranging *Lemur catta* Following Release in Natural Habitat. Am. J. Primatol. 47, 15-28.

Matsuda I, **Tuuga A** & **Higashi S** (2009): The Feeding Ecology and Activity Budget of Proboscis Monkeys. Am. J. Primatol. 71, 478-492.

Mittermeier RA, **Rylands AB**, **Schwitzer C**, **Taylor LA**, **Chiozza F** & **Williamson EA** (eds.) (2012): Primates in Peril: The World's 25 Most Endangered Primates 2010–2012. IUCN/SSC Primate Specialist Group, International Primatological Society and Conservation International, Arlington.

Nadler T (2007): Endangered Primate Rescue Center, Vietnam – Report 2004 to 2006. Vietnamese J. Primatol. 1(1), 89-103.

Nadler T (2008): Frankfurt Zoological Society: "Vietnam Primate Conservation Program" and the Endangered Primate Rescue Center, Vietnam – Report 2007. Vietnamese J. Primatol. 1(2), 81-90.

Nadler T, **Momberg F**, **Nguyen Xuan Dang** & **Lormee N** (2003): Vietnam Primate Conservation Status Review 2002: Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler T, **Vu Ngoc Thanh** & **Streicher U** (2007): Conservation Status of Vietnamese Primates. Vietnamese J. Primatol. 1(1), 7-26.

Oates JF & **Davies AG** (eds.) (1994): Colobine Monkeys: their ecology, behaviour and evolution. Cambridge University Press, Cambridge.

O'Brien TG & **Kinnaird MG** (1997): Behavior, Diet, and Movements of the Sulawesi Crested Black Macaque (*Macaca nigra*). Int. J. Primatol. 18, 321-351.

Qihai Zhou, **Fuwen Wei**, **Chengming Huang**, **Ming Li**, **Ren B** & **Luo B** (2007): Seasonal Variation in the Activity Patterns and Time Budgets of *Trachypithecus francoisi* in the Nongang Nature Reserve, China. Int. J. Primatol. 28, 657-671.

Schneider I, **Tielen IHM**, **Rode J**, **Levelink P** & **Schrudde D** (2010): Behavioral Observations and Notes on the Vertical Rangimg Pattern of the Critically Endangered Cat Ba Langur (*Trachypithecus poliocephalus poliocephalus*) in Vietnam. Primate Conservation 25, 111-117.

Stevens NJ, **Wright KA**, **Covert HH** & **Nadler T** (2008): Tail postures of four quadrupedal leaf monkeys (*Pygathrix nemaeus*, *P. cinerea*, *Trachypithecus delacouri* and *T. hatinhensis*) at the Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam. Vietnamese J. Primatol. 1(2), 13-24.

Stoinksi TS, **Beck BB**, **Bloomsith MA** & **Maple TL** (2002): A behavioral comparison of captive born, re-introduced golden lion tamarins and their wild-born offspring.Behavior 140, 137-160.

Vogt M, **Forster B** & **Riedel J** (2008): Radio tracking of Hatinh langurs (*Trachypithecus laotum hatinhensis*) at a semi-wild enclosure in Phong Nha-Ke Bang National Park, Central Vietnam. Vietnamese J. Primatol. 1(2), 3-12.

Workman C & **Covert HH** (2005): Learning the ropes: the ontogeny of locomotion in red-shanked douc (*Pygathrix nemaeus*), Delacour's (*Trachypithecus delacouri*), and Hatinh langurs (*Trachypithecus laotum hatinhensis*). Am. J. Physical Anthropology 128, 371-380.

Workman C (2010): Diet of the Delacour's langur (Trachypithecus delacouri) in Van Long Nature Reserve, Vietnam. Am. J. Primatol. 72, 317-324.

Wright BW, **Prodhan R**, **Wright K** & **Nadler T** (2008): Mandibular morphology as it relates to ingestive and digestive folivory in *Trachypithecus* and *Pygathrix*. Vietnamese Journal of Primatology 1(2), 25-32.

Zhaoyuan Li & **Rogers E** (2004): Habitat quality and activity budget of white-headed langurs in Fusui, China. Int. J. Primatol. 25, 41-54.

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Reintroduction of the 'Critically Endangered' Delacour's langur (*Trachypithecus delacouri*) – a preliminary report

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Key words: Delacour's langur, *Trachypithecus delacouri*, reintroduction

Summary

In August 2011 the first Delacour's langurs (*Trachypithecus delacouri*) were introduced into Van Long Nature Reserve. This has been the first planned and monitored release of any leaf-eating langur. Prior to reintroduction several studies were carried out on the ecology, behavior, nutrition of the species, population genetics and on habitat conditions and carrying capacity of the area.

Van Long Nature Reserve is divided into four more or less isolated parts. One smaller part of the nature reserve harbors the world's largest population of this species. This population increased through the elimination of poaching and human activities and is currently the only population with long-term viability. Several isolated populations outside Van Long Nature Reserve have been exterminated during the last decade or decreased dramatically due to poaching.

To connect the largest Delacour's langur population in the smaller part of the nature reserve with a relic population in the largest part of the nature reserve is the goal of the reintroduction. A larger population in this part would increase the possibility of an exchange of individuals supporting the panmixia and the genetic stability of the nature reserve's whole population.

Báo cáo ban đầu về việc tái hòa nhập về môi trường tự nhiên loài linh trưởng cực kỳ nguy cấp, vọoc mông trắng (*Trachypithecus delacouri*)

Tóm tắt

Tháng 8 năm 2011, những cá thể đầu tiên loài vọoc mông trắng đã được tái thả về Khu Bảo tồn thiên nhiên đất ngập nước Vân Long. Đây là dự án thả vào tự nhiên đầu tiên và có giám sát sau khi thả đối với các loài khỉ ăn lá. Trước khi thả vào môi trường tự nhiên, những nghiên cứu về sinh thái, tập tính và đặc điểm dinh dưỡng của loài cũng như nghiên cứu về di truyền học quần thể, đặc điểm hệ sinh thái và khả năng cung cấp thức ăn của khu vực tái thả đã được nghiên cứu. Khu Bảo tồn thiên nhiên đất ngập nước Vân Long được chia làm 4 phần tách biệt. Một phần nhỏ trong khu bảo tồn là nơi sinh sống của quần thể vọoc mông trắng lớn nhất thế giới. Quần thể này đang tăng trưởng về số lượng bởi các hoạt động săn bắt và tác động khác đã bị loại trừ. Quần thể này dường như là duy nhất có thể tồn tại lâu dài. Các quần thể khác ngoài Khu Bảo tồn thiên nhiên đất ngập nước Vân Long đã bị tiêu diệt hoàn toàn hoặc suy giảm nhanh chóng do hoạt động săn bắt. Mục tiêu của việc tái hòa nhập những cá thể vọoc mông trắng là nhằm tạo sự kết nối giữa quần thể lớn nhất ở Vân Long với các quần thể nhỏ hơn trong một vùng sinh thái rộng lớn. Việc kết nối thành công sẽ làm tăng tính bền vững của nguồn gen của toàn bộ quần thể lớn trong vùng.

Introduction

The Delacour's langur (*Trachypithecus delacouri*) is one of the 'Top 25 Most Endangered Primates in the World' (Mittermeier et al., 2012) and is also considered as a 'Critically Endangered' species (IUCN 2012). The langur is endemic to Vietnam and only occurs in a restricted area in a number of isolated sub-populations in the north of the country (Ebenau et al., 2011; Nadler et al., 2003, Nadler, 2004; 2010a). The species is threatened by intense hunting pressures, agricultural encroachment, and limestone quarrying for cement production. The total number is unlikely to exceed 200 individuals (Nadler, 2010b). Van Long Nature Reserve is thought to contain the largest remaining population of Delacour's langurs (Nadler, 2010a) and this is most probably the only population with long-term viability.

In 1993 the population in Van Long was discovered during extensive surveys by Frankfurt Zoological Society (FZS) to investigate the distribution and status of the species. In 2001 the area was declared a nature reserve and FZS intensified the support for protection through a close cooperation with the Management Board. A community based patrol group was established, trained and the wages are covered by FZS. The group was enlarged over the years from 20 members in 2001 to 28 members in 2011. Five ranger stations were constructed around the nature reserve to facilitate the access of the community patrol groups to the nature reserve. An important activity since the beginning of the protection efforts has been the involvement of local authorities, village leaders, village police, and local groups, like women's club, youth organization, farmers union with regular meetings at the nature reserve head quarters to inform about laws and regulations, to discuss protection activities, violations, and to raise awareness about the unique value of the area.

The monitoring of the largest subpopulations of the species outside Van Long Nature Reserve shows a dramatic decline over the last decade (Le Van Dung & Nadler 2010; Nadler 2010b). Only in Van Long Nature Reserve has the Delacour's langur population increased as a result of a complete elimination of hunting and influence of human activities in the core area of the population.

The elimination of poaching and human activities in the area resulted in the langurs becoming less fearful of human presence. It is easy to observe the langurs by boat from a close distance.

Background for the reintroduction project

Legitimacy

The Delacour's langur (*Trachypithecus delacouri*) as an endemic and critically endangered species occurs in a very restricted distribution area in northern Vietnam. Reintroduction of this species is recommended in the Biodiversity Action Plan of Vietnam (Government of the Socialist Republic of Vietnam & Global Environment Facility Project, 1994). The reintroduction of the Delacour's langur into Van Long Nature Reserve is approved by the Management Board of the nature reserve, the Provincial Forest Protection Authority and the Ministry of Agriculture and Rural Development.

The reintroduction follows the Guidelines for Reintroduction of Non-human Primates (Baker, 2002), and is the first reintroduction of any leaf-eating langur species which follows these guidelines with long-term planning and monitoring.

Locality for reintroduction

The result of protection activities in Van Long Nature Reserve, with the involvement of the local communes lead to the decision about reintroduction in this area. Over the time span of ten years the population in the core area, the eastern part of the nature reserve, more than doubled from about 50 individuals to more than 100 individuals (Nadler et al., 2003; Ebenau, 2011). But this core population of the species exists in the smallest part of the reserve and the reintroduction should stabilize the population in the whole nature reserve as probably the only one with long-term viability.

Animals for reintroduction

In 1993 the Endangered Primate Rescue Center was established in Cuc Phuong National Park and started breeding programs for highly endangered species. With five Delacour's langurs confiscated from the illegal wildlife trade 20 Delacour's langurs were born between 1996 and 2011 at the center and 16 reached maturity

Implementation of the reintroduction

Studies of the species

Prior to the final decision for Van Long Nature Reserve as a reintroduction locality several studies were carried out on ecology, behavior and nutrition of the species and on habitat conditions and carrying capacity of the area (Klein, 1999; Nguyen Thuy Hue, 2010; Workman 2010a; 2010b). Additionaly a genetic study was carried out which includes also a number of larger subpopulations outside Van Long Nature Reserve (Ebenau, 2011; Ebenau et al., 2011).

Van Long Nature Reserve – the reintroduction site

Van Long Nature Reserve is comprised of four parts which are not completely isolated but which have barriers for primates inhibiting easy contact between the subpopulations and the exchange of individuals (Fig. 1). The two barriers between the three parts of the nature reserve are a small road and an 80 m long dam. The genetic study shows a limited contact between the three subpopulations (Ebenau, 2011; Ebenau et al., 2011). The largest population, with about 100 individuals, exists on the small eastern part of the reserve. The larger western part carries only a relic population of about 20 individuals. In the past this population was reduced due to high hunting pressure. The western part of the nature reserve was chosen as a reintroduction site to support this population for further contact with the core population on the eastern part. The total area of the nature reserve comprises currently about 3000 ha. To provide a larger area for a stable population an extension of the western part is planned with an additional area of about 4000 ha.

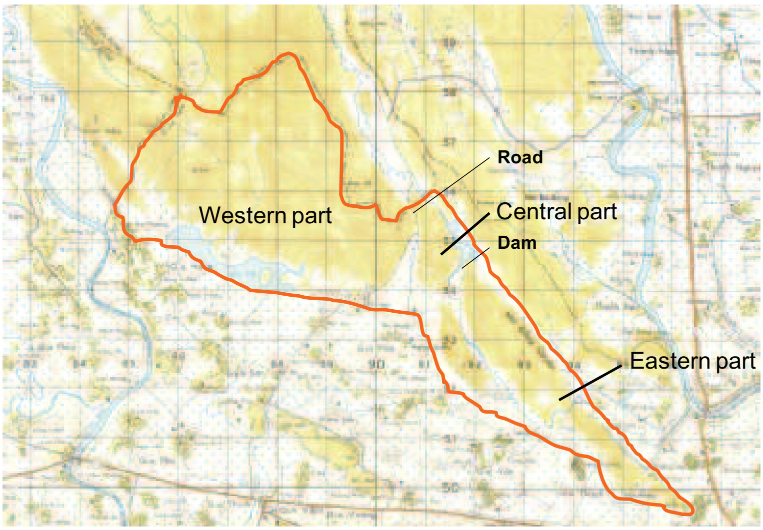

Fig.1. Map of Van Long Nature Reserve.

At the beginning of February 2011 a survey was started to locate the release site in the western part of the reserve. In total one and a half months were spent to checking potential release sites

Animals for reintroduction

A family group of three individuals has been chosen for the reintroduction. All animals are captive born, one male born in 2003, one female born in 1997, and their male offspring born in February 2001.

The animals were kept for three months in quarantine and adequate health screenings were carried out. All three individuals were equipped with GPS-radio collars from e-obs, Germany.

Transfer and release of the Delacour's langur

In Early August 2011, prior to transfer of the animals, a temporary cage was constructed at the release site to check the animals again after transportation from the Endangered Primate Rescue Center and to enable the visual contact of the animals with the new environment. The cage was constructed from 16 iron frames 1,0 x 2,5 m and covered with fishing net. The cage with a surface of 16 m^2 was furnished with a bamboo construction (Fig. 2). On August 20th the three animals were transported in separate boxes from the EPRC to the release site over a distance of about 35 km, first by car and then by hand up to the release site (Fig. 3). The animals were kept inside the cage two days/two nights and on 22nd August released into the nature reserve. Leader of province and district administrations attended the release (Fig. 4), and the release was broadcasted throughout the country by Vietnam TV (Fig. 5).

Fig.2. Temporary cage at the release site. The cage is constructed from 16 iron frames, covered with fishing net. Photo: Tilo Nadler.

Fig.3. Transport of the animals to the release site. Photo: Tilo Nadler.

Monitoring of the reintroduced Delacour's langur

The monitoring of the released animals was planned with data download of the coordinates from the GPS-radio collars over a period of one year, the time which were expected for the working period of the batteries. After this time observation of the individuals and the natural population should continue.

With the move of the animals into the cage, three observers stayed in tents close to the release site to observe the behaviour of the

Fig.4. Leader of province and district administrations attended the first release of Delacour's langur. Photo: Tilo Nadler.

Fig.5. The release of the Delacour's langur was Vietnam wide broadcasted by Vietnam TV. Photo: Tilo Nadler.

animals. The released animals were monitored daily and the coordinates of each individual also daily downloaded.

The downloaded coordinates allows information to be gathered about travel routes, home ranges, habitat use, activity rhythm and daily and seasonal differences, contact with groups of the wild population, reactions by human disturbance, and other behavioral activities (Fig. 6).

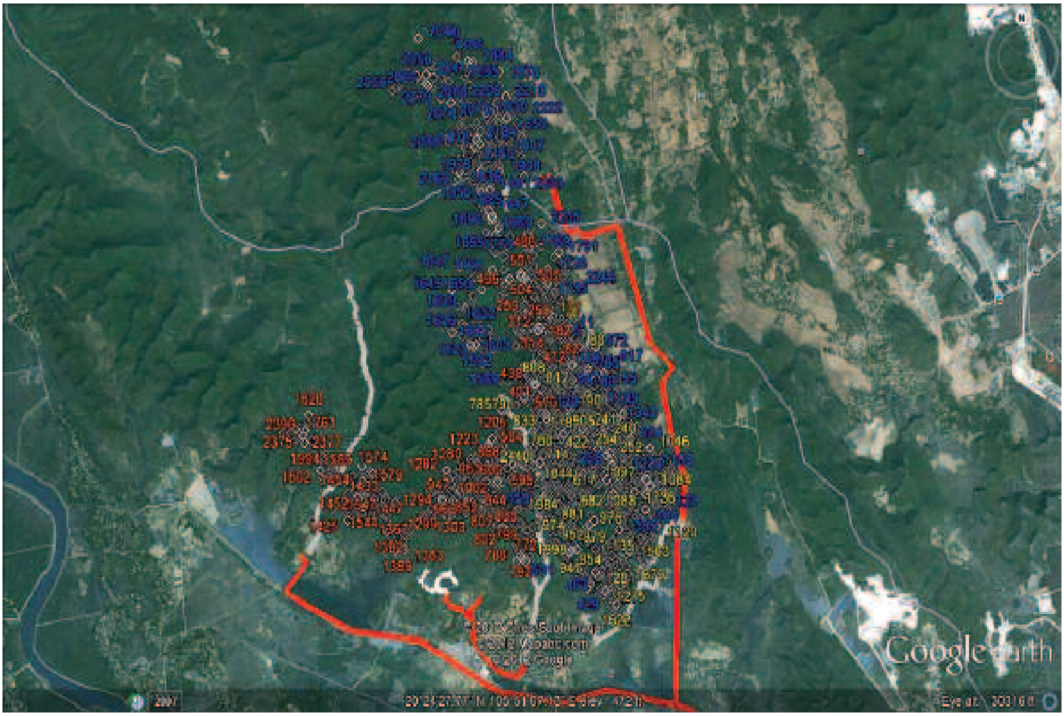

Fig.6. An example of downloaded coordinates of the three released individuals of Delacour's langur in Van Long Nature Reserve.

The release and monitoring of the released animals are the content of a PhD thesis of Fiona Agmen, student from the Australian National University, Canberra under supervision of Prof. Colin Groves. Parts of the release are also the content of a master thesis for the Vietnamese biologist Nguyen Hong Chung.

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The People's Committee and the Forest Protection Department of Ninh Binh Province supported the reintroduction with great engagement. Many thanks for the efforts to recognize the Delacour's langur as a flag ship species for the province.

References

Baker LR (ed.) (2002): Guidelines for Nonhuman Primate Re-introduction. Re-introduction News No. 21, 29-57.

Ebenau A (2011): Conservation genetics of the critically endangered Delacour's langur (*Trachypithecus delacouri*). Diploma thesis, German Primate Centre, Göttingen.

Ebenau A, **Nadler T**, **Zinner D** & **Roos C** (2011): Genetic population structure of the critically endangered Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. Vietnamese J. Primatol. Vol. 1 (5), 1-15.

Government of the Socialist Republic of Vietnam & **Global Environment Facility Project** (1994): Biodiversity Action Plan for Vietnam, Hanoi.

IUCN (2012): IUCN Red List of Threatened Species. www.iucnredlist.org. Downloaded on 5 September 2012.

Klein J (1999): Erste verhaltensbiologische Untersuchungen von Delacour- und Hatinhlanguren (*Trachypithecus delacouri* und *T. francoisi hatinhensis*) im Endangered Primate Rescue Center. Diploma thesis, Freie Universität Berlin.

Le Van Dung & **Nadler T** (2010): Status of several subpopulations of Delacour's langur (*Trachypithecus delacouri*). Frankfurt Zoological Society. (Unpubl.).

Mittermeier RA, **Rylands AB**, **Schwitzer C**, **Taylor LA**, **Chiozza F** & **Williamson EA (eds.)** (2012): Primates in Peril: The World's 25 Most Endangered Primates 2010–2012. IUCN/SSC Primate Specialist Group, International Primatological Society and Conservation International, Arlington.

Nadler T, **Momberg F**, **Nguyen Xuan Dang** & **Lormee N** (2003): Leaf monkeys: Vietnam primate conservation status review 2002. Part 2; p 69-88. Frankfurt Zoological Society and Flora & Fauna International, Hanoi.

Nadler T (2004): Distribution and status of the Delacour's langur (*Trachypithecus delacouri*) and recommendations for its long-term conservation. In Nadler T, Streicher U, Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 63-71. Frankfurt Zoological Society, Hanoi.

Nadler T (2010a): Status of Vietnamese Primates – Complements and Revisions. In Nadler T, Rawson BM, Van Ngoc Thinh (eds): Conservation of Primates in Indochina; pp. 6-7. Frankfurt Zoological Society and Conservation International, Hanoi.

Nadler T (2010b): Status of Delacour's langur (*Trachypithecus delacouri*) in some unprotected areas. Frankfurt Zoological Society. (Unpubl.).

Nguyen Thuy Hue (2010): Ecological study on Delacour's langur (*Trachypithecus delacouri*) on the semi-wild area at the Endangered Primate Rescue Center. Diploma thesis, National University Hanoi. (In Vietnamese).

Workman C (2010a): The Foraging Ecology of the Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. PhD thesis, Duke University.

Workman C (2010b): Diet of the Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. Am. J. Primatol. 72, 317-324.

Distribution of macaques (*Macaca* sp.) in central Vietnam and at the Central Highlands of Vietnam

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Key words: *Macaca*, macaques, distribution, sympatric areas, Central Highlands Vietnam.

Summary

From 2006 to 2010 the distribution and habitat conditions of macaques were surveyed in central Vietnam and at the Central Highlands in Vietnam. Rhesus macaques (*M. mulatta*) were found in mountainous areas from $12^0$6’ N to higher latitudes with low average frequency, in which higher frequencies were found from 15^0 N to $16^0$30’ N, and from 12^0 N to 13^0 N. Long-tailed macaques (*M. fascicularis*) were distributed from $16^0$30’ N to lower latitudes of almost southern Central Highland with rather high average frequency. These two species have a parapatric distribution but also areas where they are sympatric occur, from $15^0$12’ N to $16^0$24’ N, and from $12^0$6’ N to $13^0$24’ N. There are no records of Assamese macaques (*M. assamensis*) from central Vietnam and the Central Highlands. This species occurs from approximately $15^0$24’ N to higher latitude areas. Northern pig-tailed macaques (*M. leonina*) were recorded with the highest frequency of macaque species in the study area and occur in most areas in central Vietnam and the Central Highlands. They were considered to be sympatric with Assamese macaques in areas from approximately $15^0$24’ N to higher latitudes. Stump-tailed macaques (*M. arctoides*) were recorded throughout central Vietnam and the Central Highlands, excepting areas from approximately $11^0$30’ N to $12^0$24’ N. Through the economic development and the increase of human population all species have lost their habitats rapidly through logging, agricultural encroachment, conversion of forest into rubber and acacia plantations, construction of infrastructures, tourism development and hunting. Surveys on distribution and population density are urgently needed to take effective conservation measures of wildlife in central Vietnam and the Central Highlands.

Đặc điểm phân bố của các loài khỉ (*Macaca* sp.) ở khu vực Trung Trung Bộ và Tây Nguyên Việt Nam

Tóm tắt

Sự phân bố và điều kiện sống của các loài khỉ ở khu vực Trung Trung Bộ và Tây Nguyên Việt Nam đã được điều tra từ năm 2006 đến năm 2010. Loài khỉ vàng (*M. mulatta*) được báo cáo là phân bố ở các vùng nhiều núi bao gồm từ 12^0 Bắc đến các vĩ độ cao hơn với tần số xuất hiện bình quân thấp, trong đó sự phân bố của loài này tập trung chủ yếu từ 15^0-$16^0$30’ Bắc, và từ 12^0-13^0 Bắc. Loài

khỉ đuôi dài (*M. fascicularis*) được phân bố từ 16^{0}30’ Bắc đến các vĩ độ thấp hơn của hầu hết khu vực Tây Nguyên và có tần số xuất hiện bình quân khá cao. Hai loài này cùng phân bố hẹp ở những khu vực có cùng sự phân bố bao gồm khu vực từ 15^{0}12’-16^{0}24’ Bắc và từ 12^{0}6’-13^{0}24’ Bắc. Mặc dù chưa có một báo cáo nào cho thấy có sự phân bố của loài khỉ mốc (*M. assamensis*) ở khu vực Trung Trung Bộ và Tây Nguyên Việt Nam, nhưng trong nghiên cứu này cho thấy loài này vẫn có phân bố trong khoảng từ 15^{0}24’ Bắc đến các vĩ độ cao hơn. Loài khỉ đuôi lợn phía Bắc (*M. leonina*) được báo cáo có tần số xuất hiện bình quân cao nhất trong các loài khỉ ở trong phạm vi khu vực nghiên cứu và phân bố tất cả các khu vực ở Trung Trung Bộ và Tây Nguyên Việt Nam. Loài này được cho là có cùng khu vực phân bố với loài khỉ mốc từ khoảng 15^{0}24’ Bắc đến các vĩ độ cao hơn. Loài khỉ mặt đỏ (*M. arctoides*) cũng được báo cáo là phân bố hầu hết khu vực Trung Trung Bộ và Tây Nguyên Việt Nam, nhưng ngoại trừ các vùng khoảng từ 11^{0}30’-12^{0}24’ Bắc. Các loài linh trưởng đã và đang mất sinh cảnh một cách nhanh chóng bởi sự phát triển kinh tế và sự gia tăng dân số của con người thông qua các hoạt động như khai thác, xâm lấn bởi canh tác nông nghiệp, trồng rừng cao su và các loài keo, xây dựng cơ sở hạ tầng, phát triển du lịch và hoạt động săn bắt. Điều tra về phân bố và số lượng quần thể là hết sức cấp bách để tìm ra giải pháp bảo tồn hữu hiệu các loài động vật hoang dã ở khu vực Trung Trung Bộ và Tây Nguyên.

Introduction

Central Vietnam (Quang Tri, Thua Thien Hue, Quang Nam Provinces) and the Central Highlands of Vietnam (Kon Tum, Gia Lai, Dak Lak, Lam Dong, Dak Nong Provinces) encompassing from approximately 11^{0}20’ N to 17^0 N and 106^{0}30’ E to 108^{0}30’ E (Fig. 1). The area comprises many types of primary and secondary forests along the central and southern Truong Son mountain range and several chains of high mountains e.g. Bach Ma (1.440 m), Ba Na (1.460 m), Ngoc Linh (800-2.800 m), Mo Nong (800-1.000 m), Lam Vien (1.500 m), Di Linh (900-1.000 m).

The lowland area has tropical monsoon climate with two seasons, dry and rainy season. Areas with the altitude from 800 to 1.500 m (Mo Nong, Lam Vien, and Di Linh) and with the altitude up to 2.800 m (Bach Ma, Ba Na, and Ngoc Linh) have subtropical climate.

Central Vietnam and the Central Highlands have a continuous strip of the last remaining forest in Vietnam, in which a network of reserves and national parks were established, including the reserves Dakrong, Phong Dien, Cham Island, Son Tra, Sao La Thua Thien Hue, Sao La Quang Nam, Song Thanh, Northern and Southern Hai Van Pass, Ba Na, and the national parks Bach Ma,

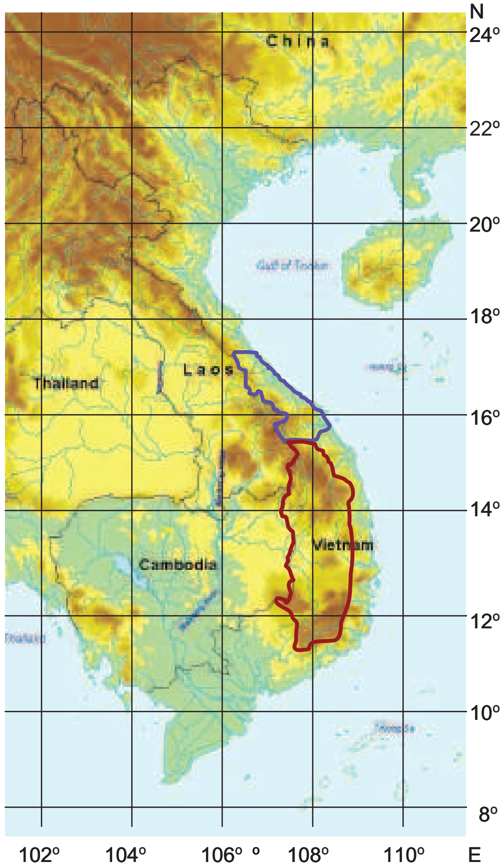

Fig.1. Areas for the interview survey about macaque occurrence. (blue: Central Vietnam, red: Central Highlands).

Ngoc Linh, Chu Mom Ray, Kon Ka Kinh, Chu Yan Sin, and Yok Don.

This area harbors a rich diversity of wildlife with many large mammal species such as Asian elephant (*Elephas maximus*), saola (*Pseudoryx nghetinhensis*), large-antlered and Annamite muntjac (*Muntiacus vuquangensis, M. truongsonensis*), Indochinese tiger (*Panthera tigris*), Asian black bear and sun bear (*Ursus thibetanus, Helarctos malayanus*). In addition, a high diversity of primates occur in this area including long-tailed, pig-tailed, rhesus, stump-tailed macaques (*Macaca fascicularis, M. leonina, M. mulatta, M. acrtoides*), red-, grey- and black-shanked douc langurs *(Pygathrix nemaeus, P. cinerea, P. nigripes*), silvered langur (*Trachypithecus margarita*), southern white-cheeked gibbon (*Nomascus siki*), northern and southern yellow-cheeked gibbons (*Nomascus annamensis, N. gabriellae*), pygmy and slow loris (*Nycticebus pygmaeus, N. bengalensis*) (Dang Ngoc Can et al., 2008; Van Ngoc Thinh et al., 2010).

Although a high number of primate species occur, the detailed distribution has not been known, especially for the more common macaque species.

Long-tailed macaques occur from central to south Vietnam, while rhesus macaques occur in northern Vietnam (Dang Ngoc Can et al., 2008), and are considered to be allopatrically distributed following the ecological segregation hypothesis (Fooden, 1982). They tend to inhabit forests other than “broad-leaf evergreen forests” that pig-tailed, stump-tailed, and Assamese macaques prefer. In Lao PDR, long-tailed macaques were reported to range from 16^{0} N to 14^{0} N, while rhesus macaques ranged from 14^{0} N to higher latitude (Hamada et al., 2010), and are sympatric distributed with long-tailed macaques between 14^{0} N and 15^{0}12’ N (Hamada et al., 2010). It is still not clear where long-tailed and rhesus macaques are allopatric distributed in central Vietnam, and where these species sympatric occur.

Although there are no records of Assamese macaques from central Vietnam and the Central Highlands (Dang Ngoc Can et al., 2008), the species occurs in southern Laos to 15^{0}12’ N (Hamada et al., 2010). For this reason the areas in Vietnam should be surveyed to clarify the distribution in Vietnam.

Stump-tailed macaques are distributed in hilly areas. This species prefers dense broadleaf evergreen forest and is primarily terrestrial (Fooden, 1990). Thus, stump-tailed macaques are considered to share broadleaf evergreen rainforest habitats with Assamese and northern pig-tailed macaques. Stump-tailed macaques are primarily terrestrial, Assamese and northern pig-tailed macaques are primarily arboreal (Fooden, 1990). Although stump-tailed macaques were recorded in most parts of Vietnam (Dang Ngoc Can et al, 2008), sympatric areas with Assamese and northern pig-tailed macaques have not been elucidated specifically.

Material and Methods

As basic references about the distribution of macaques we used Dang Ngoc Can et al., 2008; Dickinson & Van Ngoc Thinh, 2006 Fooden, 1976; 1982; 1981; 1990; 1995; 2000; Hamada et al., 2010; Nadler et al., 2010; Van Ngoc Thinh et al., 2007.

From 2006 to 2010 we interviewed 279 people in the provinces Quang Tri, Thua Thien Hue, Danang, Quang Nam, Kon Tum, Gia Lai, Dak Lak, Lam Dong, and Dak Nong along routes such as Road 14, Road 9, Road 49, Road 14B, Road 14E, Road 19, Road 26, Road 27, Road 20, and rangers of Phong Dien, Son Tra and Ba Na Nature Reserves, and Bach Ma, Ngoc Linh, Chu Mom Ray, Kon Ka Kinh, Yok Don, and Chu Yan Sin National Parks.

With a questionnaire information were collected about the primate species which inhabits forests nearby a village, the year of establishment of the village, the abundance of primate populations, the trend of abundance and reason of change, agricultural crops and damage on crops by primates, counter actions to the damage, change of human population, ethnicity of villagers, hunting and trading of wildlife, economic condition in the areas, and name, gender and age of interviewee. Geographical coordinates and altitudes were recorded by Global Positioning System.

As key for the frequency of a species the frequency of positive information of the persons questioned is used.

Photos and brochures with the features and behavioral characteristics of primates were used to identify the species. Morphological characteristics are occasionally difficult for the interviewees to distinguish rhesus, Assamese and long-tailed macaques. Assamese and rhesus macaques are quite similar in pelage color and called “yellowish monkeys”. Therefore we used some keys of pelage color and body features to indentify the species.

Primate pets were recorded and pet owners interviewed about their origins, way of acquisition, way of hunting, and the reason of keeping a pet.

The environmental and habitat conditions around the interview sites were recorded.

Results and Discussion

Distribution of macaques in Central Vietnam and at the Central Highlands of Vietnam

Rhesus macaque (*Macaca mulatta*)

Dang Ngoc Can et al. (2008) mention records of rhesus macaques (Fig. 2) from 14^0 N (An Khe District, Gia Lai Province) to the North. We recorded rhesus macaques with a frequency of about 16% of persons questioned also around $12^0$30’ N in mountainous areas with higher altitude (Dak Lak, part of Dak Nong, and part of Lam Dong Provinces). The southern Central Highland with higher elevation from around 500 to over 1,000 m asl is a suitable habitat for rhesus macaques, even in secondary forests (Fig. 3)

Fig.2. Rhesus macaque (*Macaca mulatta*). Photo: Tilo Nadler.

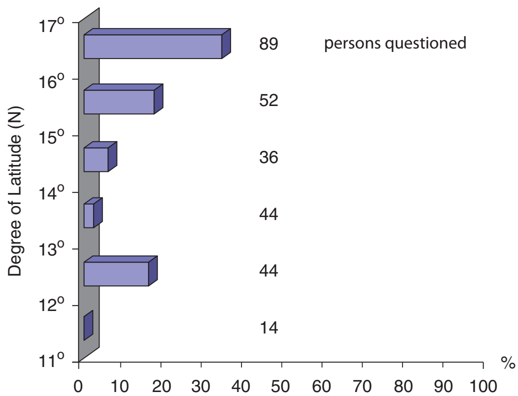

Fig.3. Frequency of positive information about the occurrence of rhesus macaque (*Macaca mulatta*) from persons questioned along the latitude.

Long-tailed macaque (*Macaca fascicularis*)

Long-tailed macaques (Fig 4) were reported to range almost south Vietnam (Dang Ngoc Can et al., 2008). But a number of individuals were also released in more northern areas, in central Vietnam and the Central Highlands (Qunag Tri Province, Hai Lang District and Phong Dien Nature Reserve, Thua Thien Hue Province) to about $16^0 30'$ N. This shows that long-tailed macaques can range not only in coastal forests but also inland forests, especially in lower areas. Long-tailed macaques and rhesus macaques occur sympatric the area between $16^0 30'$ N (Thua Thien Hue province) to 12^0 N (northern Lam Dong Province) (Fig. 5).

Fig.4. Long-tailed macaque (*Macaca fascicularis*). Photo: Tilo Nadler.

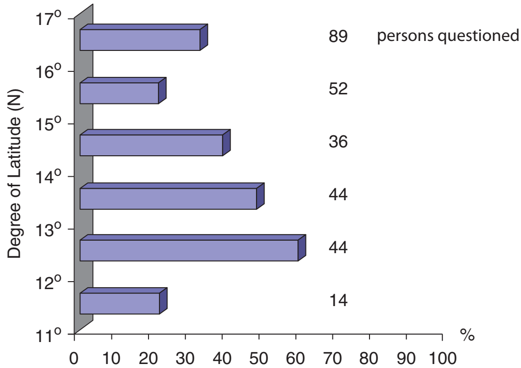

Fig.5. Frequency of positive information about the occurrence of long-tailed macaque (*Macaca fascicularis*) from persons questioned along the latitude.

Areas with a high frequency of both taxa are between $15^0 10'$ N to $16^0 25'$ N (Thua Thien Hue Province: Phong Dien and A Luoi Nature Reserves, Bach Ma National Park, northern and southern Hai Van Pass, Son Tra and Ba Na Nature Reserves, and Quang Nam Province: Cu Lao Cham Island and Tay Giang). The other sympatric area with high frequency of both taxa is located between $12^0 6'$ N and $13^0 25'$ N (Lam Dong Province: Da Nhim, Dak Nong Province: Dak Mil, and Dak Lak Province: Buon Don (Fig. 6). Long-tailed macaques tend to inhabit the riverine forests, rhesus macaques variant types of forests.

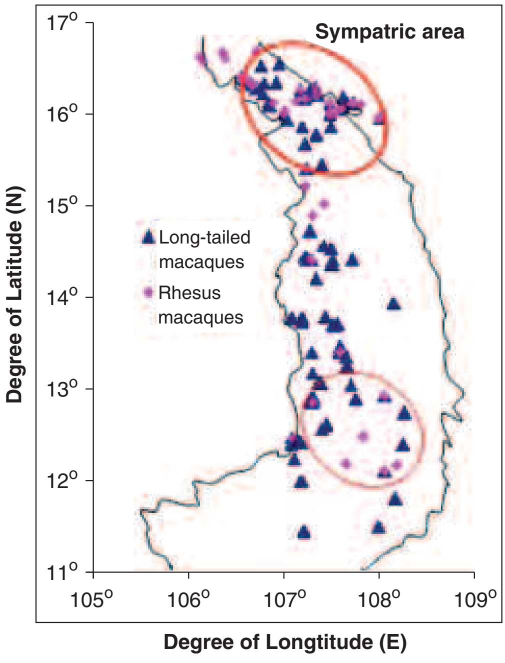

Fig.6. Sympatric area of long-tailed (*Macaca fascicularis*) and rhesus macaques (*Macaca mulatta*) in Vietnam.

Assamese macaque (*Macaca assamensis*)

There have been no previous reports on Assamese macaques (Fig. 7) from central Vietnam and the Central Highland areas (Dang Ngoc Can et al., 2008). The distribution has been considered north of $15^0 25'$ N (Fig. 8).

Fig.7. Assamese macaque (*Macaca assamensis*). Photo: Tilo Nadler.

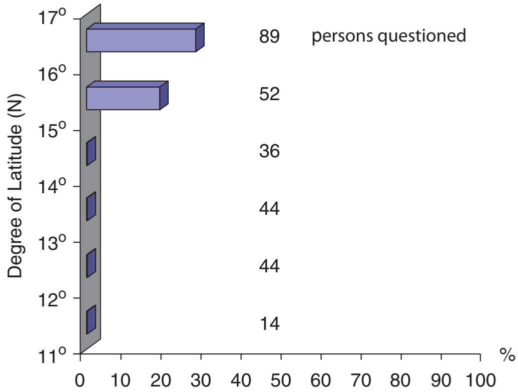

Fig.8. Frequency of positive information about the occurrence of Assamese macaque (*Macaca assamensis*) from persons questioned along the latitude.

In Truong Son and Ngoc Linh mountain ranges Assamese macaques are reported with high frequency by persons questioned. These areas have good forests with some high mountain tops also adjacent to high mountains in Laos, where the occurrence of Assamese macaques were reported. The frequency around $16^0$30' N in cooler climate and less disturbed forest was higher than in southern areas (Fig. 9).

Assamese macaques and rhesus macaques are similar pelage colors (called "yellowish monkeys''), but the interviewees described clearly the differences between these two species.

Northern pig-tailed macaque (*Macaca leonina*)

Northern pig-tailed macaques (Fig. 10) were reported in the highest frequency of persons questioned, and occurs in most areas of central Vietnam and Central Highland. The area with the greatest frequency was between 13^0 N and 14^0 N. They were also reported to inhabit many types of forests (Fig. 11). According to Fooden (1982) northern pig-tailed macaques and Assamese

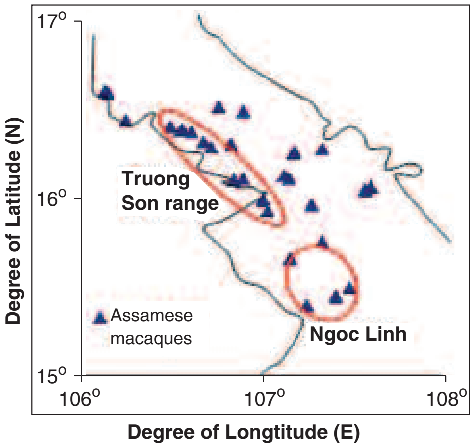

Fig.9. Frequency of positive information about the occurrence of Assamese macaque (Macaca assamensis) from persons questioned has been higher in cooler climate and less disturbed forest than in southern areas.

Fig.10. Northern pig-tailed macaque (*Macaca leonina*). Photo: Tilo Nadler.

macaques compete ecologically with each other because their habitat preferences - broadleaf evergreen forests - are similar. Although stump-tailed macaques also prefer the same forest type, but avoid competition by their terrestrial life (Hamada et al., 2010). Fooden (1982) proposed "ecological segregation hypothesis" that these two species are allopatric in general. Assamese macaques tend to be distributed in more northern areas (cooler areas) and northern pig-tailed macaques in more to the south. The boundary of the distribution is around 18^0 N. However, the distribution pattern of these species does not indicate any definite boundary in central Vietnam and the Central Highlands (Fig. 12). The study result shows that Assamese macaques can be found south to $15^0$25' N, where northern pig-tailed macaques occur, from at least $11^0$25' N to $16^0$40' N. Also in Laos was found sympatric distribution from $15^0$10' N to about 22^0 N (Hamada, 2010). The species are probably separated by different habitas. Assamese macaques prefer broadleaf evergreen forest with steep topography and northern pig-tailed macaques variant vegetations but also including broadleaf evergreen forest.

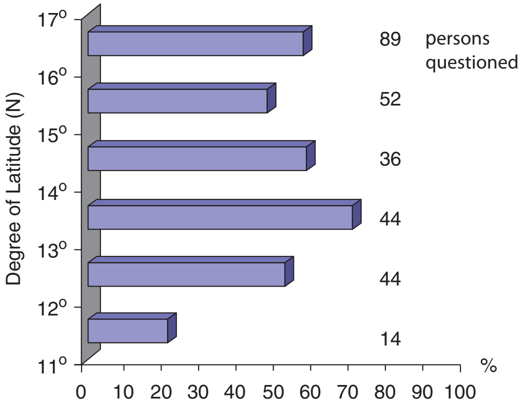

Fig.11. Frequency of positive information about the occurrence of northern pig-tailed macaque (*Macaca leonina*) from persons questioned along the latitude.

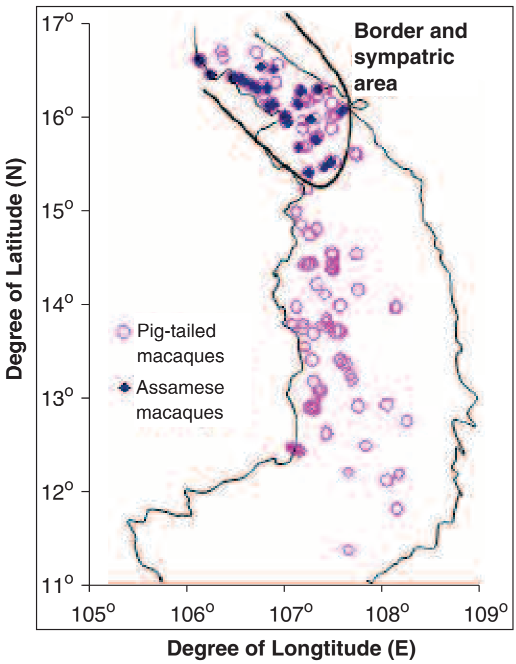

Fig.12. Southern border of the distribution of Assamese macaques (*Macaca assamensis*) and sympatric area with pig-tailed macaques (*Macaca leonina*).

Stump-tailed macaque (Macaca arctoides)

The distribution of stump-tailed macaques (Fig. 13) were reported throughout central Vietnam and the Central Highlands (Fig. 14), except the area between $11^0$30' N to $12^0$30' N (especially in eastern Lam Dong and Dak Lak Provinces) (Fig. 15). These areas are mainly covered by secondary forest which might not be a suitable habitat for stump-tailed macaques whereas northern pig-tailed macaques occur. Stump-tailed macaque had a high frequency by persons questioned.

Possible hybridization between rhesus macaques and long-tailed macaques

Indochinese long-tailed macaques have a tail length of 110% of the head-body length (Fooden, 1997; Fooden & Albrecht, 1999; Hamada et al., 2008). Rhesus macaques of the eastern distribution range, China and Indochina, have a tail length in average of 35.3% of the head-body length

Fig.13. Stump-tailed macaques (*Macaca arctoides*). Photo: Tilo Nadler.

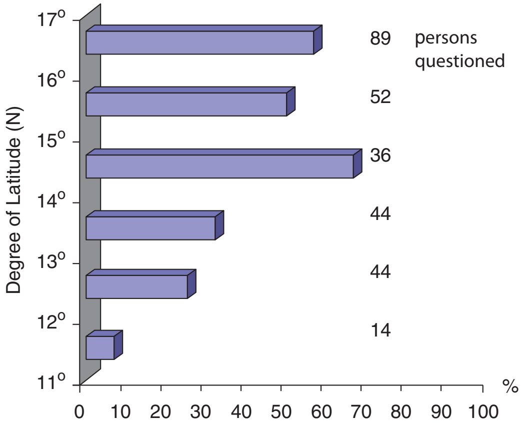

Fig.14. Frequency of positive information about the occurrence of stump-tailed macaque (*Macaca arctoides*) from persons questioned along the latitude.

(Fooden, 2000; Hamada et al., 2005). In the part of Indochina between 15^0 to 20^0 N occur rhesus macaques with longer tails which are suspected hybrids with long-tailed macaques (Fooden, 1964; 1995, 2000; Hamada et al., 2006; 2008).

We observed three phenotypical rhesus macaques in Son Tra Nature Reserve, Danang (16^0 N, 108^0 E) with tails of about 65%, 72% and 75% of head-body length. Three phenotypical long-tailed macaques on Cu Lao Cham Island (about16^0 N, 109^0 E) had tails with about 80-90% of head-body length. These observations can be a hint of hybridization but genetic analysis are necessary for evidence.

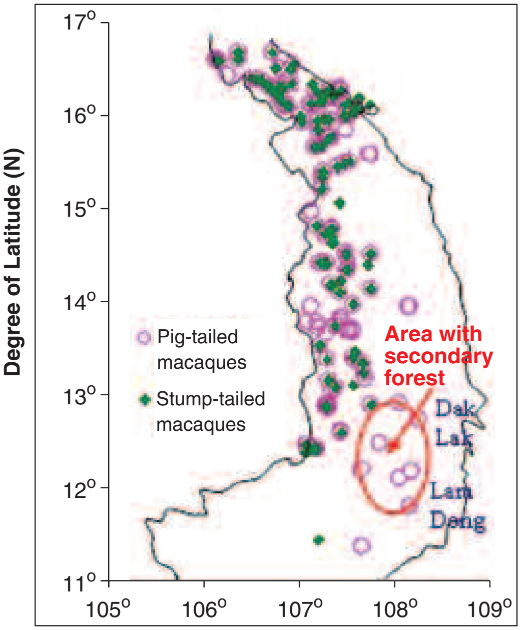

Fig.15. Sympatric area from pig-tailed (*Macaca leonina*) and stump-tailed macaques (*Macaca arctoides*).

Macaques as pets

There were 106 pet macaques recorded (Table 1)[1]. The provenances for these pets were given by owners. Many of them were caught from nearby village of the pet owner. Some of them were brought from other places, it means they are traded animals.

The number of long-tailed macaques concentrated highly between 12^0 N and 13^0 N with 6 individuals, reflecting the occurrence in this area. The highest number of rhesus macaques was recorded between 16^0 N and 17^0 N, and for stump-tailed macaques between 15^0 N and 17^0 N,

[1] **Remarks from the editors**
This high number of primates as pets demonstrates an extremely low intensity of ranger activities and of the forest protection authorities. Hunting, trading and keeping of all primates is illegal in Vietnam but the law enforcement for these obvious violations is extremely low or not existent. There exist also not any reprimands if a forest authority doesn't fulfill their duties.

probably resulting from a high population in the area or a specialized hunter. Stump-tailed macaques are also preferred for traditional medicine.

Table. 1. Number of persons questioned during the survey and frequency of positive information about the occurrence in (%) of macaques (*Macaca* sp.) along the latitude.

	Location					
	<12ºN	12-13ºN	13-14ºN	14-15ºN	15-16ºN	16-17ºN
Number of persons questiones	14	44	44	36	52	89
Macaca fascicularis	21.4	59.1	47.7	38.9	21.2	32.6
Macaca mulatta	-	15.9	2.3	5.6	17.3	33.7
Macaca assamensis	-	-	-	-	17.3	25.8
Macaca leonina	21.4	52.3	70.5	58.3	48.1	57.3
Macaca artoides	7.1	25.0	31.8	66.7	50.0	56.2

Table. 2. Recorded number of macaque pets during the survey coordinated to the latitude.

	Location						Total
	<12ºN	12-13ºN	13-14ºN	14-15ºN	15-16ºN	16-17ºN	
Macaca fascicularis	5	6	3	2	3	1	**20**
Macaca mulatta	-	1	1	1	2	6	**11**
Macaca assamensis	-	-	-	-	-	1	**1**
Macaca leonina	3	6	6	6	1	6	**28**
Macaca artoides	3	4	3	5	9	22	**46**
Total	**11**	**17**	**13**	**14**	**15**	**36**	**106**

Threats to macaques in central Vietnam and the Central Highlands

The conversion of forest into agricultural land and plantations reduce the habitat for primates. The development of infrastructure through construction of roads and dams does not only contribute to the shrinking of habitat but also improve the access for forest encroachment and hunting. The development of tourisms, supported by road constructions and buildings has an additional negative impact through fragmentation of the primate populations. The high number of recorded pets is a sign for high poaching activities. Without special measures and careful land use planning and strict law enforcement it is to expect that existing and still healthy populations of macaques decrease dramatically.

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References

Blancher A, **Bonhomme M**, **Crouau-Roy B**, **Terao K**, **Kitano T** & **Saitou N** (2008): Mitochondrial DNA sequence phylogeny of 4 populations of the widely distributed cynomolgus macaque (*Macaca fascicularis*). J. of Heredity. 99(3), 254-264.

Brandon-Jones D, **Eudey AA**, **Geissmann T**, **Groves CP**, **Melnick DJ**, **Morales JC**, **Shekelle M** & **Stewart C-B** (2004): Asian primate classification. Int. J. Primatol. 25, 97–164.

Dang Ngoc Can, **Endo H**, **Nguyen Truong Son**, **Oshida T**, **Le Xuan Canh**, **Dang Huy Phuong**, **Lunde DP**, **Kawada S-I**, **Hayashida A** & **Sasaki M** (2008): Checklist of wild mammal species of Vietnam. Shoukadoh, Kyoto. (In Vietnamese).

Dickinson C & **Van Ngoc Thinh** (2006): An assesment of the Fauna and Flora of the Green Corridor Forest Landscape, Thua Thien Hue province, Vietnam. Technical Report No.7: Green Corridor Project, WWF Greater Mekong & Vietnam Country Programme and FPD Thua Thien Hue Province, Vietnam.

Duckworth JW, **Salter RE** & **Khounboline K** (compiler) (1999): Wildlife in Lao PDR: 1999 Status Report. IUCN, Vientiane, Lao PDR.

Darlington PJ (1957): Zoogeography: The geographical distribution of animals. John Wiley and Sons, New York.

Eudey AA (1980): Pleistocene glacial phenomena and the evolution of Asian macaques. In: Lindburg DG (ed.): The Macaques: Studies in Ecology, Behavior and Evolution; pp. 52–83. Van Nostrand Reinhold, New York.

Fooden J (1964): Rhesus and crab-eating macaques: Intergradation in Thailand. Science 143, 363-365.

Fooden J (1975): Taxonomy and evolution of liontail and pigtail macaques (Primates: Cercopithecidea). Fieldiana Zool. 67, 1-169.

Fooden J (1976): Provisional classification and key to living species of macaques (Primates: *Macaca*). Folia Primatol. 25, 225–236.

Fooden J (1980): Classification and distribution of living macaques (*Macaca* Lacepede, 1799). In: Lindburg DG (ed.): The Macaques: Studies in Ecology, Behavior and Evolution; pp. 1-9. Van Nostrand Reinhold, New York.

Fooden J (1982): Ecogeographic segregation of macaque species. Primates 23, 574-579.

Fooden J (1982): Taxonomy and evolution of the sinica group of macaques: 3. species and subspecies accounts of *Macaca assamensis*. Fieldiana Zool. 10, 1-52.

Fooden J (1990): The bear macaque, *Macaca arctoides*: a systematic review. J. of Human Evolution 19, 607-686.

Fooden J (1995): Systematic review of Southeast Asian longtail macaques *Macaca fascicularis* (Raffles, 1821). Fieldiana Zool. 81, 1-119.

Fooden J (1996): Zoogeography of Vietnamese Primates. Int. J. Primatol. 17 (5), 845-899.

Fooden J (1997): Tail length variation in *Macaca fascicularis* and *M. mulatta*. Primates 38, 221-231.

Fooden J & **Albecht GH** (1999): Tail length variation in *fascicularis*-group macaques (Cercopithecidea: *Macaca*). Int. J. Primatol. 20 (3), 431-440.

Fooden J (2000): Systematic review of the rhesus macaque *Macaca mulatta* (Zimmermann, 1780). Fieldiana Zool. 96, 1-180.

Fooden J & **Aimi M** (2005): Systematic review of Japanese macaques, *Macaca fuscata* (Gray 1870). Fieldiana New Series 104.

Hamada Y, **Kurita H**, **Goto S**, **Morimitsu Y**, **Malaivijitnond S**, **Pathonton S**, **Pathontone B**, **Kingsada P**, **Vongsombath C**, **Samouth F** & **Praxaysombath B** (2010): Distribution and present status of macaques in Lao PDR. In: Nadler T, Rawson BM & Van Ngoc Thinh (eds): Conservation of Primates in Indochina; pp 27-42. Frankfurt Zoological Society and Conservation International, Hanoi.

Hamada Y, **Malaivijitnond S**, **Pathamthong S**, **Kingsada P**, **Son V. D**, **Nguyen Huu Van**, **Nguyen Van Minh**, **San A. M**, **Thu A**, **Oi T** & **Kawamoto Y** (2010): Distribution, phylo-geography and present status of macaques distributed in Indochina. In: Proceeding of the 23th Congress of International Primatological Society, Kyoto.

Hamada Y, **Suryobroto B**, **Goto S** & **Malaivijitnond S** (2008): Morphological and body color variation in Thai *Macaca fascicularis* North and South of the Isthmus of Kra. Int. J. Primatol. 29, 1271-1294.

Hamada Y, **Urasopon N**, **Hadi I** & **Malaivijitnond S** (2006): Body size, proportions and pelage color of free-ranging rhesus macaques (*Macaca mulatta*) from a zone of hybridization in northern Thailand. Int. J Primatol. 27, 497-513.

Nadler T (2010): Status of Vietnamese primates-complements and revisions. In: Nadler T, Rawson BM & Van Ngoc Thinh (eds): Conservation of Primates in Indochina; pp 3-16. Frankfurt Zoological Society and Conservation International, Hanoi.

Nadler T & **Streicher U** (2004): The Primates of Vietnam - an overview. In: Nadler T, Streicher U & Ha Thang Long (eds): Conservation of Primates Vietnam; pp 5-11. Frankfurt Zoological Society, Hanoi.

Nguyen Vu Khoi & **Shaw JC** (2005): Primate field guide. Agriculture Publishing House, Hanoi.

Satkoski J, **George D**, **Smith DG** & **Kanthaswamy S** (2007): Genetic characterization of wild and captive rhesus macaques in China. J. Medical Primatol. 37, 67-80.

Smith DG & **McDonough JW** (2005): Mitochondrial DNA variation in Chinese and Indian rhesus macaques (*Macaca mulatta*). Am. J. Primatol. 65, 1-25.

Smith DG, **McDonough JW** & **George DA** (2007): Mitochondrial DNA variation within and among regional populations of longtail macaques (*Macaca fascicularis*) in relation to other species of the fascicularis-group of macaques. Am. J. Primatol. 69, 182-198.

Van Ngoc Thinh, **Mootnick AR**, **Vu Ngoc Thanh**, **Nadler T** & **Roos C** (2010): A new species of crested gibbon, from the Annamite mountain range. Vietnamese J. Primatol. 1(4), 1-12.

Van Ngoc Thinh, **Nguyen Manh Ha**, **Dickinson C**, **Vu Ngoc Thanh**, **Minh Hoang**, **Do Tuoc** & **Nguyen Manh Dat** (2007): Primate conservation in Thua Thien Hue province, Vietnam: with special reference to white cheeked crested gibbons (*Nomascus leucogenys siki*) and red-shanked douc (*Pygathrix nemaeus nemaeus*). Technical Report No.13: Green Corridor Project, WWF Greater Mekong & Vietnam Country Programme and FPD Thua Thien Hue Province, Vietnam.

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Frankfurt Zoological Society: "Vietnam Primate Conservation Program" and the Endangered Primate Rescue Center, Vietnam - Report 2011

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Key words: Primates, Vietnam, Frankfurt Zoological Society, Vietnam Primate Conservation Program, Endangered Primate Rescue Center

Summary

The "Vietnam Primate Conservation Program" of Frankfurt Zoological Society continued with all approved project parts: the Endangered Primate Rescue Center, the "Delacour's langur Conservation Project" in Van Long Nature Reserve, the "Red-shanked douc langur Research and Conservation Project" in Son Tra Nature Reserve, Danang, the "Hatinh langur Reintroduction Project" at Phong Nha-Ke Bang National Park and the "Grey-shanked douc langur Conservation Project" in Kon Ka Kinh National Park, Gia Lai Province.

At the end of 2011 the EPRC housed 150 primates. During the year 21 individuals were born at the center, and 21 died. Four individuals were confiscated and brought to the EPRC. Two Hatinh langurs were transferred to Phong Nha-Ke Bang National Park for reintroduction and 3 Delacour's langurs were released into Van Long Nature Reserve. In 2011 the center received about 19,000 visitors; 13,000 foreigners and 6,000 Vietnamese.

As part of the "Delacour's langur Conservation Project" a Delacour's family including a male, female and a male offspring was health checked and prepared for release at the EPRC, and in August introduced into Van Long Nature Reserve. The three released animals were equipped with GPS-radio collars and monitored for about one year.

The "Red-shanked douc langur Research and Conservation Project" in Son Tra Nature Reserve continues during the year. High impacts to the area through road construction activities, tourism, poaching, trapping and collection of non-timber forest products were recorded with negative impacts to the habitat.

The joint project of Frankfurt Zoological Society and Cologne Zoo to release captive bred individuals from the Endangered Primate Rescue Center into Phong Nha-Ke Bang National Park has been a failure. The omission to continue habituation initially resulted in the inability to recapture the animals for the final release. .

The "Grey-shanked douc langur Conservation Project" in Kon Ka Kinh National Park carried out several activities to strengthen protection and continued studies on biology and ecology of grey-shanked douc langurs.

The "Vietnam Primate Conservation Program" received basic financial support from Frankfurt Zoological Society and Leipzig Zoo. Several other sources including conservation organizations, zoos and private donors contributed also to the continuation of the projects. We are grateful for all of the support which makes the work for conservation of highly endangered primate species on the brink of extinction possible.

Hội Động vật học Frankfurt: "Chương trình Bảo tồn Linh trưởng Việt Nam" và Trung tâm Cứu hộ Linh trưởng Nguy cấp, Việt Nam – Báo cáo 2011

Tóm tắt

"Chương trình Bảo tồn Linh trưởng Việt Nam" được Hội Động vật học Frankfurt tài trợ lâu dài với nhiều dự án như Trung tâm Cứu hộ Linh trưởng Nguy cấp, tỉnh Ninh Bình, "Dự án Bảo tồn voọc mông trắng" tại Khu Bảo tồn thiên nhiên đất ngập nước Vân Long, tỉnh Ninh Bình, "Dự án Nghiên cứu và Bảo tồn voọc chà vá chân đỏ" tại Khu Bảo tồn thiên nhiên Sơn Trà, Đà Nẵng, "Dự án Tái hòa nhập voọc Hà Tĩnh" tại Vườn Quốc gia Phong Nha-Kẻ Bàng, tỉnh Quảng Bình và "Dự án Nghiên cứu và Bảo tồn voọc chà vá chân xám" tại Vườn Quốc gia Kon Ka Kinh, tỉnh Gia Lai.

Đến cuối năm 2011, Trung tâm Cứu hộ Linh trưởng Nguy cấp đã cứu hộ và chăn nuôi khoảng 150 cá thể linh trưởng. Trong năm 2011 đã có 21 cá thể linh trưởng được sinh sản và có 21 cá thể bị tử vong. Tiếp nhận 4 cá thể và chuyển giao 2 cá thể voọc Hà Tĩnh tới Vườn Quốc gia Phong Nha-Kẻ Bàng cho kế hoạch tiếp tục tái hòa nhập. Ba cá thể voọc mông trắng được tái hòa nhập vào tự nhiên tại Khu Bảo tồn thiên nhiên đất ngập nước Vân Long. Trong năm 2011, Trung tâm Cứu hộ Linh trưởng Nguy cấp đã tiếp đón 13.000 lượt khách thăm quan, 9.000 lượt là khách nước ngoài và 6.000 lượt khách Việt Nam.

"Dự án Bảo tồn voọc mông trắng" được chuẩn bị một gia đình loài voọc mông trắng bao gồm một con đực (F1) một con cái (F1) và một con đực bán trưởng thành (F2) đã được chuẩn bị ở EPRC cho thả lại tự nhiên, và trong tháng 8, động vật đã được tái hòa nhập vào Khu bảo tồn thiên nhiên đất ngập nước Vân Long. Cả ba cá thể đã được gắn chip GPS tiếp sóng vệ tinh và được theo dõi trong một năm.

"Dự án Nghiên cứu và Bảo tồn loài voọc chà vá chân đỏ" tại Khu Bảo tồn thiên nhiên Sơn Trà, TP Đà Nẵng vẫn được thực hiên. Đã có nhiều ảnh hưởng tiêu cực tới khu bảo tồn như nhiều hoạt động liên quan đến mở rộng đường xá trên đảo Sơn Trà dẫn đến nhiều cây cối bị khai thác, du lịch phát triển, săn bắn, bẫy bắt và nhiều hoạt động thu lượm sản phẩm rừng khác vẫn diễn ra.

Đồng hợp tác giữa Hội Động vật học Frankfurt và Vườn thú Cologne nhằm tái hòa nhập linh trưởng quý hiếm được sinh sản trong điều kiện nuôi nhốt tại EPRC trở về tự nhiên chưa được thành công như mong muốn. Dự án đã chưa thực hiện được việc luyện động vật trở về chuồng nhốt tạm thời sau khi thả chúng vào khu bán hoang dã, do vậy đã không bắt chúng trở lại chuồng để tái hòa nhập vào tự nhiên theo kế hoạch.

"Dự án Nghiên cứu và Bảo tồn voọc chà vá chân xám" tại Vườn Quốc gia Kon Ka Kinh, Gia Lai được thực hiện tích cực với công tác tuần tra kiểm soát rừng nhằm tăng cường cho công tác bảo vệ rừng tận gốc, tuyên truyền bảo tồn cho học sinh tại trường học trong vùng đệm và nghiên cứu ngoại nghiệp thường xuyên tại Vườn quố gia Kon Ka Kinh.

"Dự án Chương trình Bảo tồn Linh trưởng Việt Nam" đã được tài trợ phần lớn từ Hội Động vật học Frankfurt và Vườn thú Leipzig. Một số nguồn khác từ các tổ chức bảo tồn, vườn thú và nhiều cá nhân hảo tâm đã tích cực hỗ trợ cho các hoạt động của dự án được duy trì. Chúng tôi xin trân trọng cảm tạ tới tất cả các cá nhân và tổ chức đã tài trợ và ủng hộ cho dự án nhằm hướng tới mục tiêu bảo tồn các loài thú linh trưởng nguy cấp cao đang đứng trước bờ vực vị tuyệt chủng.

Introduction

The "Vietnam Primate Conservation Program" of Frankfurt Zoological Society continued with all approved project parts during the year. A highlight of the program which started in 1993 has been the release of captive bred Delacour's langurs into Van Long Nature Reserve.

Endangered Primate Rescue Center

Staff

The EPRC operates with a staff of 20 Vietnamese workers. The foreign head keeper Elke Schwierz from Leipzig Zoo continued her work from autumn 2010 to end of 2011.

In March 2011 Jochen Menner started volunteer work at the center, and in September two additional volunteers from the German “DED-Weltwärts-Programm”, Lisbeth Siebert-Lang and Johannes Auth, begun to work at the center.

In July through August Jeremy Phan collected data at the center for his master thesis. [See report in this issue: Phan & Stevens (2012): A comparative study of activity budgets in captive and semi-free ranging Hatinh and Delacour’s langurs (*Trachypithecus hatinhensis* and *T. delacouri*). Vietnamese J. Primatol. 2(1), 55-66.]

Nguyen Thi Thu Hien continued her work as Vietnamese project manager for the EPRC and as project officer for the “Vietnam Primate Conservation Program”.

Primates at the EPRC

At the end of 2011 the EPRC housed 150 primates, including 124 langurs in 9 species, 19 gibbons in four species, and 10 lorises in two species. In cooperation with Forest Protection authorities 3 grey-shanked douc langurs and one pygmy loris were confiscated and brought to the EPRC. During the year 21 individuals were born (1,1 Delacour’s langur, 4,1+3? Hatinh langur, 1,0 Francois’ langur, 2,1 red-shanked douc langur, 2,2 grey-shanked douc langur, 0,1 northern white-cheeked gibbon, 0,1 southern white-cheeked gibbon, 1,0 northern yellow-cheeked gibbon). Twenty one primates died at the center.

Two male Hatinh langurs were transferred on 24.3.11 to Phong Nha-Ke Bang National Park for reintroduction, and 3 Delacour’s langurs were transferred on 20.8.11 to Van Long Nature Reserve and released on 22.8.11.

Education and PR activities

In 2011 the EPRC received about 13,000 foreign and 6,000 Vietnamese visitors. Nearly all foreign visitors to Cuc Phuong National Park visit the EPRC while Vietnamese visitors to the park travel mostly by package tour busses to the park’s center and don’t spend much time around the park head quarters where the EPRC is located. All visitors to the center are accompanied by guides from the national park which inform about the critical situation of wildlife in Vietnam and the goal of the EPRC.

Tours from schools in Hanoi were organized to visit the EPRC with special information programs.

Vietnam TV reported twice about wildlife protection and the EPRC’s work for highly endangered Vietnamese primates.

“Delacour’s langur Conservation Project” in Van Long Nature Reserve

After several years of studies of the Delacour’s langur (*Trachypithecus delacouri*), including ecology, behaviour, nutrition, genetics and habitat requirements Van Long Nature Reserve was chosen as the reintroduction site for captive bred individuals. A Delacour’s family including a male, female and a male offspring was health checked and prepared for release at the EPRC, and in August introduced into Van Long Nature Reserve. The three released animals were equipped with

GPS-radio collars and monitored for about one year, in accordance with the expected life span of the collar batteries. [See report in this issue: Nadler (2012): Reintroduction of the 'Critically Endangered' Delacour's langur (*Trachypithecus delacouri*) – a preliminary report. Vietnamese J. Primatol. 2(1) 67-72].

From February until December Fiona Agmen collected data for her PhD thesis at the Australian National University, in cooperation with the Vietnamese biologists Nguyen Hong Chung and Nguyen Van Linh.

"Red-shanked douc langur Research and Conservation Project" in Son Tra Nature Reserve, Danang

With beginning in 2010 the project continues during the year, managed by Larry Ulibarri. Beside comprehensive observations of the douc langurs the high impact to the area through construction activities, tourism, poaching, trapping and collection of non-timber forest products were recorded.

Various awareness campaigns in Danang City have been conducted beginning with a public exhibition in the center of the city which attracted about eight thousand local people including students and children.

Special canopy bridges were designed for Son Tra Nature Reserve to provide the possibility for contact between douc langur groups which are divided by the large gaps created by road construction. Completion of the canopy bridge component will be early in 2013.

[See report in this issue: Ulibarri L & Streicher U (2012): The "Son Tra douc langur Research and Conservation Project" of Frankfurt Zoological Society. Vietnamese J. Primatol. 2(1) 37-46].

"Hatinh langur Reintroduction Project" at Phong Nha-Ke Bang National Park

The joint project of Frankfurt Zoological Society and Cologne Zoo to release captive bred individuals from the Endangered Primate Rescue Center was managed by Dirk Euler. Despite his high efforts to correct the negligence of former project management finally the project has been a failure and didn't meet the expectations. In September 2007 eight habituated Hatinh langurs from a 5 ha semi-wild area at the Endangered Primate Rescue Center were transferred to a 20 ha semi-wild area in Phong Nha-Ke Bang National Park for adaptation prior release into the national park.

Through the omission of continued habituation efforts, the animals became unhabituated in a short time and recapture for the final release was not possible. Despite the animals being equipped with radio collars no efforts were made to locate the sleeping places of the group as an option for the recapture. In March 2011 two captive bred male Hatinh langurs were transferred from the EPRC to Phong Nha-Ke Bang National Park with the aim to attract the group in the semi-wild area to a large cage, but also this method failed. The Hatinh langurs in the semi-wild area only paid attention to the new arrivals for a short time and from distance.

Intensive and time consuming observations of the group inside the semi-wild area were started to identify preferred locations to place a trap cage for the langurs.

In May 2011 a security assessment for the release site was carried out and confirmed the safety of the release area. No poaching with guns was reported but snaring still exists. The migration of the released langurs into other parts of the national park places them at greater risk of poaching.

"Grey-shanked douc langur Conservation Project" in Kon Ka Kinh National Park, Gia Lai Province (by Ha Thang Long)

The project continues under management of Dr. Ha Thang Long. During 2011, the project successfully conducted three main objectives to improve conservation in Kon Ka Kinh National Park. These objectives include:

- Improving capacity of rangers in Kon Ka Kinh National Park through activities such as:

- on-the-job training for rangers in order to monitoring wildlife in the park;
- supplying essential field equipments to conduct field work. Six park rangers were selected to participate in a training course in the park's headquarter. Rangers were taught methods to monitor primates and small carnivores. Fourteen rangers of 3 ranger stations (Ayun, De Btuck, and Ko Roong) were trained by project staff and rangers which were previously trained. Five transects with a total length of about 15 km were established to monitor the grey-shanked douc langur population. Four binoculars, 2 digital cameras, 2 GPS units and 2 desktop computers were equipped in 2 ranger stations.

- Raising awareness on wildlife conservation and forest protection to local communities surrounding Kon Ka Kinh National Park. An "Education Team" which consists of 12 local teachers of 7 secondary schools and 4 park staff were trained. The project supported the "Education Team" of the park to conduct 28 visits to 7 schools in 2011. About 350 school children attended the lectures on forest protection and conservation of grey-shanked douc langurs. A sign board was constructed in the main entrance of the park with content written in both Vietnamese and Bana language.

Studying biodiversity of the park as well as distribution, population density and ecology of primates in the park. Six primate species were recorded in the park. A distribution map of primate fauna was generated. A master student of Danang University successfully conducted research on "Nutrition and Feeding behaviour of grey-shanked douc langurs in the Kon Ka Kinh National Park". [See report in this issue: Nguyen Thi Tinh et al. (2012): The feeding behaviour and phytochemical food content of grey-shanked douc langurs (*Pygathrix cinerea*) at Kon Ka Kinh National Park, Vietnam. Vietnamese J. Primatol. 2(1), 25-35].

Financial support

The "Delacour's langur Conservation Project", the "Hatinh langur Reintroduction Project", and the "Grey-shanked douc langur Conservation Project" were supported by Frankfurt Zoological Society. The Mohammed Bin Zayed Conservation Fund and Denver Zoological Society supported generously the reintroduction of the Delacour's langurs into Van Long Nature Reserve with surveys, the necessary involvement of the surrounding communes, equipment and the monitoring for the langurs. The "Red-shanked douc langur Research and Conservation Project" was supported by Frankfurt Zoological Society, the Endangered Primate Conservation Fund, the Primate Society of Great Britain, Margot Marsh Biodiversity Foundation, and private donors.

The work of the Endangered Primate Rescue Center was mainly supported by Leipzig Zoo, the International Primate Protection League (IPPL) and the ARCUS Foundation. The Zoological Society of Philadelphia supported operation costs of the center, and a donation was also received from the Zoological Society for the Conservation of Species and Populations, Germany. We would also like to thank many individuals which contributed through our Adopt-a-Monkey Program to the maintenance of the EPRC.

We are grateful for all of these supports which make the work possible towards the conservation of highly endangered primate species which are on the brink of extinction.

Publications, reports and presentations resulting from the FZS "Vietnam Primate Conservation Program" and the Endangered Primate Rescue Center

The fifth issue of the *Vietnamese Journal of Primatology* was published in September 2011. The Journal can be ordered at the EPRC but is also available on the website of the EPRC (www.primatecenter.org), the website of the IUCN/Primate Specialist group and on the website of Frankfurt Zoological Society (www.zgf.de).

Ebenau A, **Nadler T**, **Zinner D** & **Roos C** (2011): Genetic population structure of the critically endangered Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. Vietnamese J. Primatol. Vol. 1 (5), 1-15.

Bett NN (2011): Mother-infant relationships and infant development in captive grey-shanked douc langurs (*Pygathrix cinerea*). Vietnamese J. Primatol. Vol. 1 (5), 17-28

Nguyen Xuan Dang (2011): Security situation assessment of proposed langur release site in Phong Nha-Ke Bang National Park. Frankfurt Zoological Society, Cologne Zoo, Phong Nha-Ke Bang National Park. (Unpubl.).

Nadler T (2011): Frankfurt Zoological Society: "Vietnam Primate Conservation Program" and the Endangered Primate Rescue Center, Vietnam – Report 2010. Vietnamese J. Primatol. Vol. 1 (5), 69-80.

Nadler T (2011): Captive breeding of highly endangered primate species and challenges for their reintroduction. Presentation on "3rd International Conference on Wildlife Rescue in East and Southeast Asia". Kaengkrachan National Park, Thailand.

Nadler T, **Streicher U**, **Stefen C**, **Schwierz E** & **Roos C** (2011): A new species of ferret-badger, Genus *Melogale*, from Vietnam. Zool. Garten. Vol. 80 (5), 271-286.

Roos C, **Zinner D**, **Kubatko LS**, **Schwarz C**, **Mouyu Yang**, **Meyer D**, **Nash SD**, **Jinchuan Xing**, **Batzer MA**, **Brameier M**, **Leendertz FH**, **Ziegler T**, **Dyah Perwitasari-Farajallah**, **Nadler T**, **Walter L** & **Osterholz M** (2011): Nuclear versus Mitochondrial DNA: Evidence for Hybridization in Colobine Monkeys. BMC Evolutionary Biology.

Schwierz E (2011): Breeding, parental care and hand rearing of langurs at the EPRC. Presentation on "3rd International Conference on Wildlife Rescue in East and Southeast Asia". Kaengkrachan National Park, Thailand.

Streicher U (2011): Die Kleideraffen von Danang. Gorilla 2/2011, 10-12..

Appendix

Register of primates at the EPRC 2011 – up to date 31.12.2011

(☐*Species only kept in EPRC and nowhere else in the world)

No.	Date of arrival	Sex	Date born or estimated	Sire	Dam	Source	Current status
Delacour's langur *Trachypithecus delacouri* (*)							
1-01	Jan.93	M	1990	wild	wild	confiscated	EPRC
1-02	Jan.93	M	1990	wild	wild	confiscated	EPRC
1-04	17.5.94	M	1993	wild	wild	confiscated	EPRC
1-06	28.7.96	F	28.7.96	1-01	1-03	born EPRC	EPRC
1-07	21.2.98	M	21.2.98	1-01	1-03	born EPRC	EPRC
1-09	3.4.01	F	3.4.01	1-01	1-03	born EPRC	20.8.11 to Van Long
1-10	4.6.01	M	4.6.01	1-02	1-05	born EPRC	20.8.11 to Van Long
1-12	7.12.02	M	7.12.02	1-01	1-03	born EPRC	EPRC
1-13	9.7.03	F	9.7.03	1-02	1-06	born EPRC	EPRC
1-15	14.7.04	M	14.7.04	1-01	1-03	born EPRC	EPRC
1-16	1.6.05	M	1.6.05	1-04	1-08	born EPRC	EPRC
1-17	27.10.05	F	27.10.05	1-02	1-06	born EPRC	EPRC
1-18	19.4.07	M	19.4.07	1-04	1-08	born EPRC	EPRC
1-19	8.1.08	M	8.1.08	1-02	1-06	born EPRC	EPRC
1-20	30.1.08	M	30.1.08	1-10	1-09	born EPRC	20.8.11 to Van Long
1-21	29.7.08	F	29.7.08	1-07	1-13	born EPRC	EPRC
1-23	20.5.10	F	20.5.10	1-02	1-06	born EPRC	EPRC
1-25	20.3.11	M	20.3.11	1-07	1-13	born EPRC	ERPC
1-26	29.6.11	F	27.6.11	1-10	1-09	born EPRC	EPRC
Hatinh langur *Trachypithecys hatinhensis* (*)							
2-01	11.5.93	M	1990	wild	wild	confiscated	EPRC
2-03	13.1.94	F	1993	wild	2-02	confiscated	EPRC
2-05	9.4.94	F	1994	wild	2-04	confiscated	EPRC
2-09	14.1.96	F	ad.	wild	wild	confiscated	EPRC
2-10	6.2.96	M	6.2.96	2-01	2-08	born EPRC	EPRC
2-11	27.4.96	F	27.4.96	2-01	2-04	born EPRC	EPRC
2-12	27.11.96	M	1995	wild	wild	from private	EPRC
2-13	28.3.97	M	28.3.97	2-01	2-09	born EPRC	EPRC
2-14	22.5.97	F	22.5.97	2-01	2-08	born EPRC	EPRC
2-17	11.12.97	F	1994	wild	wild	from tourists	EPRC
2-20	11.3.98	F	1995	wild	wild	from tourists	EPRC
2-22	24.2.99	M	24.2.99	2-01	2-08	born EPRC	EPRC
2-23	9.4.99	M	9.4.99	2-01	2-09	born EPRC	EPRC
2-24	25.3.00	M	25.3.00	2-15	2-17	born EPRC	24.3.11 to Phong Nha
2-26	20.11.00	M	20.11.00	2-15	2-11	born EPRC	24.3.11 to Phong Nha
2-27	7.1.01	F	7.1.01	2-15	2-20	born EPRC	EPRC
2-32	4.4.02	F	4.4.02	2-15	2-17	born EPRC	EPRC
2-36	14.11.03	F	14.11.03	2-12	2-05	born EPRC	EPRC
2-41	28.11.04	M	28.11.04	2-01	2-09	born EPRC	EPRC
2-46	1.8.05	F	ca. 2004	wild	wild	confiscated	EPRC
2-47	27.11.05	M	27.11.05	2-12	2-05	born EPRC	EPRC
2-48	14.2.06	F	14.2.06	2-15	2-11	born EPRC	EPRC
2-49	29.6.06	F	29.6.06	14-01	2-14	born EPRC	EPRC
2-50	28.9.06	M	28.9.06	2-12	2-03?	born EPRC	†11.4.11
2-51	20.10.06	M	20.10.06	2-10	2-27	born EPRC	EPRC
2-52	31.10.06	F	31.10.06	2-10	2-32	born EPRC	EPRC

2-53	10.12.06	M	10.12.06	2-15	2-20	born EPRC	EPRC
2-54	30.3.07	M	30.3.07	2-15	2-17	born EPRC	EPRC
2-56	??.9.07	M	??.9.07	2-12	2-36	born EPRC	EPRC
2-57	18.3.08	F	18.3.08	14-01	2-14	born EPRC	EPRC
2-58	19.5.08	F	19.5.08	2-15	2-11	born EPRC	EPRC
2-59	29.12.08	M	29.12.08	2-12	2-03	born EPRC	EPRC
2-60	1.4.09	M	1.4.09	2-10	2-27	born EPRC	EPRC
2-62	??.5.09	M	??.5.09	2-12	2-05	born EPRC	EPRC
2-63	4.6.09	F	4.6.09	2-15	2-20	born EPRC	EPRC
2-64	20.1.10	M	20.1.10	14-01	2-14	born EPRC	EPRC
2-68	28.10.10	M	28.10.10	2-15	2-20	born EPRC	EPRC
2-69	27.11.10	M	27.11.10	2-01	2-09	born EPRC	†12.2.11
2-70	2.3.11	F	2.3.11	2-47	2-46	born EPRC	†2.3.11
2-71	3.2.11	M	3.2.11	2-13	2-36	born EPRC	†5.2.11
2-72	13.2.11	M	13.2.11	2-10	2-27	born EPRC	†30.6.11
2-73	5.3.11	M	5.3.11	2-15	2-17	born EPRC	EPRC
2-74	6.4.11	M	6.4.11	2-10	2-32	born EPRC	EPRC
2-75	x.5.11	?	x.5.11	2-12	2-03	born EPRC	EPRC
2-76	x.5.11	?	x.5.11	2-12	2-05	born EPRC	EPRC
2-77	24.11.11	?	24.11.11	2-47	2-46	born EPRC	EPRC

Black langur *Trachypithecus hatinhensis* morph "*ebenus*" (*)

14-01	12.1.98	M	1996	wild	wild	from tourists	EPRC

Laos langur *Trachypithecus laotum* (*)

3-01	26.9.95	M	1995	wild	wild	confiscated	EPRC

Grey langur *Trachypithecus crepusculus*

4-04	22.1.97	F	1996	wild	wild	from private	EPRC
4-05	14.4.00	F	1999	wild	wild	confiscated	EPRC
4-07	24.1.02	F	24.1.02	4-06	4-04	born EPRC	EPRC

Cat Ba langur *Trachypithecus poliocephalus* (*)

15-01	8.11.98	F	1998	wild	wild	Cat Ba NP	EPRC
15-04	2.6.03	M	2.6.03	15-02	15-01	born EPRC	EPRC
15-06	1.3.10	M	1.3.10	15-04	15-01	born EPRC	EPRC

Francois' langur *Trachypithecus francoisi*

17-01	8.1.02	F	1997	wild	wild	confiscated	EPRC
17-02	30.9.05	M	2003	wild	wild	confiscated	EPRC
17-05	27.2.11	M	27.2.11	17-2	17-01	born EPRC	EPRC

Red-shanked douc langur x Hatinh langur *Pygathrix nemaeus* x *Trachypithecus hatinhensis*

18-01	14.10.03	F	14.10.03	6-9/12?	2-03	born EPRC	EPRC

Red-shanked douc langur *Pygathrix nemaeus*

6-02	17.3.96	F	1992	wild	wild	confiscated	†26.1.11
6-05	8.5.97	M	ad.	wild	wild	confiscated	EPRC
6-06	24.5.97	M	1994	wild	wild	from tourists	EPRC
6-09	10.7.97	M	1997	wild	wild	confiscated	EPRC
6-12	28.11.97	M	1997	wild	wild	from tourists	EPRC
6-14	12.1.98	M	1996	wild	wild	from tourists	EPRC
6-16	2.4.98	M	1994	wild	wild	from tourists	EPRC
6-21	30.12.98	F	30.12.98	6-05	6-02	born EPRC	EPRC

6-28	19.8.00	M	1996	wild	wild	confiscated	EPRC
6-29	25.4.01	M	25.4.01	6-05	6-13	born EPRC	EPRC
6-31	21.4.02	F	21.4.02	6-06	6-02	born EPRC	EPRC
6-32	24.2.03	F	24.2.03	6-06	6-02	born EPRC	†23.2.11
6-37	25.8.04	M	25.8.04	6-06	6-02	born EPRC	EPRC
6-38	13.12.04	F	ad.	wild	wild	confiscated	EPRC
6-39	13.4.05	M	ad.	wild	wild	confiscated	EPRC
6-41	9.5.05	F	9.5.05	6-12	6-21	born EPRC	EPRC
6-42	11.6.05	M	April 05	wild	wild	confiscated	EPRC
6-46	17.8.06	F	2001	wild	wild	confiscated	EPRC
6-53	17.10.07	F	2003	wild	wild	confiscated	EPRC
6-55	2.2.08	F	2.2.08	6-28	6-46	born EPRC	EPRC
6-56	6.2.08	F	6.2.08	6-08	6-30	born EPRC	†5.3.11
6-58	27.3.08	F	27.3.08	6-16	6-32	born EPRC	EPRC
6-60	20.7.08	M	2007	wild	wild	confiscated	EPRC
6-61	14.3.09	M	14.3.09	6-12	6-21	born EPRC	†14.2.11
6-62	17.3.09	M	17.3.09	6-28	6-31	born EPRC	EPRC
6-63	9.6.09	M	2002	wild	wild	conf. Hue	†2.1.11
6-64	31.3.10	F	ad.	wild	wild	confiscated	EPRC
6-67	2.5.10	M	2.5.10	6-16	6-32	born EPRC	†20.1.11
6-69	19.8.10	M	19.8.10	6-28	6-46	born EPRC	EPRC
6-70	21.8.10	M	21.8.10	6-16	6-38	born EPRC	†15.2.11
6-72	21.3.11	M	21.3.11	6-12	6-21	born EPRC	†21.3.11
6-73	19.5.11	F	19.5.11	6-06	6-53	born EPRC	EPRC
6-74	27.6.11	M	27.6.11	6-05	6-64	born EPRC	EPRC

Grey-shanked douc langur *Pygathrix cinerea* (*)

7-04	4.8.97	M	1994	wild	wild	confiscated	EPRC
7-09	13.2.01	M	ca.1996	wild	wild	confiscated	EPRC
7-11	15.12.01	F	ca. 1997	wild	wild	confiscated	EPRC
7-13	12.7.02	F	ad.	wild	wild	confiscated	EPRC
7-14	18.8.02	M	1998	wild	wild	confiscated	EPRC
7-16	11.12.02	M	ad.	wild	wild	confiscated	EPRC
7-19	13.3.03	M	subad.(1998)	wild	wild	confiscated	EPRC
7-24	15.1.04	F	15.1.04	7-04	7-13	born EPRC	EPRC
7-25	9.11.04	M	2000	wild	wild	confiscated	EPRC
7-28	6.6.05	F	6.6.05	7-01	7-11	born EPRC	EPRC
7-29	14.8.05	F	ca. 2005	wild	wild	confiscated	EPRC
7-30	9.11.05	F	ad.	wild	wild	confiscated	EPRC
7-34	19.10.06	F	2000	wild	wild	confiscated	EPRC
7-37	24.12.06	M	2003	wild	wild	confiscated	EPRC
7-39	17.3.07	M	2003	wild	wild	confiscated	EPRC
7-40	10.10.07	M	10.10.07	7-09	7-34	born EPRC	EPRC
7-45	5.12.08	F	2007	wild	wild	confiscated	EPRC
7-46	4.3.09	M	2005	wild	wild	confiscated	EPRC
7-47	11.3.09	M	2004	wild	wild	confiscated	EPRC
7-48	8.3.09	F	8.3.09	7-19	7-30	born EPRC	EPRC
7-49	8.4.09	M	2009	wild	wild	confiscated	EPRC
7-52	25.2.10	M	2005	wild	wild	confiscated	EPRC
7-55	6.5.10	M	6.5.10	7-09	7-34	born EPRC	EPRC
7-56	17.4.11	F	17.4.11	7-04	7-13	born EPRC	EPRC
7-57	25.4.11	F	ad.	wild	wild	confiscated	EPRC
7-58	25.4.11	F	2/2011	wild	7-57	confiscated	†3.10.11
7-59	16.4.11	M	16.4.11	7-19	7-29	born EPRC	EPRC

7-60	28.4.11	F	28.4.11	7-25	7-28	born EPRC	EPRC
7-61	28.8.11	M	28.8.11	7-19	7-11	born EPRC	EPRC
7-62	2.12.11	F	2.12.11	wild	wild	confiscated	EPRC
Black-shanked douc langur *Pygathrix nigripes*							
13-05	15.3.01	M	1996	wild	wild	confiscated	†31.1.11
Northern white-cheeked gibbon *Nomascus leucogenys*							
8-01	30.9.94	F	1993	wild	wild	from foreigner	EPRC
8-03	28.5.02	M	1999	wild	wild	confiscated	EPRC
8-08	19.11.04	F	2001	wild	wild	confiscated	EPRC
8-09	9.9.11	F	9.9.11	8-03	8-08	born EPRC	†16.9.11
Southern white-cheeked gibbon *Nomascus siki*							
9-02	18.9.93	F	1993	wild	wild	from foreigner	EPRC
9-05	10.11.94	M	1992	wild	wild	from foreigner	EPRC
9-06	24.2.95	F	1993	wild	wild	from tourists	EPRC
9-08	1.12.98	F	1998	wild	wild	from tourists	EPRC
9-09	23.6.99	M	23.6.99	9-05	9-02	born EPRC	EPRC
9-11	25.7.02	F	25.7.02	9-03	9-06	born EPRC	†22.5.11
9-12	17.12.02	M	17.12.02	9-05	9-02	born EPRC	EPRC
9-13	21.11.06	F	21.11.06	9-05	9-02	born EPRC	EPRC
9-15	15.7.09	M	15.7.09	9-05	9-02	born EPRC	EPRC
9-16	23.12.11	F	23.12.11	9-12	9-08	born EPRC	EPRC
Northern yellow-cheeked gibbon *Nomascus annamensis* (*)							
20-01	6.2.97	F	1994	wild	wild	confiscated	EPRC
20-02	9.7.10	M	2005	wild	wild	Cu Chi	†10.2.11
20-03	10.7.11	M	10.7.11	20-01	20-02	born EPRC	†13.11.11
20-04	21.7.11	F	2010	wild	wild	confiscated	EPRC
Southern Yellow-cheeked crested gibbon *Nomascus gabriellae*							
10-04	3.6.01	F	1997	wild	wild	confiscated	EPRC
10-05	11.6.04	F	2001	wild	wild	confiscated	EPRC
10-07	7.10.06	F	2005	wild	wild	confiscated	EPRC
10-08	7.10.06	F	2005	wild	wild	confiscated	EPRC
Northern Slow loris *Nycticebus bengalensis*							
11-09	20.11.07	F	ad.	wild	wild	confiscated	EPRC
11-10	22.6.08	F	ad.	wild	wild	confiscated	EPRC
11-11	9.5.09	F	ad.	wild	wild	confiscated	EPRC
Pygmy loris *Nycticebus pygmaeus*							
12-36	22.2.01	M	22.2.01	12-09	12-04	born EPRC	EPRC
12-72	24.2.06	F	ad.	wild	wild	confiscated	EPRC
12-88	17.5.07	F	ad.	wild	wild	confiscated	EPRC
12-97	12.4.08	F	ad.	wild	wild	confiscated	EPRC
12-102	Febr.09	M	2/2009	wild	12-99	born EPRC	†8.1.11
12-103	Febr.09	M	2/2009	wild	12-99	born EPRC	EPRC
12-110	6.8.09	M	2008	wild	wild	from private	EPRC
12-112	29.4.10	M	ad.	wild	wild	confiscated	EPRC
12-113	12.2.11	F	ad.	wild	wild	from private	†1.3.11

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Books and Monographs

Groves CP (2001): Primate Taxonomy. Washington DC.

Edited books and book chapters

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 dissertation, University Cologne.

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