...with the description of a new gibbon species

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Cover: Northern buff-cheeked gibbon (*Nomascus annamensis* nov. spec.), male. Photo: T. Nadler

A new species of crested gibbon,
from the central Annamite mountain range

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Key words: Hylobatidae, *Nomascus*, crested gibbon, Vietnam, Laos, Cambodia, new species

Summary

Crested gibbons are endemic to the Indochinese bioregion and occur only in Vietnam, Laos, Cambodia and southern China. However, their diversity is not completely understood and the number of recognized species is still under debate. Recent investigations divide crested gibbons into six species, namely *Nomascus hainanus, N. nasutus, N. concolor, N. leucogenys, N. siki* and *N. gabriellae*. However, there is evidence that gibbons in the range of *N. siki* represent two taxa. Based on genetic, acoustic and morphological data, a new gibbon species - *Nomascus annamensis* - is herein described.

Loài vượn mới ở dãy Trung Trường Sơn

Tóm tắt

Vượn có mào đặc hữu ở vùng sinh thái Đông Dương và chỉ được tìm thấy ở Việt Nam, Lào, Campuchia và Nam Trung Quốc. Tuy nhiên, sự đa dạng của chúng vẫn chưa hoàn toàn biết đến và số lượng loài ghi nhận vẫn còn tranh luận. Những nghiên cứu gần đây phân chia vượn có mào thành 6 loài bào gồm *Nomascus hainanus, N. nasutus, N. concolor, N. leucogenys, N. siki* và *N. gabriellae*, tuy nhiên bằng chứng đã chứng minh có sự hiện diện của hai giống trong loài *N. siki*. Căn cứ vào dữ liệu phân tích về gen, âm học và hình thái, thì loài mới về vượn được mô tả là loài *Nomascus annamensis*.

Introduction

Crested gibbons, genus *Nomascus*, represent one of four gibbon genera constituting the primate family Hylobatidae (Brandon-Jones et al., 2004; Roos & Geissmann, 2001; Mootnick, 2006; Mootnick & Fan in press). *Nomascus* differs from other gibbon genera in various morphological, anatomical, acoustic and chromosomal features (Carbone et al., 2009; Geissmann et al., 2000; Groves, 1972, 2001; Mootnick, 2006; Mootnick & Fan, in press; Müller et al., 2003). All taxa in this genus show strong sexual dichromatism, with the adult females varying from orange, buff, tan, tawny or yellow in coloration, and males and immatures being black, with some species having light cheeks (Geissmann et al., 2000; Groves, 2001; Mootnick, 2006; Mootnick & Fan in press). In adult

males and immatures, the crown hair is erect, which gives them their common name "crested gibbons". Crested gibbons occur in Vietnam, Laos, Cambodia and parts of southern China. They are mainly restricted to the region east of the Mekong River and the western black gibbon (*N. concolor*) is the only species that has crossed the upper Mekong to the west (Geissmann et al., 2000; Groves, 2001) (Fig. 1).
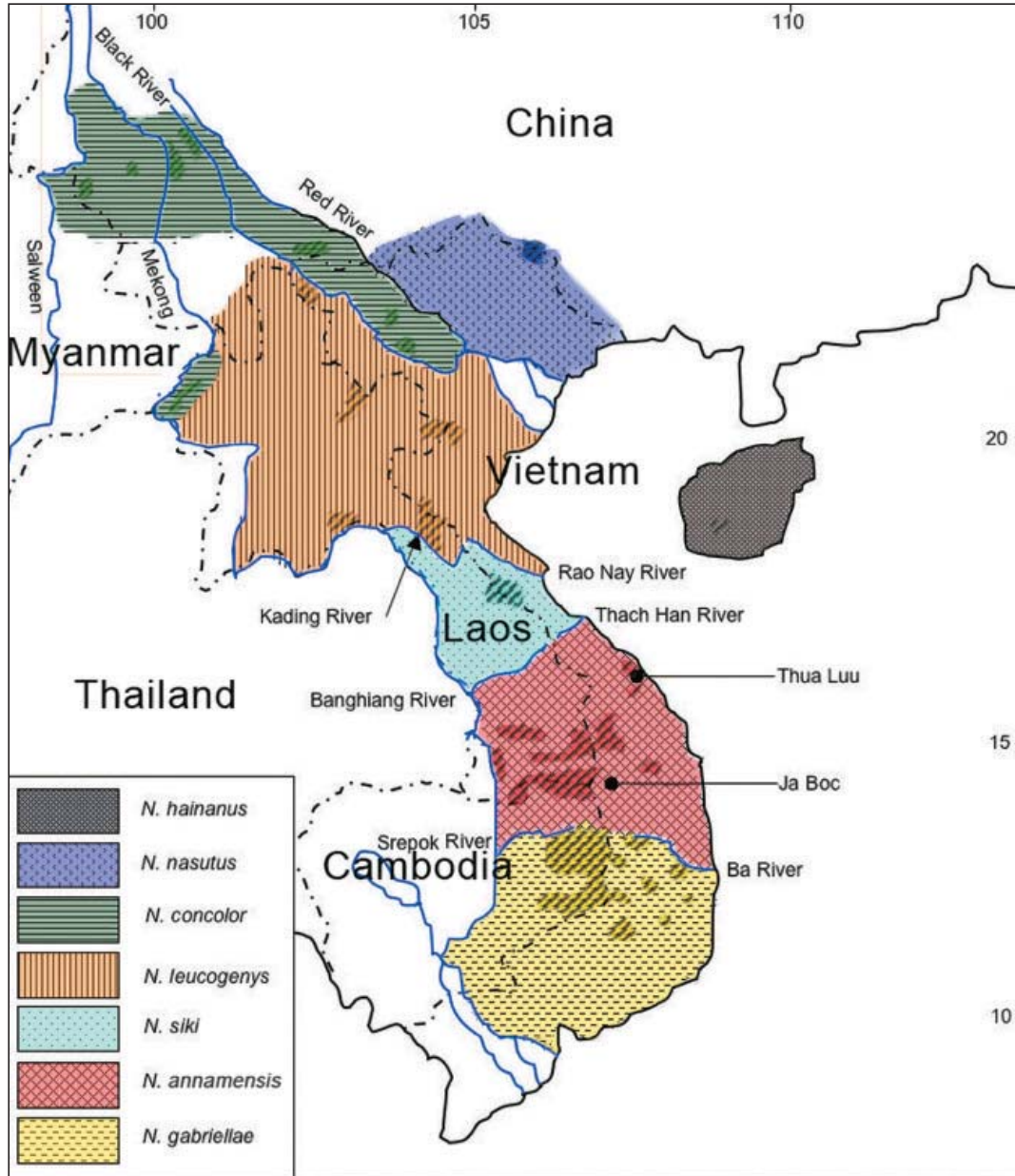
Fig.1. Historical distribution of crested gibbon species 19th and early 20th century, and the current shrunk and fragmented distribution (after Chinese Primate Specialist Group, 1996; Duckworth, 2008; Geissman, 1995; Traeholt et al., 2006; Van Ngoc Thinh et al., in press 2; Zhang Yongzu et al., 2002).
Country borders are indicated as dashed lines. Thua Luu and Ja Boc indicate the type localities of *N. siki* and *N. annamensis*, respectively. Note that Thua Luu as type locality of *N. siki* is most likely incorrect.

The classification of crested gibbons has been disputed over decades. Initially, all taxa were lumped into one species, *N. concolor* (Chivers, 1977; Groves, 1972; Haimoff et al., 1982; Marshall & Sugardjito, 1986; Napier & Napier, 1967), but recent investigations based on morphological, genetic and acoustic data divided them into four, five or even six species (Geissmann, 1997; 2000; 2007; Geissmann et al., 2000; Groves, 2001; Monda et al., 2007; Mootnick, 2006; Roos, 2004; Roos et al.,

2007; Takacs et al., 2005; Van Ngoc Thinh et al., 2010). According to the most recent classification (IUCN, 2010; Mootnick & Fan, in press; Van Ngoc Thinh et al., 2010), a total of six crested gibbon species, including the Hainan gibbon (*N. hainanus*), the eastern black gibbon (*N. nasutus*), the western black gibbon (*N. concolor*), the northern white-cheeked gibbon (*N. leucogenys*), the southern white-cheeked gibbon (*N. siki*) and the buff-cheeked gibbon (*N. gabriellae*), are recognized. Moreover, recent acoustic and genetic data provide evidence that gibbons in the range of the southern white-cheeked gibbon represent two taxa (Geissmann, 2007; Geissmann et al., 2000; Konrad & Geissmann, 2006; Roos, 2004; Van Ngoc Thinh et al., in press 1; in press 2; submitted). Both are likely to be separated from each other by the Banghiang River in Laos and the Thach Han River (Quang Tri River) in Vietnam (Van Ngoc Thinh et al., in press 2) (Fig. 1).

Which of both taxa has to be given a new species name is a dilemma due to geographical distribution. The type locality of *N. siki* (Delacour, 1951) is Thua Luu (16°16'N, 108°00'E) in Thua Thien-Hue Province, Vietnam. This site is well in the range of the southern taxon and about 200 km south of the southernmost distribution of the northern taxon (Van Ngoc Thinh et al., in press 2) (Fig. 1). Although the holotype of *N. siki* (British Museum of Natural History - BM[NH] 1933.4.1.6[a]) is a subadult male. The teeth are not completely erupted (Fig. 2) but its pelage coloration is fully developed and clearly can be assigned to the northern taxon (Fig. 3). Unfortunately, information about whether Jean Delacour and Pierre Jabouille collected the specimen on 4th February 1931 in the wild near Thua Luu or whether they obtained the gibbon at a market or from a poacher is not traceable. However, since Thua Luu is close to the coast and along the Vietnamese national railway line and the national road no. 1, the specimen could have come in trade from a wild origin other than Thua Luu.

Since the cheek coloration and shape of the *N. siki* holotype clearly resembles that of the northern taxon, its putative type locality Thua Luu seems to be incorrect. Thus, we conclude that the *N. siki* holotype refers to the northern taxon (with now an unknown type locality), while the southern taxon remains unnamed. Accordingly, and since no synonym is available for the southern taxon, we herein described it as a new species.

Fig.2. Skull of the *N. siki* type specimen. The teeth are not fully erupted. Photo: Anna Barros.

Fig.3. Skin of the *N. siki* type specimen. Photo: Anna Barros.

Nomascus annamensis nov. spec.

Holotype

ZMVNU M735 at the Zoological Museum of the Vietnam National University, Hanoi, Vietnam (ZMVNU). Skin of an adult male (weight 7 kg) collected on January 28, 1980 in Ja Boc, Sa Thay District, Kon Tum Province, Vietnam. Hands and feet are missing from the skin (Fig. 4 and 5). GenBank accession number of the complete mitochondrial cytochrome b gene (1140 bp): GU595010.

Fig.4. Skin of the holotype of *N. annamensis* nov. spec. at the Zoological Museum of the National University Hanoi. Photo: Tilo Nadler.

Fig.5. Head of the holotype of *N. annamensis* nov. spec. at the Zoological Museum of the National University Hanoi. Photo: Tilo Nadler.

Type locality

Ja Boc, Sa Thay District, Kon Tum Province, Vietnam (ca.14°25' N, 107°35' E, Chu Mom Ray National Park) (Fig. 1).

Paratypes

ZMVNU M733: Skin of a young male, changing colour from buff to black, collected in May 1982 in Sa Son, Sa Thay District, Kon Tum Province, Vietnam. GenBank accession number of the complete mitochondrial cytochrome b gene (1140 bp): GU595011. ZMVNU M734: Skin of an adult male collected on January 28, 1980 in Ja Boc, Sa Thay District, Kon Tum Province, Vietnam. In the complete mitochondrial cytochrome b gene, M734 has an identical haplotype as the holotype M735 (GenBank accession number: GU595010). The skins of the paratypes are incomplete; hands and feet are missing and parts of the head.

Diagnosis and Description

N. annamensis mainly resembles *N. gabriellae* in external characteristics. Adult males and immatures ($n = 3$) are black in color, and when in the sun light there are a few silvery hairs intermixed. The chest has a brownish tinge that contrasts with the black body. They have a noticeable crest, and black hairs under the orbital ridges. Their cheek patches were deep orangish gold (varied in color in some individuals) reaching less than halfway up the ears with a rounded upper margin, and connected under a black chin (Fig. 6 and 7). *N. annamensis* adult males and immatures clearly differ from *N. leucogenys* (Fig. 8 and 9) and *N. siki* (Fig. 10 and 11) in having
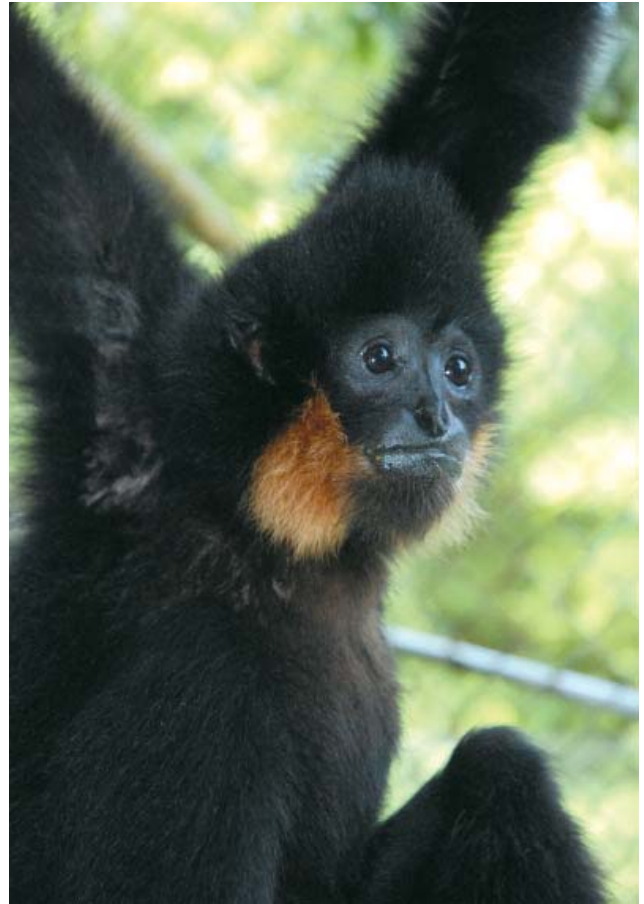
Fig.6 and 7. Subadult male of *N. annamensis* nov. spec. housed at the Endangered Primate Rescue Center, Vietnam. Photo: Tilo Nadler.

Fig.8. Juvenile male of *N. leucogenys*. Photo: Tilo Nadler.

Fig.9. Adult male of *N. leucogenys*. Photo: Tilo Nadler.

goldish instead of white cheeks that did not extend as far up the sides of the face, and from *N. gabriellae* by being in the darker scale of coloration of the cheek patches (Fig 12). .

Fig.10. Juvenile male of *N. siki*. Photo: Tilo Nadler.

Fig.11. Adult male of *N. siki*. Photo Tilo Nadler.

Fig.12. Adult male of
     N. gabriellae.
     Photo Tilo Nadler.

Adult females of *N. annamensis* (Fig. 13 and 14) do not show differences to adult females of *N. gabriellae* (Fig. 15 and 16), but are clearly different from *N. siki* (Fig. 17 and 18) (Mootnick 2006; Mootnick & Fan, in press). The size, intensity of color, and position of the black streak on the head is variable among individuals. The amount of dark hairs on the chest also varied.

Fig.13 and 14. Adult female of *N. annamensis* nov. spec. housed at the Endangered Primate Rescue Center, Vietnam. Photo: Tilo Nadler.

Fig.15. Adult female of *N. gabriellae*. Photo: Tilo Nadler.

Fig.16. Adult female *N. gabriellae*. Photo: Tilo Nadler.

Fig.17. Adult female *N. siki*. Photo: Tilo Nadler.

Fig.18. Adult female *N. siki*. Photo: Tilo Nadler.
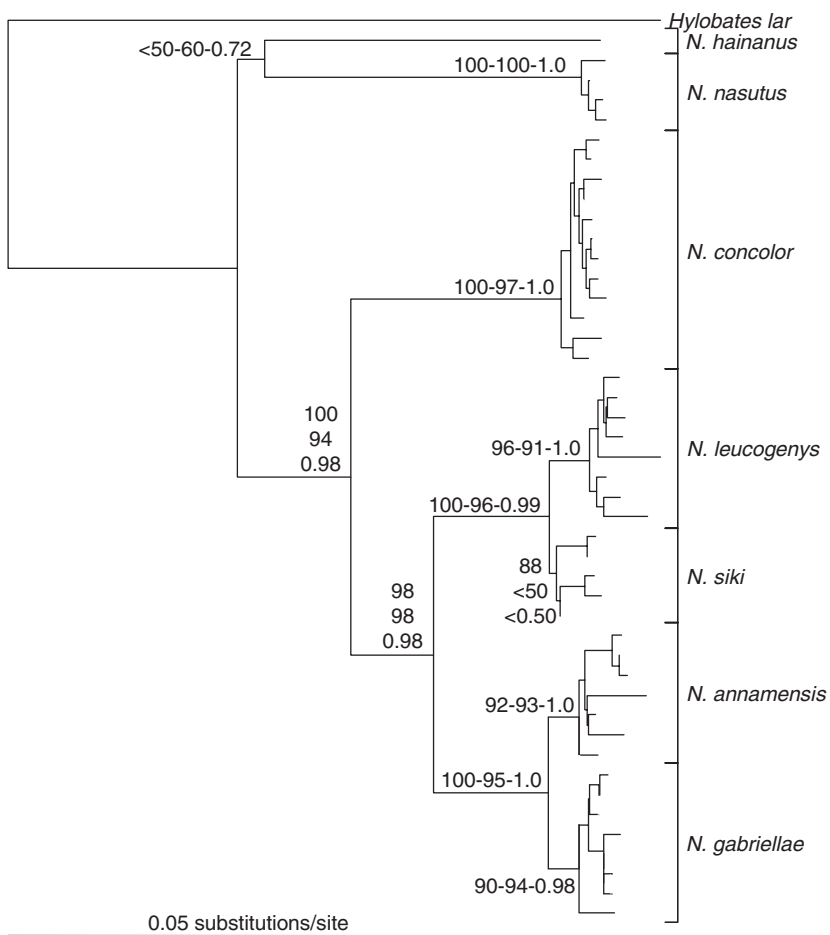
Fig.19. Phylogenetic relationships among crested gibbon species based on complete mitochondrial cytochrome b sequence data. Modified after Van Ngoc Thinh et al. (in press 2). Numbers on branches refer to support values as obtained from neighbor-joining, maximum-likelihood and Bayesian reconstructions, respectively.

Based on complete mitochondrial cytochrome b gene sequence data, *N. annamensis* is closest related to *N. gabriellae* (Fig. 19). In this gene, *N. annamensis* (n=22) differs from *N. gabriellae* (n=69), *N. siki* (n=32) and *N. leucogenys* (n=29) in 1.26 (SD±0.11)%, 3.23 (SD ±0.45)% and 3.58 (SD±0.35)%, respectively. Intra-specific variation for *N. annamensis, N. gabriellae, N. siki* and *N. leucogenys* is 0.48 (SD±0.05)%, 0.42 (SD±0.03)%, 0.38 (SD±0.03)% and 0.43 (SD±0.06)%, respectively.

N. annamensis differs from the other light-cheeked species in several acoustic features, e.g. frequency and tempo (Fig. 20), which can clearly be differentiated by discriminant function analysis (Fig. 21). Details are exposed by Van Ngoc Thinh *et al.* (in press 1; submitted).
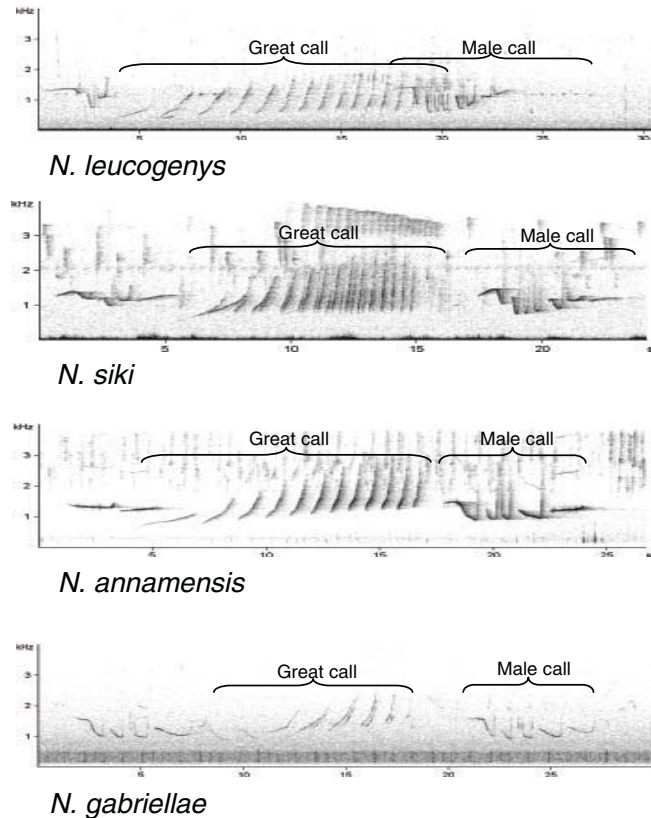
Fig.20. Spectograms of *N. leucogenys, N. siki, N. annamensis* and *N. gabriellae*. Modified after Van Ngoc Thinh *et al.* (submitted).
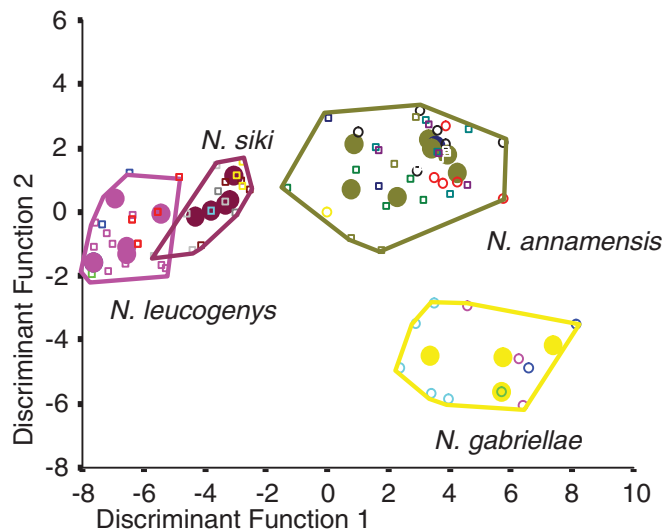
Fig.21. Discriminant function analysis of acoustic data. Modified after Van Ngoc Thinh *et al.* (submitted).

Etymology

The species is named after the central part of the Greater Annamite mountain range in the border region of Vietnam, Laos and Cambodia. English name: northern buff-cheeked gibbon, French name: Gibbon à joues jaunes du Nord, German name: Nördlicher Gelbwangen-Schopfgibbon.

Distribution

N. annamensis occurs in Vietnam, Laos and Cambodia, east of the Mekong River (Fig. 1). In Vietnam, it is distributed south of the Thach Han River (Quang Tri River) (about 16°40'-16°50' N) south to the Ba River (about 13°00'-13°10' N) in the provinces Quang Tri, Thua Thien-Hue, Thanh Po Da Nang, Quang Nam, Quang Nai, Kon Tum, Gia Lai, Binh Dinh and Phu Yen (Van Ngoc Thinh et al., in press 2). In Laos, the species occurs in the southern provinces Savannakhet, Saravan, Champasak, Xekong and Attapeu. Its northernmost locality in Laos is unknown, but most likely it is separated from *N. siki* by the Banghiang River (about 16°00'-16°03' N). In Cambodia, *N. annamensis* is distributed in the northeastern provinces Stung Treng and Rattanakiri, north of the Srepok River (about 13°30' N). Genetic and/or acoustic data confirm its occurrence in Vietnam in Phong Dien Nature Reserve, Da Krong Nature Reserve, Sao La Nature Reserve, Bach Ma National Park, Song Thanh Nature Reserve, Chu Mom Ray National Park and Kon Ka Kinh National Park, in Laos in Xe Pian National Biodiversity Conservation Area, Xe Sap National Biodiversity Conservation Area, and Xe Bang-Nouan National Biodiversity Conservation Area, and in Cambodia in Virachey National Park (Duckworth, 2008; Konrad & Geissmann, 2006; Ruppel, 2010; Van Ngoc Thinh et al., in press 2, submitted).

This report presents the first description of *N. annamensis* based on morphological, genetic and song analysis. Accordingly, there are seven species in the genus *Nomascus*. This information will assist with the conservation of the genus *Nomascus*, and in the prevention of hybridization in captive conservation programs.

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Fig.22. Subadult male of *N. annamensis* nov. spec. Photo: Tilo Nadler.

Fig.23. Adult female of *N. annamensis* nov. spec. Photo: Tilo Nadler.

Color variation in Hatinh langurs (*Trachypithecus* [*laotum*] *hatinhensis*)

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Summary

Over the years, the Endangered Primate Rescue Center has housed 67 Hatinh langurs (*Trachypithecus* [*laotum*] *hatinhensis*). This large number allows for the first overview of variability in coloration. The typical pattern on the black head of the Hatinh langur is white cheeks, extending behind the ears and down to the neck. The color gradually changes from a light grey to clear white. If the black langur is included in this row there is a clinal variation from black to white.

Females of all Indochinese "limestone langurs" have an extended white pubic patch. The extension and form of the patch varies and can be used to differentiate individuals.

Tông màu sắc long loài voọc Hà Tĩnh (*Trachypithecus* [*laotum*] *hatinhensis*)

Tóm tắt

Trải qua nhiều năm, Trung tâm Cứu hộ Linh trưởng Nguy cấp (EPRC) đã nuôi giữ 67 cá thể voọc Hà Tĩnh (*Trachypithecus* [*laotum*] *hatinhensis*). Với số lượng cá thể nhiều như vậy đã bước đầu đưa ra được khái quát về sắc màu lông khác nhau của động vật. Đặc trưng nổi bật của voọc Hà Tĩnh là lông đầu màu đen có râu quai nón màu trắng kéo dài qua tai tới sau gáy. Phần râu quai nón này có nhiều tông màu lông từ xám nhạt với dải lông râu nhỏ đến trắng tinh với mảng lông râu trắng lớn. Nếu xếp một cá thể voọc đen tuyền vào cùng hàng với những cá thể có các tông màu râu khác nhau thì rất dễ dàng phân biệt sắc màu đen và trắng.

Một điều đặc trưng nữa là các cá thể cái "voọc núi đá vôi" khu vực Đông Dương thường có mảng da trắng ở chỗ háng. Các mảng da trắng này cũng giúp trong việc phân biệt giữa các cá thể.

Introduction

The Hatinh langur was described by Dao Van Tien (1970) as a subspecies of the Francois' langur (*Trachypithecus francoisi*) based on two specimens. Live animals were not known before 1992 (Le Xuan Canh, 1993). Since then, studies in the wild (Pham Nhat et al., 1996; Timmins et al., 1999; Haus et al., 2009), on a captive population at the Endangered Primate Rescue Center, Cuc Phuong National Park, and in a semi-wild area in Phong Nha-Ke Bang National Park have increased our understanding of this taxon (Nadler, 1994; 1996; 1997; Vogt et al., 2008). The systematic position of the taxon was revised based on molecular genetic and morphological features (Nadler et al., 2002; Roos, 2002; Roos et al., 2007). There is still, however, a lack of information about the variation of color pattern. Knowledge about coloration could be helpful in field identification and in gathering detailed information from the field for the closely related Lao langur (*T.* [*l.*] *laotum*) and

the black langur (*T.* [*l.*]

Fig.1. In Hatinh langurs (*Trachypithecus* [*laotum*] *hatinhensis*) there is a clinal variation in the intensity and extension of cheek coloration. Hatinh langurs with less prominent white cheeks are difficult to distinguish from black langurs in the field. Photos: Tilo Nadler.

hatinhensis morph *ebenus*). The systematic position and distribution of the black langur is still unresolved (Nadler, 2009).

Coloration of the Hatinh langur

Studying color variation in the field is very difficult. Different situations during observations (distance, light, movement of the animals) often make comparisons impossible. The Endangered Primate Rescue Center has kept over the years 67 Hatinh langurs, which includes 19 wild caught animals and 48 born at the center. This large number allows for a first overview on the variability of coloration.

Body coloration

The body coloration is usually described as black (Nadler et al., 2002) and this is – even upon close inspection of an animal or a specimen – mostly accurate. When compared to the glossy black hair of the Francois' langur (*Trachypithecus francoisi*), however, the Hatinh langur's hair appears to have a dark brown tinge.

Color pattern on the head

The typical pattern of the taxon is white cheeks on a black head, extending behind the ears and down to the neck. The color gradually varies between adult individuals from a smoky grey to clear white, and the extension of the cheeks are very variable (Fig. 1). If the black langur is included there is a clinal variation in the head coloration from a completely black head to a black head with bright white cheeks. The cheek pattern and coloration in Hatinh langurs changes also with age. Juveniles have a yellowish or brownish tinge in the white cheeks (Fig. 2). In adult Hatinh langurs the coloration and pattern of the cheeks doesn't change. Cheek color is the same in males and females and shows the same clinal variation.
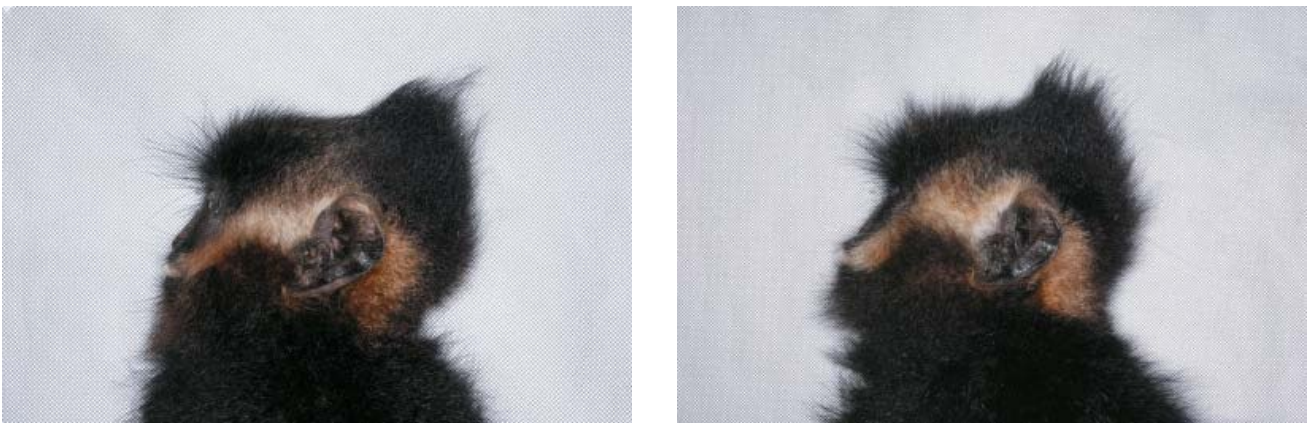
Fig.2. The cheeks of juvenile and subadult Hatinh langurs have a yellowish or brownish tinge; the animals are 15 and 44 months old. Photo Tilo Nadler.

The color of the cheeks does not usually change as an individual ages, however, in the case of a black langur at the Endangered Primate Rescue Center that had an entirely black head as a juvenile and subadult. By the age of ten years old the animal had developed smoky-grey cheeks where the typical Hatinh langur has a white or greyish color (Nadler, 2009).

The cheeks of the Francois' langur are always clear white. The form of the cheeks is slightly different in the Francois' langur. Their cheeks have mostly longer hairs that often form a tip close to the mouth. The Hatinh langurs do not have these tips but they do have a small white moustache that connects the cheeks. Francois' langurs do not have any white hairs along the upper lip (Fig. 3, 4 and 5).

Fig.3. Adult male Hatinh langur (*Trachypithecus* [*laotum*] *hatinhensis*). Hatinh langurs have a thin white moustache. The hairs of the cheeks do not form tips at the corner of the mouth and are shorter than in Francois' langurs. Photo: Tilo Nadler.

Fig.4. Adult male Francois' langur (*Trachypithecus francoisi*). Francois' langurs lack a white moustache. Also, the hairs on the cheeks are mostly longer than in Hatinh langurs and often form a tip at the corner of the mouth. Photo: Tilo Nadler.

Fig.5. Juvenile male Francois' langur (*Trachypithecus francoisi*) with prominent tips at the corners of the mouth. Photo: Tilo Nadler.

Color pattern of the pubic patch

In all six taxa of the Indochinese "limestone langurs", Cat Ba langur (*Trachypithecus* [*poliocephalus*] *poliocephalus*), white headed langur (*T.* [*p.*] *leucocephalus*), Delacour's langur (*T. delacouri*), Laos langur (*T.* [*laotum*] *laotum*), Hatinh langur, and black langur, females have grey, white or yellowish hairs in the pubic area. This area also shows a clinal variation in the size of depigmented skin. The variation ranges from small patches of depigmented skin to large ones (Fig. 6).

Fig.6. Females of Hatinh langurs (*Trachypithecus* [*laotum*] *hatinhensis*) have white hairs in the pubic area and a clinal variation in the extension of depigmented skin. Photos: Tilo Nadler.

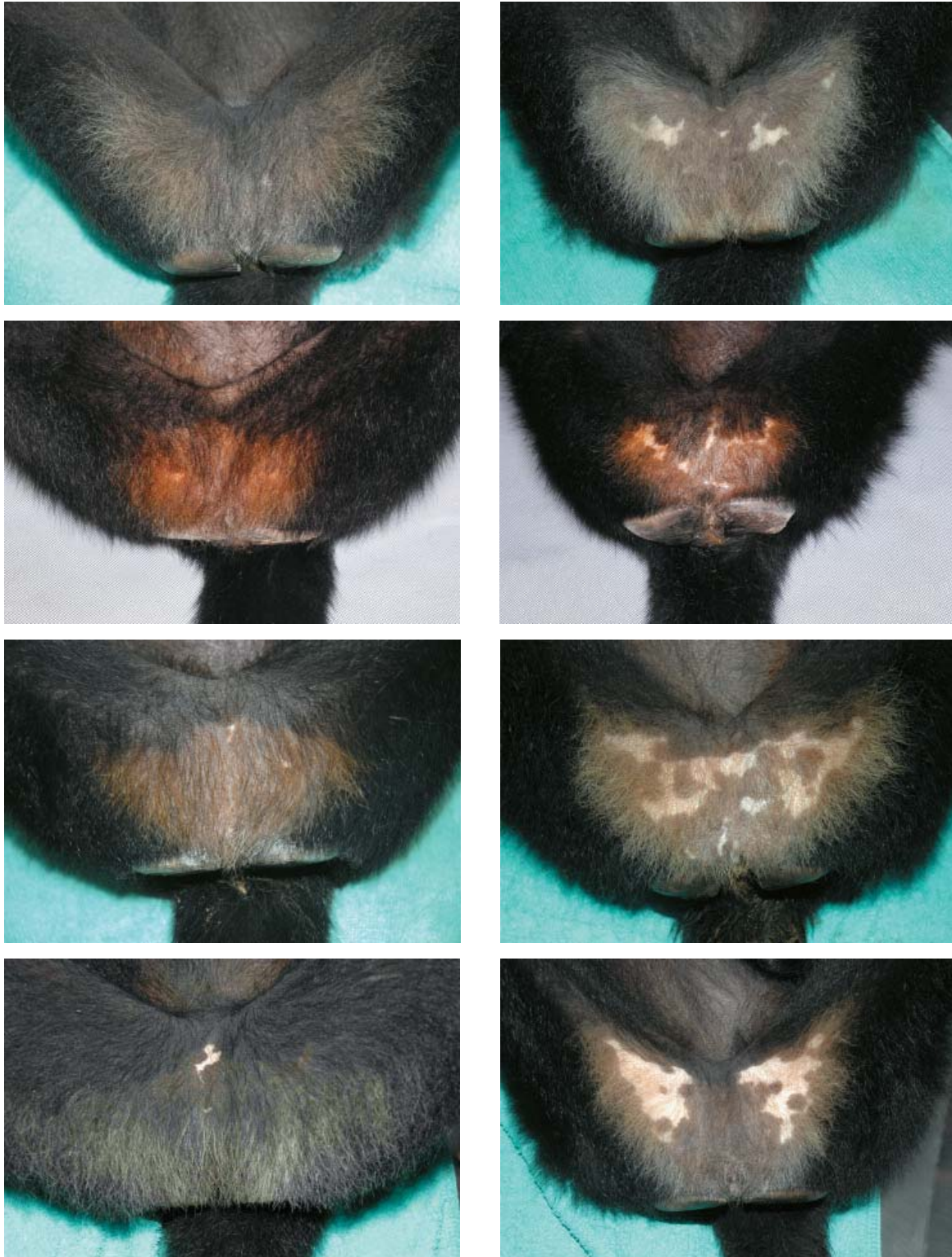The grey, white or yellowish hairs in the pubic area, can be used in the field to determine the sex of the animal. If the skin is depigmented than this hairs are easily visible. The extension and shape of the depigmented area varies across individuals and can be used for identification of individuals. The extension and intensity of the pubic patch do not change with age. In Hatinh langur females, the extension of the depigmented area is not correlated with the intensity of cheek coloration.

Male langurs never have white hairs or depigmentation in the pubic area. The only bright parts are the callosities and in adult males the white or pinkish penis. (Fig. 7)

Fig.7. Male Hatinh langurs (*Trachypithecus* [*laotum*] *hatinhensis*) do not have white hairs nor depigmented skin in the pubic area. In adult males the white or pinkish penis is normally visible; juvenile and adult animal. Photo: Tilo Nadler.

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Another population of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) discovered in Ha Giang Province, Vietnam

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Key words: Tonkin snub-nosed monkey, new population

Summary

During field surveys a new population of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) was discovered in Tung Vai forest of Quan Ba District, Ha Giang Province. As a result of the census survey in April 2008, a group of 14 -20 individuals were confirmed by observations in the as well as information of 2-3 additional unconfirmed groups of 20-40 individuals. Poaching is a major threat to the survival of the animals. Gunshots were heard during the surveys and local people hunting with guns observed.

The Tonkin snub-nosed monkey is listed as "Critically Endangered" and recognized as one of the world's 25 most endangered primates. The confirmation of this population is globally and nationally very significant for the conservation of the species and might be considered the second most viable population after that of Khau Ca.

Một quần thể khác voọc mũi hếch (*Rhinopithecus avunculus*) được phát hiện ở tỉnh Hà Giang, Việt Nam

Tóm tắt

Qua các cuộc điều tra thực địa một quần thể mới của loài voọc mũi hếch (*Rhinopithecus avunculus*) được phát hiện ở khu rừng Tùng Vài của huyện Quản Bạ, tỉnh Hà Giang. Kết quả của cuộc điều tra quần thể vào tháng 4/2008, một bầy gồm 14 – 20 cá thể đã được xác định bằng các quan sát cùng với đó thông tin về 2 – 3 bầy chưa được xác định khác với khoảng 20 – 40 cá thể. Săn bắt là mối đe dọa chính đối với sự tồn tại của những cá thể voọc này. Nhiều tiếng súng đã được nghe thấy trong suốt các cuộc điều tra và có quan sát được một số người dân địa phương vào rừng săn bắt có súng.

Voọc mũi hếch được xếp hạng "Cực kỳ Nguy cấp" và được coi là một trong số 25 loài linh trưởng nguy cấp nhất thế giới. Việc xác định quần thể có tâm rất quan trọng quốc gia và quốc tế đối với việc bảo tồn loài linh trưởng này và có thể coi như là quần thể khả sinh thứ hai sau quần thể ở Khau Ca.

During field surveys a new population of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) was discovered in Tung Vai forest of Quan Ba District, Ha Giang Province (Fig. 1). The primary observations and only photos of this population were made in October 2007 (Fig. 2). As a result of the census survey in April 2008, a group of 14 -20 individuals were confirmed by

Fig.1. Location of Tung Vai forest, Quan Ba Distric, Ha Giang Province.

Fig.2. Tonkin snub-nosed monkey in Tung Vai forest. Photo: Le Khac Quyet.

observations in the Ta Boc area as well as information of 2-3 additional unconfirmed groups of 20-40 individuals in Ma Cha Phin and Ta Lay areas (Le Khac Quyet et al., 2008). This is the second population of Tonkin snub-nosed monkey discovered in Ha Giang, the first being discovered in Khau Ca area in 2002 (Fig. 3) (Le Khac Quyet, 2004). A noteworthy aspect of this present discovery is that it represents a range extension for this species 40 km to the northwest. Because this population lives within a few kilometers of the border with China it brings up the likelihood that this species is not endemic to Vietnam but additional surveys on the Chinese side of the border is needed to evaluate this possibility.

Fig.3. Tonkin snub-nosed monkey in Khau Ca area of Ha Giang Province. Photo: Le Khac Quyet.

Fig.4. Local hunter in Tung Vai forest. Photo: Le Khac Quyet.

Poaching is a major threat to the survival of the Tonkin snub-nosed monkeys in Tung Vai forest. Le Khac Quyet et al. (2008) reported that they heard gunshots and observed some local people hunting with guns in the forest during their field surveys (Fig. 4). Cardamom (*Amomum* sp.) cultivation is very common in Tung Vai forest and is encroaching on the monkeys habitat (Fig. 5 and 6). Illegal timber logging and non-timber forestry products collection are also activities that likely disturb the Tonkin snub-nosed monkeys in Tung Vai (Le Khac Quyet et al., 2008).

To protect this new population, the Fauna & Flora International (FFI) – Vietnam Conservation Support Programme and the Ha Giang Forest Protection Branch initially implement conservation activities including establishment of three community-based patrol groups and awareness raising for local communities in Tung Vai, Ta Van and Cao Ma Po Communes (Hoang Van Tue, Ha Giang Forest Protection Branch, pers. comm., 2010).

The Tonkin snub-nosed monkey is recognized as one of the world's 25 most endangered primates (Le Khac Quyet et al., 2009) and restricted to a small area in northern Vietnam where it is endemic. It is estimated that only approximately 250 individuals exist today living in Tuyen Quang and Ha Giang Provinces (Boonratana & Le Xuan Canh, 1994; Nadler et al., 2003; Le Khac Quyet, 2004; Le Xuan Canh & Boonratana, 2006; Le Khac Quyet & Vu Ngoc Thanh, 2006; Le Khac Quyet et al., 2008; Covert et al., 2008).

The Tonkin snub-nosed monkey is listed as "Critically Endangered" in the 2009 IUCN Red List of Threatened Species (IUCN, 2009) and as "Critically Endangered" in the Red Data Book of Vietnam (Ministry of Science, Technology and Environment, 2007). It is legally protected from hunting and national trade by Vietnam's Government Decree No. 32/2006/ND-CP; and from international trade by Appendix I of CITES (CITES, 1998). Threats to the animals throughout their range are hunting for traditional medicine as well as habitat loss, fragmentation and degradation (Nadler et al., 2003; Le Xuan Canh & Boonrantana, 2006; Le Khac Quyet & Vu Ngoc Thanh, 2006; Covert et al., 2008).

According to Le Khac Quyet et al. (2008), the confirmation of a new population of 14 to 20 individuals in Tung Vai forest, Quan Ba District, Ha Giang Province, is globally and nationally very significant for efforts to conserve this species, particularly given the apparent rapid population declines at Na Hang and Cham Chu. When one compares the known populations (Table 1), the population in Tung Vai might be considered the second most viable population after that of Khau Ca. Of particular importance, the presence of three infants (probably born in late 2007 or early

Fig.5. Cardamom cultivation in Tung Vai forest. Photo: Le Khac Quyet.

Fig.6. Tung Vai forest. Photo: Le Khac Quyet.

2008) that were recorded during this survey provide significant hope that this population is breeding and has the potential for growth. Additional surveys, monitoring, and behavioral ecology work by trained primatologists is clearly needed to further our understanding of the viability of the population in Tung Vai and adjacent areas.

Table. 1. Distribution areas and number of Tonkin snub-nosed monkeys recorded in Vietnam.

Location	Year	Number		Sources
		Confirmed	Estimated	
Khau Ca area (Ha Giang Province)	2009	92	100	Le Khac Quyet, pers. observ.
Tung Vai forest (Ha Giang Province)	2008	14	20-40	Le Khac Quyet et al. (2008)
Tat Ke Sector of Na Hang Nature Reserve (Tuyen Quang Province)	1993 1998 2004 2005	72 13 40 17	80 16 - 22	Boonratana & Le Xuan Canh (1994) Booratana (1999) Wolters (2004) Dong Thanh Hai (2007)
Ban Bung Sector of Na Hang Nature Reserve (Tuyen Quang Province)	1993 1999 2005	23 0 0	50 40-45 50	Boonratana & Le Xuan Canh (1994) Nguyen Xuan Dang & Nguyen Tuong Son (1999) Le Xuan Canh & Boonratana (2006)
Cham Chu Nature Reserve (Tuyen Quang Province)	2001 2006	8 0	70 8-12	Long & Le Khac Quyet (2001) Dong Thanh Hai et al. (2006)

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Activity budget of grey-shanked douc langurs (*Pygathrix cinerea*) in Kon Ka Kinh National Park, Vietnam

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Key words: Activity budget, *Pygathrix cinerea*, seasonality

Summary

The grey-shanked douc langur (*Pygathrix cinerea*) is an endemic primate to Vietnam and was only recently described (Nadler, 1997). The species is listed as "Critically Endangered" (IUCN, 2010), with an estimated number of less than 1,000 individuals. However, there is poor understanding of the behaviour and ecology of this species. This paper provide the first data on the activity budget of a group with about 88 individuals in Kon Ka Kinh National Park. The results are based on 480 hours of direct observation in the wild. The animals spent most of the time for resting (37.0%) follow by travelling (25.8%) socialising (25.1%), and feeding (11.9%).

Seasonality significantly influenced the activity budget of the animals resulting in increased resting and socialising in the wet season and decreased feeding and travelling. Adult females spent more time feeding, resting and travelling than adult males, while adult males spent more time being vigilant. Long periods of resting might be related to the fermentation process of the cellulose in their plant diet.

Nghiên cứu quỹ thời gian hoạt động của loài vọoc chà vá chân xám (*Pygathrix cinerea*) tại Vườn Quốc gia Kon Ka Kinh, Việt Nam

Tóm tắt

Loài vọoc chà vá chân xám (*Pygathrix cinerea*) là loài linh trưởng đặc hữu của Việt Nam và mới được mô tả gân đây (Nadler, 1997). Loài này được liệt vào danh sách các loài "Cực kỳ Nguy cấp" của tổ chức Bảo tồn Quốc tế (IUCN, 2010), với chỉ khoảng 1000 cá thể sót lại trong tự nhiên. Tuy nhiên, những hiểu biết về tập tính và sinh thái của loài còn rất ít. Trong bài báo này chúng tôi công bố những số liệu đầu tiên về tập tính hoạt động của loài, tập trung vào quỹ thời gian hoạt động của một đàn gồm 88 cá thể chà vá tại Vườn Quốc gia Kon Ka Kinh. Số liệu được phân tích dựa trên 480 giờ quan sát trực tiếp các cá thể trong điều kiện tự nhiên. Kết quả cho thấy loài đã sử dụng thời gian nhiều nhất cho việc nghỉ ngơi (37%), tiếp theo là di chuyển (25,8%), hoạt động xã hội bầy đàn (25.1%) và cuối cùng là việc ăn (11,9%). Chu kỳ mùa ảnh hưởng rõ rệt đến quỹ thời gian hoạt động của loài. Trong mùa mưa, thời gian dành cho việc nghỉ ngơi và hoạt động xã hội bầy đàn tăng lên còn thời gian dành cho việc ăn và di chuyển giảm xuống. Những con cái trưởng thành dành nhiều thời gian cho việc ăn, di chuyển và hoạt động xã hội bầy đàn hơn những con đực trưởng thành. Trong khi đó, những con đực trưởng thành lại

dành nhiều thời gian cho việc cảnh giới bảo vệ đàn. Thời gian nghỉ ngơi lâu của loài chà vá chân xám có thể liên quan đến đặc trưng của hệ tiêu hóa và thức ăn chính của loài là lá cây rừng. Quá trình lên men trong dạ dày nhờ vi khuẩn để chuyển hóa xenlulo ở lá cây thành chất dinh dưỡng.

Introduction

The proportion of time that animals spend in different activities and the duration of each activity through the day are important aspects of species ecology (Clutton-Brock, 1974; Chapman & Pavelka, 2005). Identifying how primates budget their activity throughout the day and the year is important for understanding how they interact with their environment and invest their energy and time for optimum reproduction and survival (Defler, 1995). Variation in activity budget, such as time spent feeding and ranging, is associated with the availability and distribution of food sources, which are influenced by environmental factors, such as rainfall and temperature (Milton, 1982; Oates, 1987).

Activity budgets of many colobine species have been studied in Africa and Asia (Clutton-Brock, 1975; Bennett, 1983; Fashing et al., 2007; Guo et al., 2007; Kirkpatrick, 2007; Matsuda et al., 2009). In general, the colobines spend a remarkably high proportion of their time resting and a very low proportion of their time socialising. Activity budgets of many primate species are significantly influenced by seasonality. Activity patterns of grey-shanked douc langurs have not been previously studied. In this study we analysed the daily and yearly activity budget, seasonal influences and the differences between sex and age classes.

Material and Methods

Data collection

The study was carried out in Kon Ka Kinh National Park in Gia Lai Province from August 2007 to July 2008.

Scan-sampling method (Altmann, 1974) at 5-minute intervals was used for data collection on the activity budgets. Only one activity was recorded for each individual in one scan. A total of 7,390 observations were made for different sex/age classes.

Activities were grouped into five main categories: feeding, resting, travelling, socialising and other. There were 35 sub-categories of activity. The data record started in the morning when the first member of the group left the sleeping tree and ended in the evening when the last member of the group entered the sleeping tree. The observer normally arrived at the sleeping tree 30 minutes before sunrise and left 30 minutes after sunset to ensure that the first activity and the last activity of the langurs would be observed (Fig. 1 and 2).

Data analysis

Budgets for each major activity (feeding, resting, socialising, travelling, and others) were calculated by obtaining the ratio between total records of a particular activity and total records of all activities. Because data of the category "other" were so few, only accounting for less than 1% of the annual activity budget, they are excluded from data set. A one-way Chi-square test was used to assess the difference in frequency of each activity annually. A two-way Chi-square test was used to test the independence of activity budget versus seasonality, sex classes and age classes.

Fig.1 and 2. Grey-shanked douc langurs (*Pygathrix cinerea*) at Kon Ka Kinh National Park. Photo: Ha Thang Long.

Results

Activity time

The daily activity of the langurs began between 5am and 6am. The earliest time that the animals started their activity was 5:15am on 14th April 2008 and the latest time was 6:20am on 17th May 2008. The earliest time the langurs ceased daily activities was 5:04pm on 14th January 2008 and the latest time was 6:45pm on 11th May 2008.

The time of sunrise differed significantly between wet season and dry season (t= -3.98, df=43, p<0.0001). Mean time of sunrise was 5:56am (n=19) in the dry season and 6:21am (n=26) in the wet season. Thus, the sun rises 25 minutes earlier in the dry season than in the wet season, but, the starting activity was not correlated with time of sunrise of (r_s= -0.14, p=0.62, n=14).

The time of sunset differed significantly between wet season and dry season (t= 2.42, df=45, p=0.01). Mean sunset time was 5:51pm (n=21) in the dry season and 5:33pm (n=26) in the wet season. Thus, the sun set 18 minutes later in the dry season than in the wet season. Cessation of activity was also not correlated with time of sunset (r_s= -0.005, p=0.9, n=18).

Activity budget

The activity budget for the five major activities is shown in Fig. 3. Time budgets for different activities - feeding, resting, travelling and socialising - varied significantly (X^2=936.14, df=3, p<0.0001). The langurs spent the highest proportion of time resting (37.0%), followed by travelling (25.8%) and socialising (25.1%). The proportion of time spent on feeding was lowest (11.9%). The high proportion of time spent on resting is consistent with other studies on colobines. The langurs need more resting time for the food fermentation process.
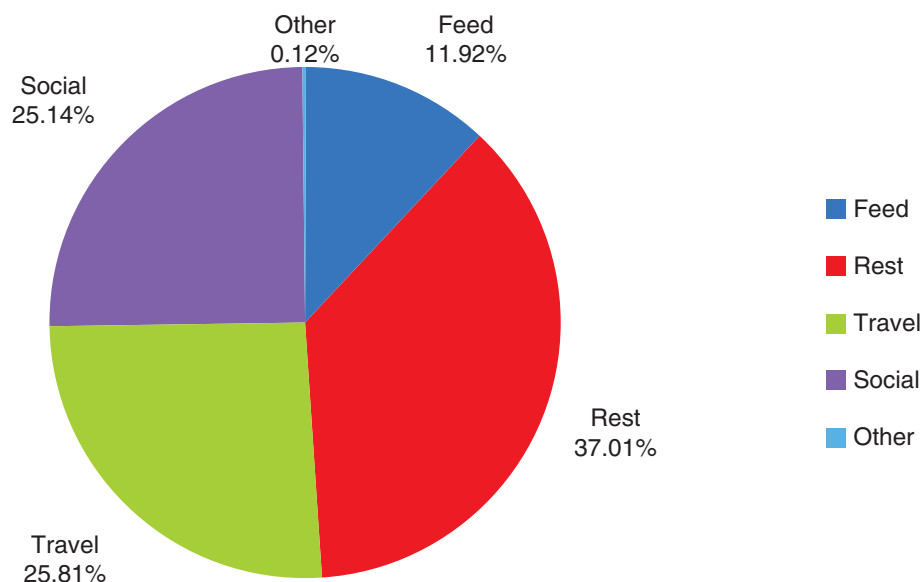

Fig.3. Annual activity budgets of grey-shanked douc langurs.

Daily activity budget

Variations in the daily time budget for different activities are presented in Fig. 4. Differences in daily budget between the wet and dry season are shown in Fig. 5.
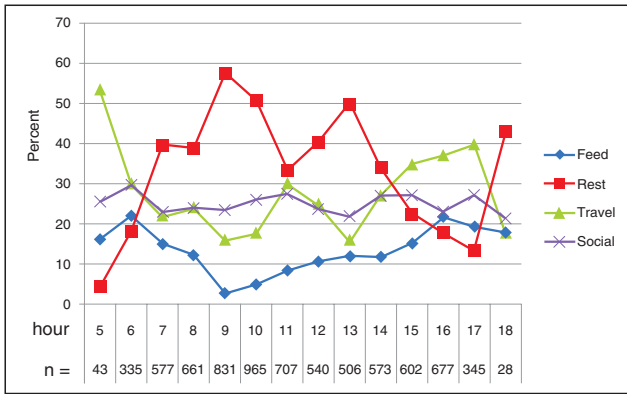
Fig.4. Variation in daily activity budgets from 5:00am to 6:00pm.
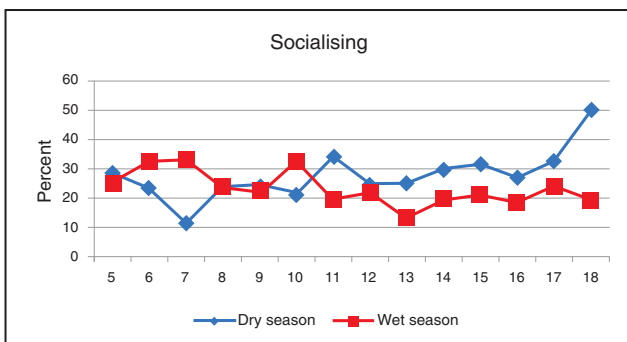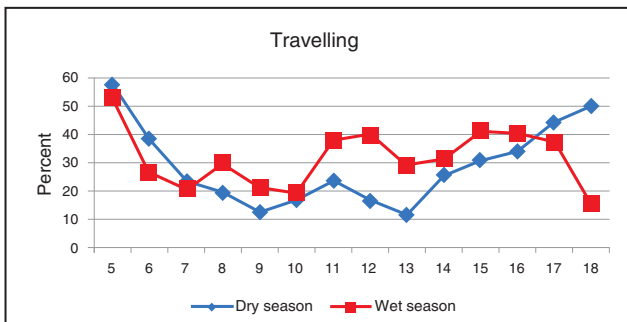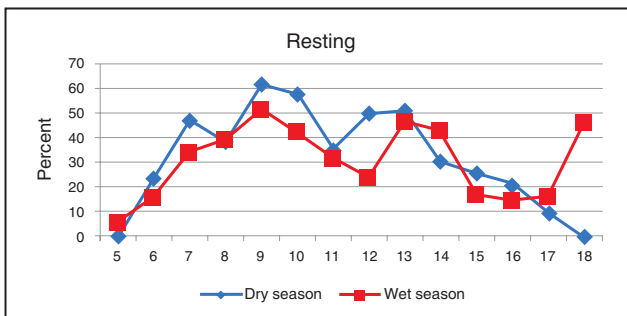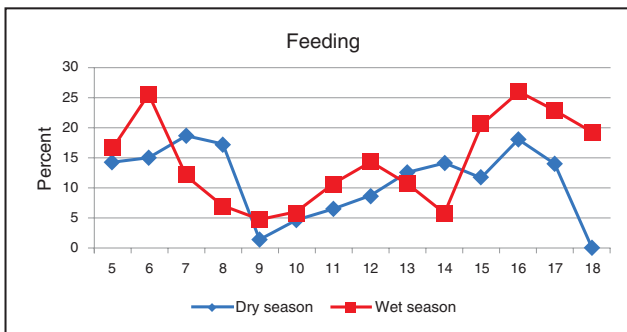
Fig.5. Seasonal differences in daily activities during dry and wet season.

The time budget for these activities varied significantly during a day (X^2=780.31, df=39, p<0.0001). The monkeys fed as soon as they moved out from the sleeping site; they fed all day, but there were two main feeding peaks, one in the early morning at 6:00am and the other in the late afternoon at 4:00pm. Feeding activity was reduced mostly by 9:00am when the monkeys rested. The time budget for feeding was negatively correlated with resting (r_s= - 0.74, p=0.002, n=14). This means that when the monkeys rested they reduced feeding activity.

The daily feeding pattern of the langurs changed between wet season and dry season. In the dry season, the langurs fed more frequently and evenly in every hour of the day. The proportion of feeding time during a day ranges from 1.4 to 18.7%. There were two feeding peaks at 7:00am and 4:00pm. Conversely, in the wet season, the monkeys fed more extensively in the early hours of the day 6:00 am (25.4%) and late afternoon 4:00pm (25.9%). The proportion of time spent feeding in a single day ranged from 4.7 to 25.9%. In general, the monkeys fed extensively at particular times of the day in the wet season, but they fed more frequently and evenly between different hours of the day in the dry season.

The langurs rested during two periods of the day. The first period of resting was after feeding from 9:00am to 10:00am and the second period was from 1:00pm to 2:00pm. In the first resting period, the langurs spent the greatest proportion of their time being inactive (57.6%). This was even greater than the proportion of time spent resting at midday (50.0%). So, unlike many other diurnal primates, which often have one period of resting time in the middle of the day, grey-shanked douc langurs had a second rest period during the day.

The pattern of the two resting periods applied to both wet and dry seasons and the monkeys spent different amounts of time resting through the day between the two seasons. For example,

the monkeys did not rest at all in the early hours of the day and late hours in the afternoon in the dry season, while they rested during these hours in the wet season.

The monkeys travelled mostly in early morning from 5:00am to 6:00am, when they moved out of their sleeping site and searched for food, and in the late afternoon around 5:00pm to find a sleeping site. The pattern of travelling was quite similar in the wet and dry seasons in the first half of the day, but it was dissimilar in the second half of the day (Fig. 5). The monkeys travelled more in the afternoon in the wet season than they did in the dry season, probably because of the difference in temperature pattern. The temperature was hot in the afternoon in the dry season, which may promote inactivity, while in the wet season the monkeys became active as the temperature lowers in the afternoon. Time budget for travelling was negatively correlated with that of resting (r_s= - 0.94, p<0.001, n=14). This means that when the monkeys travelled more they spent less time resting.

The monkeys spent fairly consistent proportions of time socialising during the day (ranging from 21.4 to 29.6%). The time budget for socialising was not correlated with feeding, resting and travelling. Socialising activities were displayed like this: at 6:00am, the infants and juveniles were playing, scrambling and calling each other, while the adults were feeding. Between 9:00am and 10:00am, the group engaged more frequently in social activities such as group grooming between adult females, playing between juveniles, and calling between mothers and infants. Social activities decreased at midday around 1:00pm as sleeping increased. The main social activity was self-grooming during this time. In the afternoon, from 3:00pm to 4:00pm, the social activity involved calling between group members during travelling.

Activity budget and monthly variation

Monthly variations in time budgets for different activities are presented in Fig. 6. Budgets for major activities, such as feeding, resting, travelling, and socialising varied significantly between months (X^2=754.89, df=33, p<0.0001). The activity budgets were different between November 2007 and January 2008.
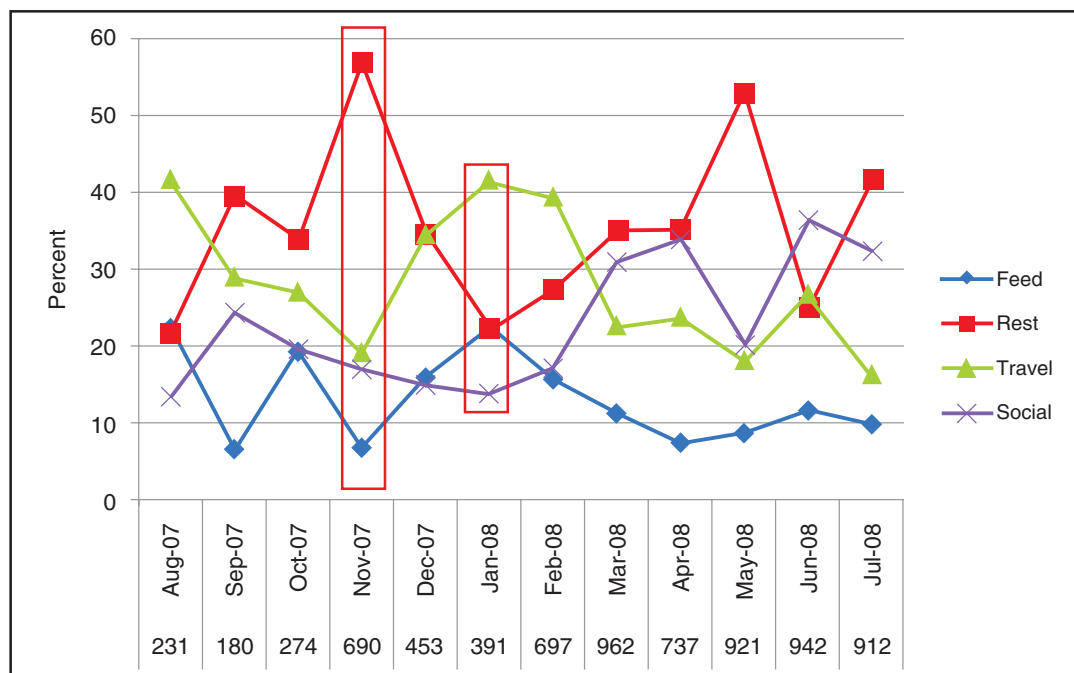
Fig.6. Variation in monthly activity budget.

In January 2008, the monkeys spent more time feeding (22.7%), and travelling (41.4%) and less time resting (22.5%). Conversely, the monkey spent the most amount of time resting (56.81%), the least amount of time feeding (6.95%) and a lower proportion of time travelling (19.13%) in November 2007. This contrast may result from differences in weather conditions, and differences in food availability, such as young leaves and fruits.

During the dry season in January 2008, the availability of fruits was low (ranked 10th in the 12 months of study) and the availability of young leaves was quite high (Production Index ranked 5th). The monkeys spent 86% of time feeding on young leaves and 3% on fruits. During the wet season in November 2007, the availability of fruits was high (ranked 3rd in the 12 months of study) and young leaves were low (ranked 9th). The monkey diet comprised of 48% fruit and 49% young leaves.

Activity budget and seasonality

Seasonal variations in budget for different activities - feeding, resting, travelling and socialising - are presented in Fig. 7.

Proportion of times spent in major activities differed significantly between wet and dry seasons (X^2=103.3, df=3, p<0.0001). The monkeys spent more time resting in the wet season (41.1%) than in the dry season (31.7%). The proportion of time spent feeding in the dry season (13.4%) was higher than in the wet season (10.7%). The proportion of time the monkeys spent travelling in the dry season (30.4%) was much higher than in the wet season (22.2%). The monkeys spent nearly the same amount of time socialising in both seasons (25.7%) and (24.3%). This means that seasonality influenced significantly the activity budget of grey-shanked douc langurs in Kon Ka Kinh National Park. The same result was also found in black-shanked douc langurs, in the south of Vietnam (Hoang Minh Duc, 2007). Seasonality affected strongly the productivity of food resources, such as young leaves and fruits in the study site. Variations in food availability have regulated the activity budget of the monkeys, especially feeding and ranging.

Wet season (n=4,150)

Dry season (n=3,240)
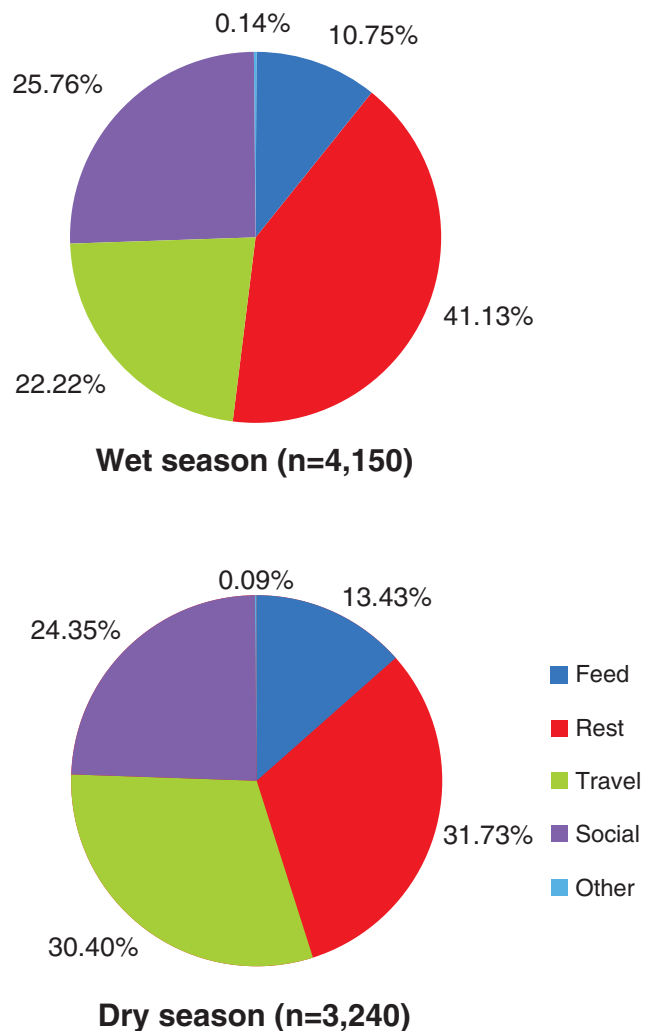
Fig.7. Variation in activity budgets between dry and wet seasons.

Difference in activity budgets between sex/age classes

Variation in activity budget between males and females are presented in Fig. 8, between age classes in Fig. 9, and for combined sex/age classes in Fig. 10.

Fig.8. Variation in activity budgets between males and females.

Fig.9. Variation in activity budgets among different age classes.

Fig.10. Variation in activity budgets between adult males and adult females.

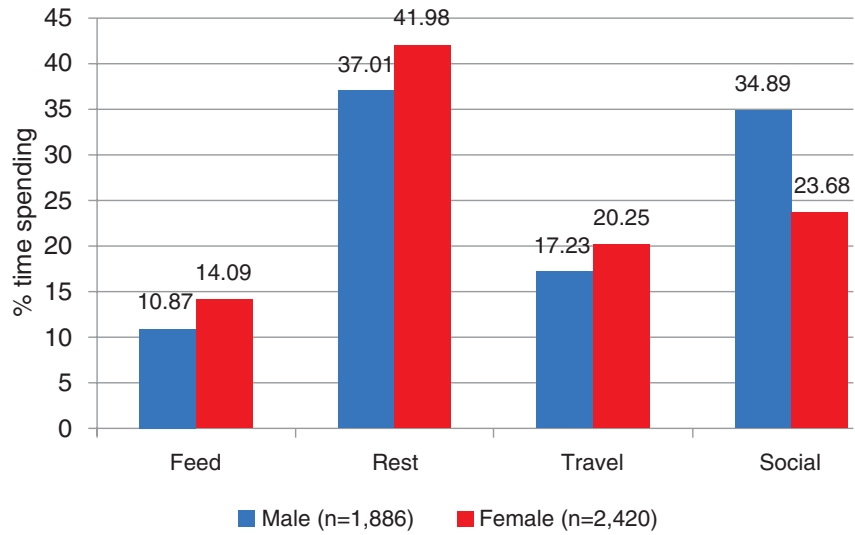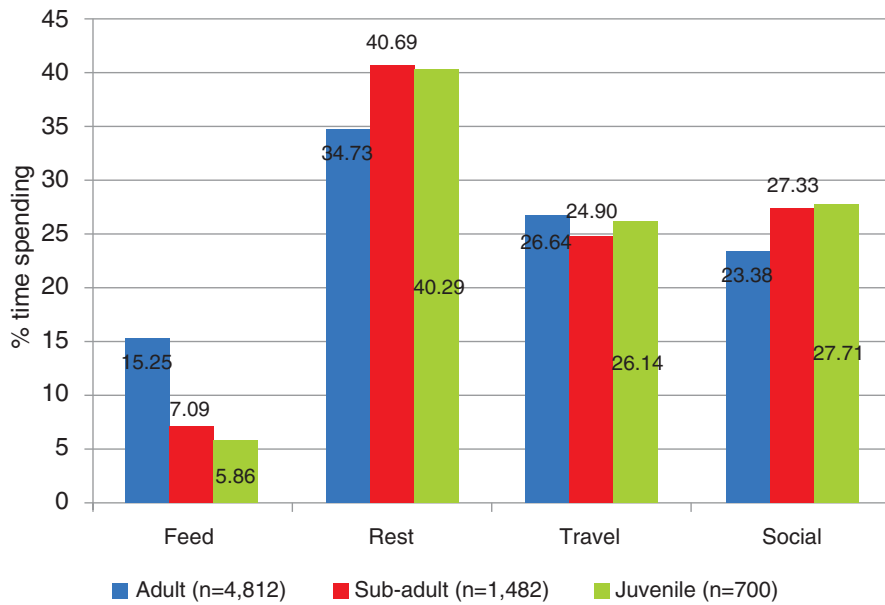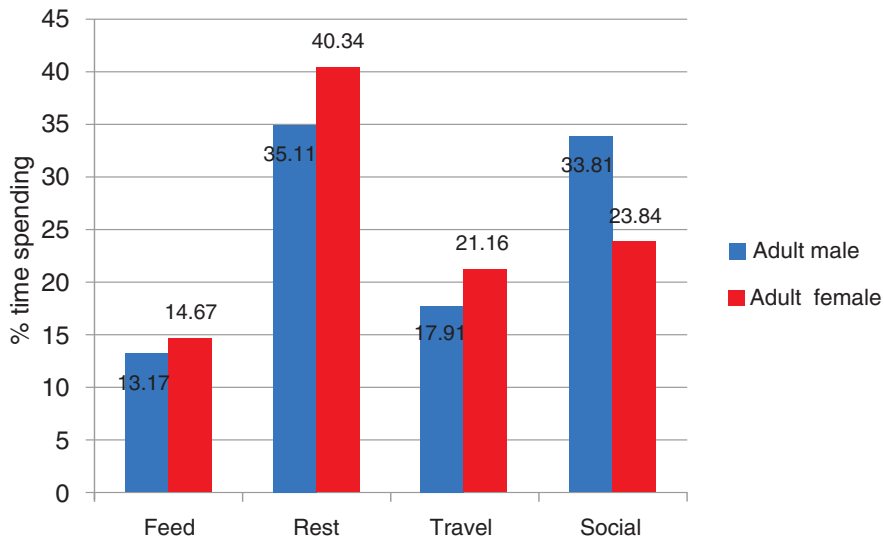Among 7,380 total observations, there were 1,886 observations on females and 2,420 on males. The proportions of time spent in major activities - feeding, resting, travelling and socialising - varied significantly between male and female (X^2=66.95, df=3, p<0.0001). Female monkeys spent more time feeding (14.0%) than males (10.8%). Female monkeys also spent more time resting 41.9% than males 37.0%, and more time travelling (20.2% versus 17.2%). Males, however, spent more time in social activity (34.8%) than females (23.6%).

Among 7,380 observations, there were 4,819 observations on adults, 1,483 on sub-adults, and 700 on juveniles. Budgets for the major activities of feeding, resting, travelling and socialising varied significantly between age classes (X^2=113.49, df=6, p<0.0001). Adults spent more time feeding (15.2%) than sub-adults (7.0%) and juveniles (5.8%). Adults spent less time in social activity (23.3%) than sub-adults (27.3%) and juveniles (27.7%). Sub-adults spent more time resting (40.6%) than adults (34.7%).

Variation in time spending for main activities varied significantly between adult males and adult females (X^2=41.92, df=3, p<0.0001). Adult females spent more time feeding (14.6%) than adult males (13.1%). Similar results were also found for resting and travelling. Adult females spent 40.3% of their time resting, while adult males spent 35.1%. For travel time, adult females spent 21.1% and adult males spent 17.9%, but the adult males spent much more time socialising (33.8%) than adult females (23.8%). The reason for more socialising behaviour in adult males may be due to vigilance being labelled as social, which contributed to a large amount of time and interaction between adult males.

Discussion

Resting time and fermentation process

The grey-shanked douc langurs spent the greatest proportion of time resting (37.1%), which is quite consistent with activity budgets of other colobines in Africa and Asia (e.g., *Colobus guereza* Fashing, 2001c; *Trachypithecus auratus* Kool, 1989; *Pygathrix nigripes* Hoang Minh Duc, 2007; *Pygathrix nemaeus* Otto, 2005; *Pygathrix nigripes* Rawson, 2006). One possible explanation was that these monkeys fed heavily on mature leaves, which need to be fermented in the foregut (stomach) in order to extract energy from them. The fermentation process requires a long resting period. Fashing (2007) provided data on time spent resting by different colobines in Africa to support this hypothesis. Nine populations of Colobus spent 54% of their time resting, eight *Piliocolobus* populations spent 47%, and one *Procolobus* population spent 40%. So, this might suggest that the long time spent resting relates to a physiological adaptation of leaf-eating primates.

Dasilva (1993) argued that prolonged resting is a behavioural adaptation to the low-energy strategy of leaf-eating primates, rather than a physiological adaptation for fermentation. She pointed out that not only colobine monkeys consume large amounts of leaves. So also do other primates, such as *Alouatta palliata* and *Brachyteles arachnoides*, which have simple stomachs. According to Milton (1979) *Alouatta palliata* spent from 40% to more than 90% of their daily feeding time eating leaves. The species spent up to 65% of their daily hours sleeping and resting. Dasilva (1993) concluded that the high proportion of resting may be related to high proportion of leaves in diets, but may not necessarily relate to fore-gut fermentation. Leaf-eating is a low-energy strategy, but it requires fermentation either in the stomach or caecum/colon, so this must be related to resting. Note that colobines eat more mature leaves than the New World monkeys mentioned, which should increase the resting/fermentation link.

Resting normally occurs in mid-day for many diurnal primates (Fleagle, 1999). Due to the heat rise in the mid-day primates have to rest to balance their body temperature (Oates, 1987). In this study, the monkeys had two periods of resting. The first resting period was from 9:00am to 10:00am and the other was around mid-day. The resting period in the mid-day can be explained by thermo-regulation, but it is unclear why the monkeys need the first rest period between 9:00am and 10:00am and what the role of this resting period is in their daily lives. The activity pattern shows that the monkeys feed around 6:00am and then gradually rest more. The peak of resting was at 9:00am, when the monkeys spent nearly 60% of their time resting. This pattern demonstrates that resting time is necessary and is related to fermentation in leaf-eating colobines.

Comparison of activity budgets among odd-nosed monkeys

Odd-nosed monkeys share several common morphological characteristics. The annual activity budget of grey-shanked douc langurs was compared to 6 other species of odd-nosed monkey in Asia (Table 1). The result revealed that almost all 7 species spent very high proportions of time resting. The lowest proportion of time was spent socialising in all of these species. Proportion of time allocated to main activities decreased in the following order: resting, feeding, travelling and socialising. *Rhinopithecus roxellana* spent the most time feeding (35.8%); *Nasalis larvatus* spent the highest proportion of time resting (76.5%); *Pygathrix nemaeus* travelled most (49.0%); *Pygathrix cinerea* socialised most (25.8%); *Pygathrix cinerea* fed least (11.9%); and *Nasalis larvatus* socialised least 3.5%.

Table. 1. Comparison of activity budgets among members of the odd-nosed monkey group.

Species	Site	Feeding	Resting	Socialising	Travelling	Others	References
Pygathrix cinerea	Kon Ka Kinh National Park, Vietnam	11.9	37.0	25.1	25.8	-	This study
P. nigripes	Nui Chua National Park and Bu Gia Map National Park, Vietnam	35.0	42.9	5.9	14.6	-	Hoang Minh Duc, 2007
P. nemaeus (in captivity)	Cuc Phuong National Park, Vietnam	34.0	49.0	5.0	7.0	3.0	Otto, 2005
Nasalis larvatus	Menanggul River, Sabah, Malaysia	19.5	76.5	-	3.5	-	Matsuda et al., 2009
Rhinopithecus avunculus	Khau Ca Forest, Vietnam	14.8	31.9	23.5	19.8	9.9	Dong Thanh Hai, 2008
R. roxellana	Qinling Mountains, China	35.8	36.2	-	22.9	5.1	Guo et al., 2007
R. bieti	Tacheng, Yunnan, China	35.0	33.0	13.0	15.0	-	Ding & Zhao, 2004

Kool (1989) suggested that direct comparison of activity budgets between species may have potential bias because: (1) the definition of activity varied between studies; (2) differences in age/sex class composition of study groups may bias activity budgets based on group activity; and (3) differences in visibility conditions between study areas may result in varying degrees of bias when using the scan-sampling method. Thus, the comparison of activity budgets among odd-nosed monkeys only provides a basis for further discussion. Great care should be taken when conducting a direct comparison; the same method should be used for an effective comparison.

Seasonality and activity budget

Activity budget of the grey-shanked douc langurs in Kon Ka Kinh National Park is significantly influenced by seasonality. The monkeys spent much time feeding and travelling in the dry season, but they spent significantly more time resting in the wet season. The same result was found in the sister species, *Pygathrix nigripes*. Hoang Minh Duc (2007) reported that the black-shanked douc langurs spent more time feeding in the dry season (41.5%) than in the wet season (31.7%), but they spent more time resting in the wet season (45.5%) than in the dry season (37.9%). Dasilva (1992) also found that *Colobus polykomos* decreased their feeding and increased resting during the wet season.

The differences in resting and feeding between wet season and dry season may be related to an energy-conserving strategy for primates (Fashing, 2007). There are several significant costs that monkeys have to balance during the wet season. Firstly, while raining, visual conditions could limit food-searching activity. The cost of energy expended while feeding in the rain might exceed the energy benefit from gaining more food. Raemaekers (1980) reported that heavy showers caused siamangs (*Symphalangus syndactylus*) to halt their activities until the rain lessened. In this study, the grey-shanked douc langurs also stopped their activity during heavy showers, and the heavy rain happened more frequently in the wet season.

Secondly, body temperature will decrease due to heat loss from body to wet fur in the wet season. Primates are expected to rest to save energy. Some even changed their resting posture to reduce the loss of energy in the wet weather. Evidence from *Colobus polykomos* was that the monkeys changed their resting posture through increased "hunching" and "lying" during the wet season (Dasilva, 1992; 1994). Milton (1979; 1982) suggested that *Alouatta palliata* change their body postures to conserve energy. In this study, the grey-shanked douc langurs also increased significantly the "hunching" position for resting during the wet season (from 50.6% in dry season to 71.0% in wet season). Therefore the monkeys showed that they also economise behaviourally in the wet season by resting more.

Thirdly, differences in diet composition in the wet season may also lead to decreased feeding and increased resting. Fruits and seeds generally provide more energy than leaves (Waterman & Kool, 1994). Dasilva (1992) found that seeds provided many more calories (kcal/g fresh weight) than young leaves and fruits in Tiwai Island. Nutritional value, such as the protein/fibre ratio, lipids, sugars in young leaves, fruits and seeds, changed according to study site (Kay & Davies, 1994). Thus, the monkeys can quickly obtain their daily nutritional needs when they eat more fruits and seeds.

In this study, the monkeys fed very high proportions of fruits and seeds in the wet season. On average, their diet comprised 69.5% fruits and seeds in the wet season. The monkeys ate up to 96% fruits with a high proportion of seeds in August, September and October, when the availability of

fruits was greatest. It is clear that the monkeys obtained their daily energy requirement quicker, and they reduced feeding to save energy in wet weather. In fact, the feeding pattern of the monkeys in the wet season was very intensive early in the day, rather than feeding more frequently and evenly through the day in the dry season. Further study of nutritional value of food items (seeds, fruits and young leaves) eaten by the langurs in Kon Ka Kinh National Park will provide a clearer explanation.

The difference in time spent travelling between wet and dry seasons was a result of a negative correlation between resting and travelling. Thus, when the monkeys increased resting time in the wet season, travel time decreased. The reverse occurred in the dry season, when the monkey decreased resting and increased travel. Ecological factors that affect resting time in the wet season were explained above, but there was another factor that could result in increased travel time in this study - human disturbance and the semi-habituated nature of the observed groups. In the dry season, the monkeys were more alert for human presence, including researchers. The sound of people stepping on dry leaves made the monkeys more aware of their presence and this led to increased travel. Hoang Minh Duc (2007) also found that the unhabituated groups of black-shanked douc langurs travelled more due to human disturbance.

The category "travelling" was quite ambiguous. It did not just involve the monkeys moving between trees, but it also included moving in the same tree. For a clearer description, the category "move" should be recorded as a sub-category of "travel".

Difference in time budget between adult females and adult males

Food intake requirement of adult females is believed to be higher than adult males due to the additional metabolic requirements of pregnancy and lactation. Thus, the proportion of time spent feeding by adult females is higher than adult males per unit body weight (Clutton-Brock, 1977; Demment, 1978). Post (1980) provided evidence that adult female yellow baboons (*Papio cynocephalus*) spent more time feeding than adult males per unit of body weight. He also found that the average proportion of time spent feeding by pregnant females was substantially higher than lactating females in the same group. In this study, the proportion of time spent feeding by adult females was higher than adult male. The species is a sexually monomorphic primate, and the results are consistent with other studies.

Acknowledgments

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Water consumption of Delacour's langurs (*Trachypithecus delacouri*) and grey-shanked douc langurs (*Pygathrix cinerea*) in captivity

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Key words: Water consumption, Delacour's langur, grey-shanked douc langur, *Trachypithecus delacouri, Pygathrix cinerea*

Summary

There are no information about the amount of water consumption of Delacour's langurs (*Trachypithecus delacouri*) and grey-shanked douc langurs (*Pygathrix cinerea*). This study provides the first long-term observation and measurement about water consumption of these species in captivity. The study was carried out at the Endangered Primate Rescue Center, Vietnam.

The study analyzed water consumption through food and active drinking. Both species cover about 60% of their demand on water through food which is provided as freshly cut leaves and about 40% through active drinking. The total water consumption is correlated with the air temperature, and increase by Delacour's langurs from 0,07 ml/g body weight by 24°C to 0.18 ml/g body weight by 32°C air temperature, and by grey-shanked douc langurs from 0,10 ml/g body weight by 24°C to 0,16 ml/g body weight by 32°C air temperature.

Tập tính uống nước ở loài vọoc mông trắng (*Trachypithecus delacouri*) và loài vọoc chà vá chân xám (*Pygathrix cinerea*) trong điều kiện nuôi nhốt

Tóm tắt

Cho đến nay, những hiểu biết về lượng nước tiêu thụ của loài vọoc mông trắng (*Trachypithecus delacouri*) và loài vọoc chà vá chân xám (*Pygathrix cinerea*) chưa được nghiên cứu. Bài báo này cung cấp những dữ liệu đầu tiên căn cứ trên một nghiên cứu dài hạn đo đếm lượng nước tiêu thụ của hai loài trên. Nghiên cứu được thực hiện tại Trung tâm Cứu hộ Linh trưởng Nguy cấp, Việt Nam. Nghiên cứu đã đo đếm lượng nước tiêu thụ từ hai nguồn: thức ăn và việc uống nước. Kết quả cho thấy, cả hai loài đều hấp thụ khoảng 60% nhu cầu về nước từ thức ăn là lá cây tươi, 40% nhu cầu được hấp thụ từ việc uống nước trực tiếp. Tổng lượng nước tiêu thụ tương quan tỷ lệ thuận với nhiệt độ môi trường sống. Ví dụ: Ở loài vọoc mông trắng, lượng nước tiêu thụ tăng từ 0,07 ml/g trọng lượng cơ thể tại nhiệt độ 240 C lên 0,18 ml/g tại nhiệt độ 320 C. Tương tự ở loài chà vá chân xám từ 0,10 ml/g lên 0,16 ml/g.

Introduction

In recent years several studies were carried out about food and food contents on Colobines (Nijboer & Dierenfeld 1996; Otto, 2005; Pham Nhat et al., 2000; Workman, 2010) but the water consumption of these species are not studied yet. There are only some assumptions about the

water demand on the species (National Research Council, 2003; Nijboer et al., 1997). Based on missing observations on active water consumption of douc langurs in the wild Lippold (1977; 1998) supposed that red-shanked douc langurs (*Pygathrix nemaeus*) cover the total water demand only with their food.

In this study carried out from July to October 2008 at the Endangered Primate Rescue Center, Vietnam the total water consumption of Delacour's langurs and grey-shanked douc langurs was investigated and divided into water consumption through food and active water consumption through drinking. The total water consumption was also recorded in correlation of the air temperature.

The climate conditions at the Endangered Primate Center are identical with the condition in the distribution areas of the species and food composition and feeding times also very similar to the conditions in the wild.

Materials and Methods

Animals

The water consumption of Delacour's langurs were recorded on two adult individuals, one male about 10 years old and one female about 5 years old kept in one cage. The weight of the male was 8.7 kg, and of the female 8.4 kg.

The water consumption of grey-shanked douc langurs were recorded on two adult individuals, one male of 10 years old and one adult female also kept in one cage. The weight of the male was about 12 kg and of female weighed about 8 kg.

The couples are kept in cages 10 m x 5.5 m x 3.5 m, furnished with bamboo poles.

Water consumption through food

The leaves, provided in bundles of twigs containing about 10 to 12 tree species which partially changed daily (Table 1). The animals were fed three times a day: 6:30 to 7:00am, 11:00 to 11:30am and 4:00 to 4:30pm. The consumed amount of leaves was recorded through weighing before and after feeding.

To record the water content identical bundles of leaves were dried, first on air and than in an exsiccator with silica gel. An average of water content in the leaves by percentage was recorded and taken into account.

Active water consumtion through drinking

Water inside the cages was provided in bowls with about 25 cm diameter. Every morning and evening the water content was measured and the difference recorded as consumed water. Observations ensured that the data do not record urine or the jumping of the animals to the water bowls. The evaporation of the water

Table. 1. Most common food tree species during the study.

Family	Species
Asteraceae	*Chromolaena odoratum* L.
Convolvulaceae	*Ipomoea batatas* L.
Euphorbiaceae	*Sapium discolor* Müll.Arg.
Fabaceae	*Leucaena leucocephala* Lam. *Delonix regia* Bojer *Dalbergia balansae* Prain
Malvaceae	*Hibiscus rosa-sinensis* L.
Oleaceae	*Ligustrum confusum* Decne
Oxalidaceae	*Averrhoa carambola* L.
Rubiacea	*Wendlandia paniculata* DC.
Rutaceae	*Euodia lepta* Merr.
Sapindaceae	*Nephelium chryseum* Blume *Dimocarpus longan* Lour.

during the day was taken into account through identical water bowls outside the cages.

Weather condition

Important parameters for the water consumption are air temperature and humidity. During the feeding times – three times a day – temperature and humidity was recorded and as daily "average air temperature".

Statistics

The recorded data were statistical analyzed with SPSS, and the normal distribution with Kolmogorov-Smirnov and Shapiro-Wilk-Test. The average of the data was determined with paired and not paired one and two side T-tests, and correlation analysis following Pearsons R.

Results

Water consumption through food

Delacour's langurs consumed through food - depending from the air temperature (by 24 and 32°C) - between 0.065 to 0.098 ml/g body weight which results in a daily water consumption through food between 566 to 853 ml for the male (8.7 kg) and between 546 to 823 ml for the female (8.4 kg).

The grey-shanked douc langurs consumed roughly the same amount, between 0.065 to 0.095 ml/g body weight (by 24 and 32°C). For the 12 kg male is this 780 to 1.140 ml/day and for the 8 kg female 520 to 760 ml/day (Fig. 1).

Fig.1. Daily water consumption of Delacour's langurs (*Trachypithecus delacouri*) and grey-shanked douc langurs (*Pygathrix cinerea*) through leaves in relationship to the daily average air temperature during feeding time.

The food consumption increased with the higher air temperature which is probably caused by a higher energy and water demand.

Water consumption through drinking

The animals of both species regularly cover their water demand through drinking (Fig. 4 and 5). This behavior is also supported by observations in semi-wild areas at the Endangered Primate Rescue Center and in the wild (Fig. 6 and 7) (Nadler, 2008; Workman, 2010).

Fig.4. Delacour's langur (*Trachypithecus delacouri*) drinking in a cage at the Endangered Primate Rescue Center. Photo: Hanno Kullik.

Fig.5. Grey-shanked douc langur (*Pygathrix cinerea*) drinking in a cage at the Endangered Primate Rescue Center. Photo: Hanno Kullik.

Fig.6. Black-shanked douc langurs (*Pygathrix nigripes*) drinking rain water from a natural "water bowl" in a granite block. Photo: Tilo Nadler.

The Delacour's langurs consumed daily 0.01 to 0.08 ml/g body weight (by 24 and 32°C). The water consumption increased with the increase of the air temperature (Fig. 2). The Delacour's langur male consumed daily between 87 to 696 ml and the female between 84 and 672 ml (by 24 and 32°C).

Grey-shanked douc langurs consumed 0.03 to 0.06 ml/g body weight (by 24 and 32°C). There was also an increase of the consumption with the increase of the air temperature.

The grey-shanked douc langurs drunk more water below 28°C than Delacour's langurs but above 28°C the water consumption of Delacour's langurs was higher.

The douc langur male consumed daily between 360 to 720 ml and the female between 240 and 480 ml (by 24 and 32°C).

Total water consumption and the relationship to air temperature

The total water consumption increased with the air temperature, resulting in a higher amount of consumption from leaves and through drinking water (Fig. 3). The total water consumption of Delacour's langurs increase from 0.07 ml/g body weight by an air temperature of 24°C to 0.18 ml/g body weight by an air temperature of 32°C. For an individual with an average weight of 8.5 kg is this a daily amount of 595 ml and 1.530 ml respectively.

The total water consumption of grey-shanked douc langurs increased from 0.10 ml/g body weight by an air temperature of 24°C to 0.16 ml/g body weight by an air temperature of 32°C. For a male with 12 kg body weight is a daily amount of 1.200 ml and 1.920 ml respectively.

Discussion

Observations in the wild and in the semi-wild areas at the Endangered Primate Rescue Center show various langurs consume water from water sources on the ground. The rare observations in the wild are most probably the result of shy behavior of the animals in close distance to an observer. The animals don't visit the ground if they discover an observer.

Observations on Delacour's langurs and grey-shanked douc langurs in captivity show that the animals regularly consume water which is most probably necessary for digestion and metabolism. About 60% of the total water demand is covered from the leaves which contain a rather high amount of water but 40% was consumed through active drinking.

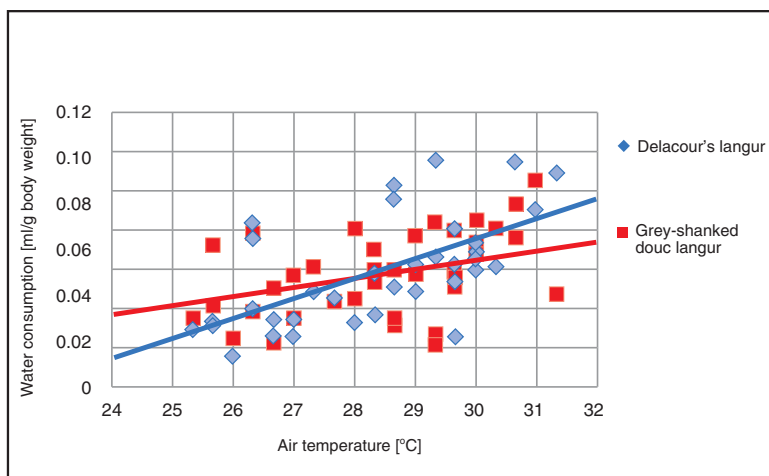**Fig.7.** Delacour's langur group moves to a lake for drinking. Photo: Tilo Nadler.

Fig.2. Daily water consumption of Delacour's langurs (*Trachypithecus delacouri*) and grey-shanked douc langurs (*Pygathrix cinerea*) through drinking in relationship to the daily average air temperature during feeding time.
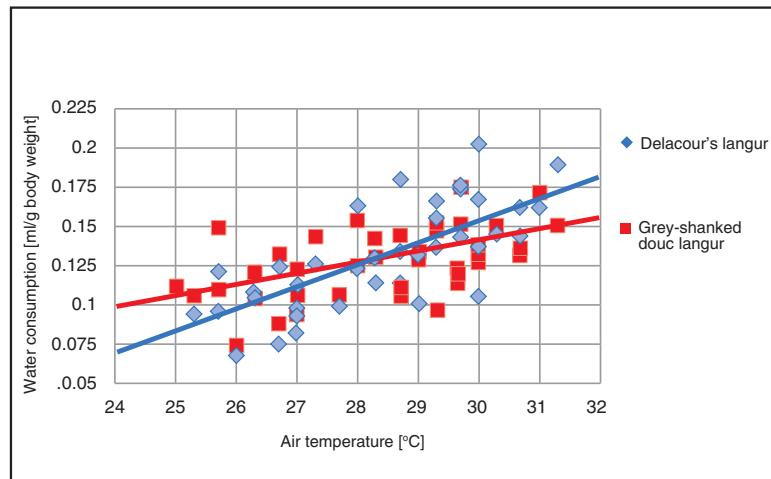
Fig.3. Daily total water consumption of Delacour's langurs (*Trachypithecus delacouri*) and grey-shanked douc langurs (*Pygathrix cinerea*) in relationship to the daily average air temperature during feeding time. (Pearson Correlation: Delacour-langurs r = 0,721, p=0,01, n=38; grey-shanked douc langurs r = 0,624, p=0,01, n=39).

Most probably all Indochinese langurs and douc langurs are dependent on active water consumption through drinking in addition to the water content in food, mostly leaves.

There is little information about the amount of water consumed on other primate species, especially Colobines and folivore species. Hanuman langurs (*Semnopithecus entellus*) which are frugivore and folivore, with a high amount of fruits (15% to 25%), cover their water demand mostly through food but drink also water if available (Chalise, 1994; Koenig & Borries, 2001; Sayers & Norconk, 2008). The mantled howler monkeys (*Alouatta palliata*) cover their demand on water through food, but likely visit other water sources (such as depressions at junctures of tree limbs and trunk) (Glander, 1978). This species is probably more of a frugivore and prefers juicy fruits (Nowak, 1999; Wilson & Reeder, 2005). Rhesus macaques (*Macaca mulatta*) and long-tailed macacques (*Macaca fasciicularis*) have a daily demand on drinking water of 4% to 8% of the body weight (0.04 to 0.08 ml/g body weight in captivity; German Primate Center, 2010). Schroederus et al. (1999) measured water intake in rhesus monkeys (*Macaca mulatta*). This study shows that older monkeys drank significantly less than young adults (380 ml/day and 750 ml/day respectively). Suzuki et al. (1989) measured for long-tailed macaques a daily total water intake from food and drinking water of 0.076 ml/g body weight for males and 0.10 ml/g body weight for females, and Zorbas et al. (1997) for rhesus macaques a daily mean water intake of 0.122 ml/g body weight.

Compared to this data the daily demand on water consumption by Delacour's langurs and grey-shanked douc langurs is rather high. Delacour's langurs consumed daily 7 to 18% of the body weight, grey-shanked douc langurs 10 to 16% relative to air temperatures of 24 and 32°C respectively.

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On the hairs and hair cuticle structure of douc langurs (*Pygathrix* sp.) and the Tonkin snub nosed monkey (*Rhinopithecus acunculus*)

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Key words: *Pygathrix, Rhinopithecus avunculus*, hair structure

Summary

The study describes and compares the hair cuticle structure of the three species of douc langurs, *Pygathrix cinerea, P. nemaeus* and *P. nigripes* in comparison to *Rhinopithecus avunculus*. In the latter the hair diameter and cuticle height is smaller than in the three species of *Pygathrix*. The cuticles in general have smooth to crenate edges and are variable in all regions of the hair. A clear differentiation of the species on the basis of hair cuticle structure is not possible. Only the discriminant analysis shows some separation between the species.

Về các loại lông và cấu trúc biểu bì lông của các loài chà vá (*Pygathrix* sp.) và voọc mũi hếch (*Rhinopithecus acunculus*)

Tóm tắt

Nghiên cứu này mô tả và so sánh cấu trúc biểu bì lông của ba loài chà vá, *Pygathrix cinerea*, *P. nemaeus* và *P. nigripes* với sự so sánh với loài voọc mũi hếch *Rhinopithecus avunculus*. Về sau cùng, đường kính lông và chiều cao biểu bì là nhỏ hơn trong ba loài của giống *Pygathrix*. Nhìn chung, các biểu bì có cạnh trơn đến hình tai bèo và thay đổi trong tất cả các vùng lông. Sự khác biệt rõ ràng của các loài về gốc của cấu trúc biểu bì lông là không thể. Chỉ có phân tích biệt số cho thấy một vài phân cách giữa các loài.

Introduction

Currently three species of douc langurs (*Pygathrix*) are recognized in Vietnam. All three species are relatively poorly known. In outer morphology the coloration of the thigh pelage is the most obvious difference between the three Vietnamese species: being red in *P. nemaeus*, black in *P. nigripes* and grey in *P. cinerea*. The grey-shanked douc langur (*P. cinerea*) has only recently been described due to differences in coloration (Nadler, 1997). The species status was supported by molecular genetic data (Roos, 2004). The grey-shanked douc langur is listed as "Critically Endangered", and is one of the world's 25 most endangered primates (Mittermeier et al. 2009). The red-shanked douc langur and the black-shanked douc langur (*P. nigripes*) are listed as "Endangered" (IUCN, 2009). The Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) is endemic to Vietnam, listed as "Crticically Endangered" and also belongs to the world's 25 most endangered primates.

Douc langurs belong to the subfamily Colobinae within the family Cercopithecidae. The Colobinae

include the genera *Presbytis, Nasalis, Rhinopithecus, Semnopithecus, Trachypithecus* and *Pygathrix* (Brandon-Jones et al., 2004). Molecular genetic data support a monophyletic clade consisting of *Nasalis*, *Pygathrix* and *Rhinopithecus*, with *Rhinopithecus* and *Pygathrix* probably being sister taxa (Sterner et al., 2006).

The hair cuticle structure has been studied for several taxonomic groups and in different regions and is used in comparative determination of wild animals, such as in the analysis of scats to determine food items. Some comparative studies, particularly of the hair cuticle structure of European mammals, are given by Debrot et al. (1982), Teerink (1991) and Meyer et al. (2002). The hair cuticle structure of primates has rarely been studied aside from in *Homo* sapiens.

In this paper the hairs and the hair cuticle structure of the three species of douc langurs is described in order to see if it offers the possibility to differentiate the species. Also, comparisons are made to *Rhinopithecus avunculus*.

Material and Methods

The fur of mammals consists of two types of hair: primary or guard hairs, also called overhair, and secondary hairs, which are usually curled and form the insulating wool hair coat and are therefore also called underhair. To study the cuticle structure, guard hairs were used. The shaft (the region of the hair that extends beyond the skin surface) has three regions: the apical region or tip that often has a spindle-shaped or flattened thickening called the shield, underneath which the medium region is followed by the basal region that thins towards the base of the hair. The cuticle structure varies in the regions, particularly in the apical and basal. (Meyer et al. 2002; Teerink 1991) The hairs of the studied species do not show a shield and thus the middle portion of the hair was considered the medium part.

The study is based on the hairs of 10 skins of *Pygathrix*: 2 of *P. cinerea* (B24006, B 24817), 6 of *P. nemaeus* (B13913, B19400, B19854, B15777, B19853, B19855), 2 of *P. nigripes* (B19857, B19856) and 1 of *Rhinopithecus avunculus* (B18785) from the Senckenberg Naturhistorische Sammlungen Dresden, Museum für Tierkunde (MTD). For each species, 15 primary hairs from the back and from the thigh were cut from the skins at their very base, cleaned in warm tepid water and fixed on cardboard. Here the lengths of the hairs were measured and coloration was noted. Short pieces of the tips, medium region, and bases of hair from the specimen's backs were taken and mounted on aluminum stubs, then coated with platinum for 120 seconds for use with the scanning electron microscope (SEM). Pictures of the hairs were taken in the SEM at different resolutions. Hair diameter, height of cuticle, cuticle area and number of cuticles per mm2 were recorded from the medium part of the hairs. Measurements of the cuticle structures were done on the SEM photos using the program "Image J" on a PC.

Statistical analyses of the measurements include students' t-tests for statistically significant differences between the species and discriminant analyses of all species. The DA was done using Wilk's lambda statistic, and all variables were entered simultaneously, with equal prior probabilities of group membership based on the pooled within-group covariance matrix.

All statistical analyses were performed using SPSS 16.

Results

Outer morphology and coloration

The hairs of the thigh and back of the *Pygathrix* species differ in coloration. The main characteristic of the three species is the coloration of the thigh and thus it is not surprising that these hairs are black in *P. nigripes*, grey in *P. cinerea* and red in *P. nemaeus*. The hairs of the thigh are uniform in color and are

shorter than the hairs of the back in all three species. The hairs of the back are clearly banded with creamy white and dark brown or black bands; the dark bands are usually slightly longer (about 4 mm) compared to the light ones (about 3 mm). The base is usually creamy and the tip is always dark in the three species of *Pygathrix*.

In the studied specimen of *R. avunculus* the hairs of the back and thigh are of a similar brownish grey color.

A thickened shield cannot be observed in any of the hairs of the studied species.

Hair length and diameter

The length of back hairs varied greatly between the individuals of *Pygathrix* studied, while the thigh hairs appeared more uniform in size. In Table 1 the descriptive statistics of hair lengths are given. The hairs of the back are longest in *P. cinerea*. This is supported by statistically significant differences in the back hair length between *P. cinerea* and *P. nemaeus*, *P. cinerea* and *P. nigripes* and *P. cinerea* and *R. avunculus*. Also the thigh hairs are significantly longer in *P. cinerea* than in *P. nemaeus* and *P. nigripes* (Fig. 1). The back hairs are significantly longer in *P. nigripes* than in *P. nemaeus*.
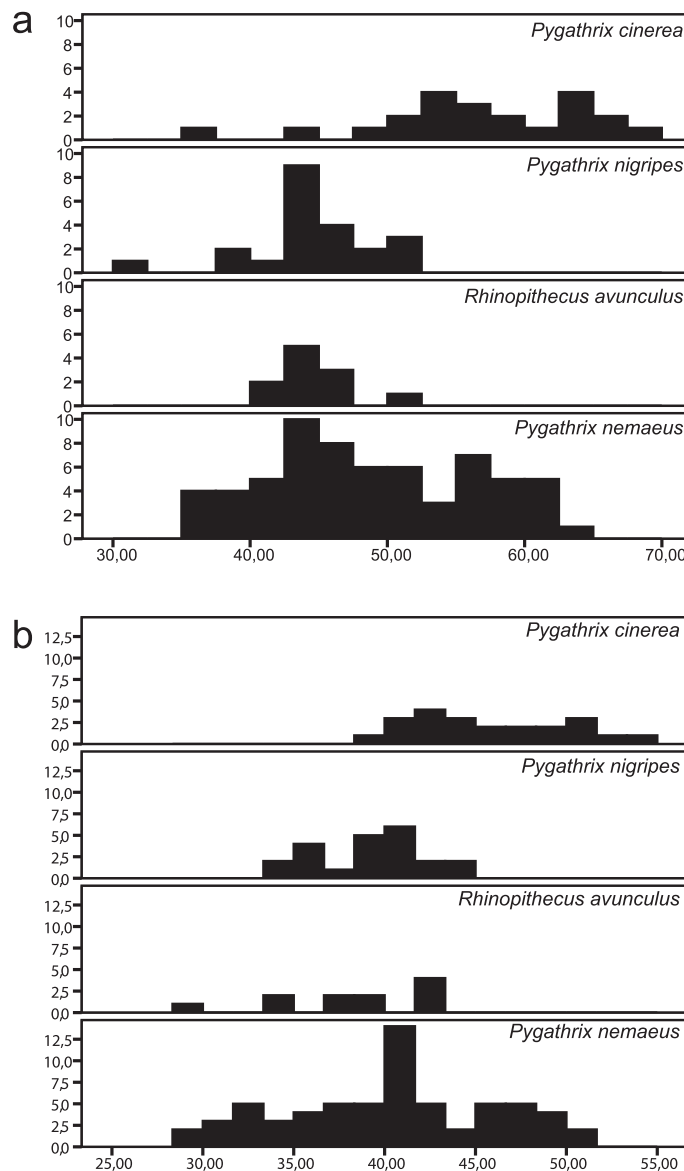

Fig.1. Frequency of hair length of back (a) and thigh (b) of the three species of *Pygathrix* and *Rinopithecus avunculus*.

The hairs of *R. avunculus* are clearly thinner than the hairs of *Pygathrix*. *P. cinerea* has the largest hair diameters (Table 2).

Hair cuticle structure of the species

The gross morphology of the hair cuticle structure of the hairs on the back of the three species of *Pygathrix* is fairly similar (Fig. 2 and 3a-c). Despite the cleaning of hairs prior to analysis the base often showed more dirt particles than the rest of the hair and the scale edges were often not as clear as in other parts of the hair.

In *P. nemaeus* the base of the scales are usually crenate to slightly crenate and even fairly smooth (Fig. 2c). The scales differ more in height in areas with crenate scales than in areas with smooth scales. Generally the scales are long and form a flat mosaic (see Meyer et al., 2002). The scales are of intermediate height and are usually at a right angle to the long axis of the hair, though deviations of about 25° occur. In the medium part the scales are smoothly crenate, have an intermediate height and are usually at a right angle to the long axis of the hair, although deviations of -20° occur. At the tip, the scales are smoothly crenate, and in some areas the scales are fairly high.

In *P. cinerea* the cuticle structure is very similar. At the base, the scales are crenate to nearly smooth; in the middle part more crenate, and crenate and higher at the tip (Fig. 2d-f). At the base and in the medium part the scales are usually rectangular to the long axis of the hair. Also, strongly bent scales can be seen at the tip, forming the single chevron pattern of Meyer et al. (2002).

The pattern in *P. nigripes* (Fig. 3a-c) is again very similar to *P. nemaeus*. Overall scale edges appear more smooth than in *P. nemaeus* and in the medium part scales are in some areas arranged in the single chevron pattern which is not visible at the base or tip.

In *Rhinopithecus avunculus* (Fig. 3d-f) the scales at the base are smooth to slightly crenate and the middle part is usually also crenate at the tip. Overall the scales are at a right angle to the long axis to the hair, although slight deviations occur.

There is noticeable variation in crenation of the edges of the scales in all regions of the hair in all studied species. In general the scales at the base are smoother and higher than in the middle part. The tip in particular shows fairly irregular scale edges and higher scales. Therefore, hair cuticle structure in the apical part appears the most irregular. However, even in the middle part, sometimes scales are more crenate and irregular.

The variability in cuticle height is reflected by the large range and high standard deviation in all species (Table 2). In *R. avunculus* the cuticle height and number of cuticles per mm^2 is similar to that in the *Pygathrix species*, but the cuticle area and hair diameter are markedly smaller (Table 2).

Discussion

Overall there is variability in hair cuticle structure in all parts of the hairs. Variability is minimal in the medium part of the hair below the shield and therefore this area is regarded most suitable for the study and measurement of cuticles (Meyer et al., 2002). Nevertheless, even in this region of the hair there is a high variability in all measured parameters (Table 2).

The study of the cuticle structure in all parts of the hairs did not indicate clear differences useful for differentiating the species although that could have been expected as hairs are sometimes used to determine species (e.g. in stomach contents or feces). However, Meyer et al. (1997) noted that the identification of mammals with the hair cuticle structure is sometimes difficult due to the variability along
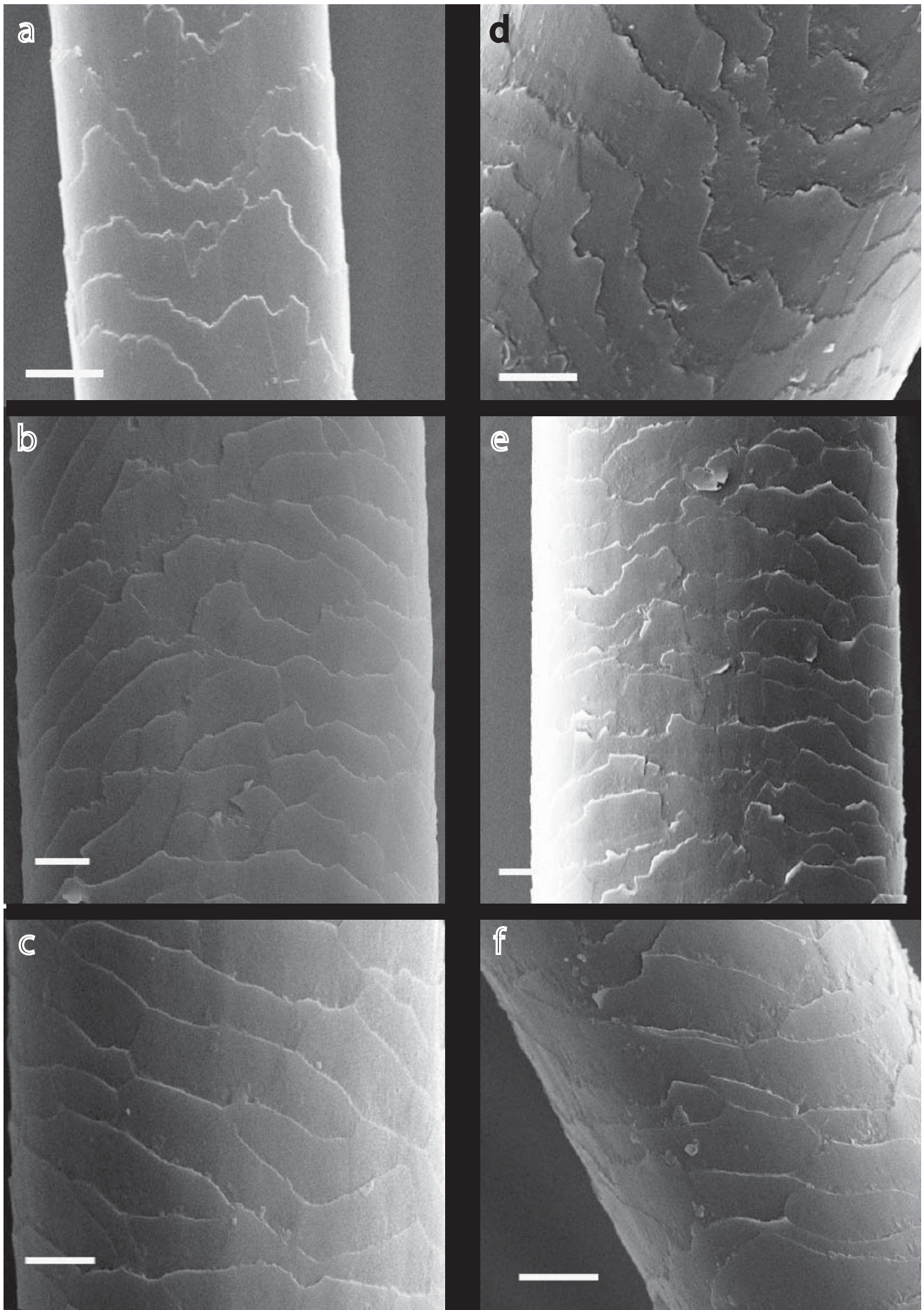
Fig.2. Hair cuticle structure of hairs of the back of *Pygathrix nemaeus* (a-c; a MTD B 19400, b, c MTD B 19855) and *Pygathrix cinerea* (d-f; d, e MTD B24817, f MTD B 24006). Apical part (a, d), medium part (b, e) and basal part (c, f) of the hair. Scale bar = 10 μm.

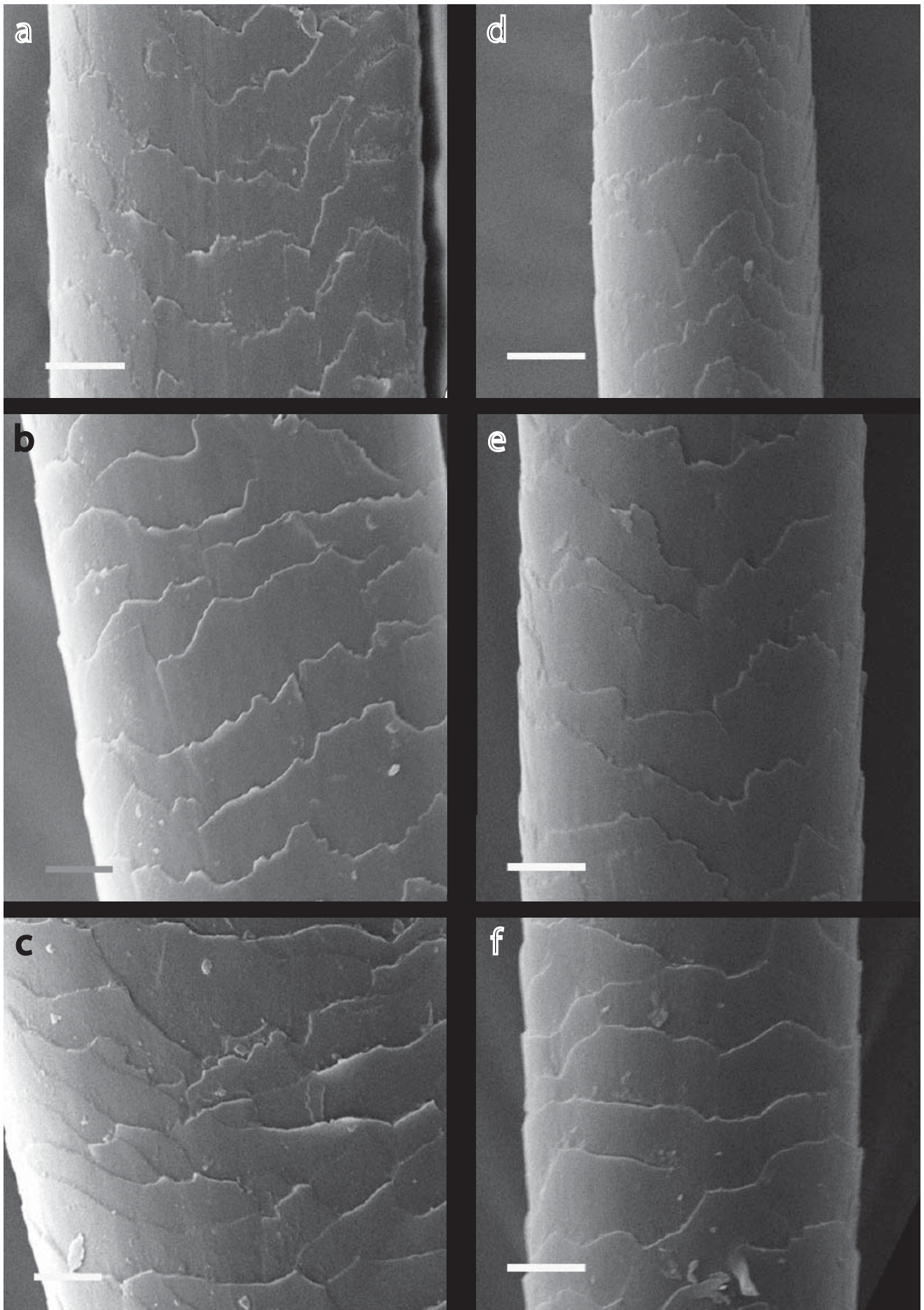**Fig.3.** Hair cuticle structure of hairs of the back of *Pygathrix nigripes* (a-c, MTD B19857) and *Rinopithecus avunculus* (d-f, MTD B18785). Apical part (a, d), medium part (b, e) and basal part (c, f) of the hair. Scale bar = 10 µm.

the hair and between different types of hair. In this study only hairs of the same region of the back were used thus reducing the difficulty to distinguish between cuticle patterns between hair types. The three species of Vietnamese douc langurs are distinguished on the color of their thigh but also on the basis of molecular genetic data (Roos, 2004).

The hair diameter and the cuticle area are smaller in *Rhinopithecus avunculus* than in the three species of *Pygathrix*. These two parameters mainly influence the functions of the discriminant analysis (DA, Fig. 4). The DA shows some separation of the samples: *Rhinopithecus avunculus* is separated from the others by function 1, which is mainly influenced by hair diameter and the three species of *Pygatrhix* are separated by function 1 and 2, the latter of which is mainly influenced by cuticle area. The sample presented here might be regarded small for statistical analysis, but this is due to the availability of skins of douc langurs. Even though the same number of specimens could not be studied for each species, differences that might be useful to differentiate between the species should have been detected.
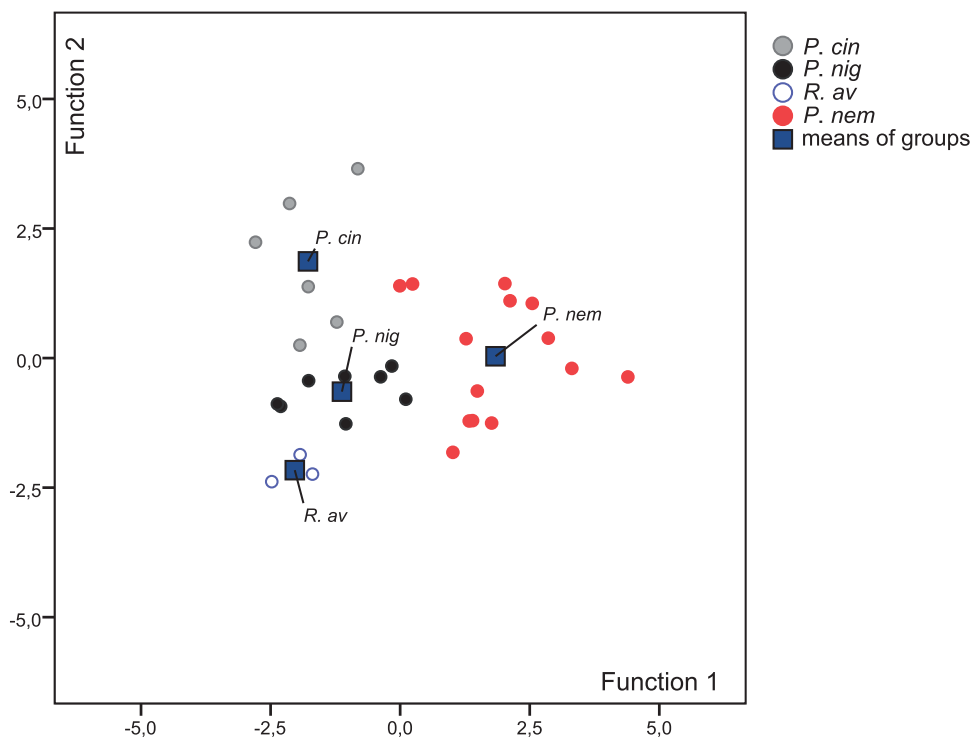
Structure Matrix

	Function		
	1	2	3
cuticle area	.708[*]	.133	-.683
hair diameter	-.055	.882[*]	-.411
cuticles/mm^2	.079	.031	.918[*]
cuticle heigth	-.016	.009	-.467[*]

Common correlation within the groups between discriminant variables and canonical discriminant functions.
Variables are ordered according to their absolute correlations within the functions
* greatest absolute correlation between each variable and a discriminant function

Fig.4. Discriminant analysis (DA) based on several hair and cuticle parameters of the middle part of hairs of the back of *Pygathrix cinerea* (*P. cin*), *P. nigripes* (*P. nig*), *P. nemaeus* (*P. nem*) and *Rhinopithecus avunculus* (*R. av*).

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The *Pedicinus* species (Insecta, Phthiraptera, Anoplura, Pedicinidae) on douc langurs (*Pygathrix* spp.)

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Key words: *Pygathrix* spp., lice, *Pedicinus*, new species, Vietnam

Summary

All three species of Southeast-Asian douc langurs (*Pygathrix* spp.) harbor a host-specific species of *Pedicinus* (*Neopedicinus*). Using freshly collected material of known provenance, these were identified as *Pedicinus tongkinensis* Mey, 1994 ex *Pygathrix nemaeus*, *Pedicinus atratulus* nov. spec. ex *Pygathrix nigripes*, and *Pedicinus curtipenitus* nov. spec. ex *Pygathrix cinerea*. The three species described here are closely related to each other and belong to the newly created "*ancoratus* species group" within the subgenus *Neopedicinus*.

Loài *Pedicinus* (Insecta, Phthiraptera, Anoplura, Pedicinidae) trên các loài Chà vá (*Pygathrix* spp.) ở Đông Nam Á

Tóm tắt

Cả ba loài chà vá (*Pygathrix* spp.) của Đông Nam Á là nơi trú ngụ của một loài ký sinh *Pedicinus* (*Neopedicinus*). Sử dụng vật liệu được thu thập tươi từ nguồn gốc đã biết, các loài này được xác định là *Pedicinus tongkinensis* Mey, 1994 ex *Pygathrix nemaeus*, *Pedicinus atratulus* nov. spec. ex *Pygathrix nigripe*s, và *Pedicinus curtipenitus* nov. spec. ex *Pygathrix cinerea*. Ba loài được mô tả ở đây có quan hệ gần gũi với nhau và thuộc về "nhóm loài ancoratus" mới được tạo ra trong giống phụ *Neopedicinus*.

Introduction

The colobine genus of the douc langurs *Pygathrix* E. Geoffroy St.-Hilaire, 1812 is endemic to Indochina. Three monotypic species are distinguished (Roos & Nadler, 2001, Nadler et al., 2003, Nadler, 2007). The only lice of the genus *Pedicinus* found on these monkeys until now were from the red-shanked douc langur *Pygathrix nemaeus* (Mey 1994) (Fig. 1). But thanks to Tilo Nadler's special interest in parasite infestation in monkeys, *Pedicinus* has now also been found on *Pygathrix nigripes* (Fig. 2) and *P. cinerea* (Fig. 3) in the wild or in captivity at the Endangered Primate Rescue Center in Cuc Phuong National Park in Vietnam. The results of the taxonomic treatment of these new findings are presented here.

Material and Methods

All material was collected by Tilo Nadler and his co-workers mostly from freshly dead douc

Fig.1. Red-shanked douc langur (*Pygathrix nemaeus*). Photo: Tilo Nadler.

Fig.2. Black-shanked douc langur (*Pygathrix nigripes*). Photo: Tilo Nadler.

Fig.3. Grey-shanked douc langur (*Pygathrix cinerea*). Photo: Tilo Nadler.

langurs at the Endangered Primate Rescue Center (EPRC), Cuc Phuong National Park. The collected material was dry-stored then preserved as permanent specimens in Canada balsam, which are now deposited in the animal louse collection of the Natural History Museum in Rudolstadt (NMR) (Thüringen), Germany. Examination methodology (especially measurements), terminology, and systematics approach follow the revision of Kuhn & Ludwig (1967).

Pedicinus (*Neopedicinus*) on douc langurs

The *Pedicinus* samples collected from all three *Pygathrix* species (Cercopithecidae, Colobinae) in Vietnam belong to the subgenus *Neopedicinus* Fahrenholz, 1916 (originally introduced into the literature as a genus).

Besides *Neopedicinus*, the subgenera *Pedicinus* Gervais, 1844 (with one polytypic species on Asian macaques *Macaca* spp.) and *Parapedicinus* Kuhn & Ludwig, 1967 (with at least 3 mono- and 2 polytypic species on African and Asian Cercopithecinae and Colobinae) are distinguished (Kuhn & Ludwig, 1967; Mey, 1994).

Following examination of the material presented here, it is gradually becoming apparent that *Pedicinus ancoratus* Ferris (Fig. 4) is most likely not a polytypic species, as Mey (1994) had to assume. It seems much more to be the case that several closely related *Pedicinus* species occur on Asian colobines, which can be brought together in the *ancoratus* species group (Table 1). Along with the eponymous species *P. tongkinensis*, which is here raised to species rank, this encompasses the two newly described species below. All four have in common the characteristic form of the end of the penis (Fig. 5).
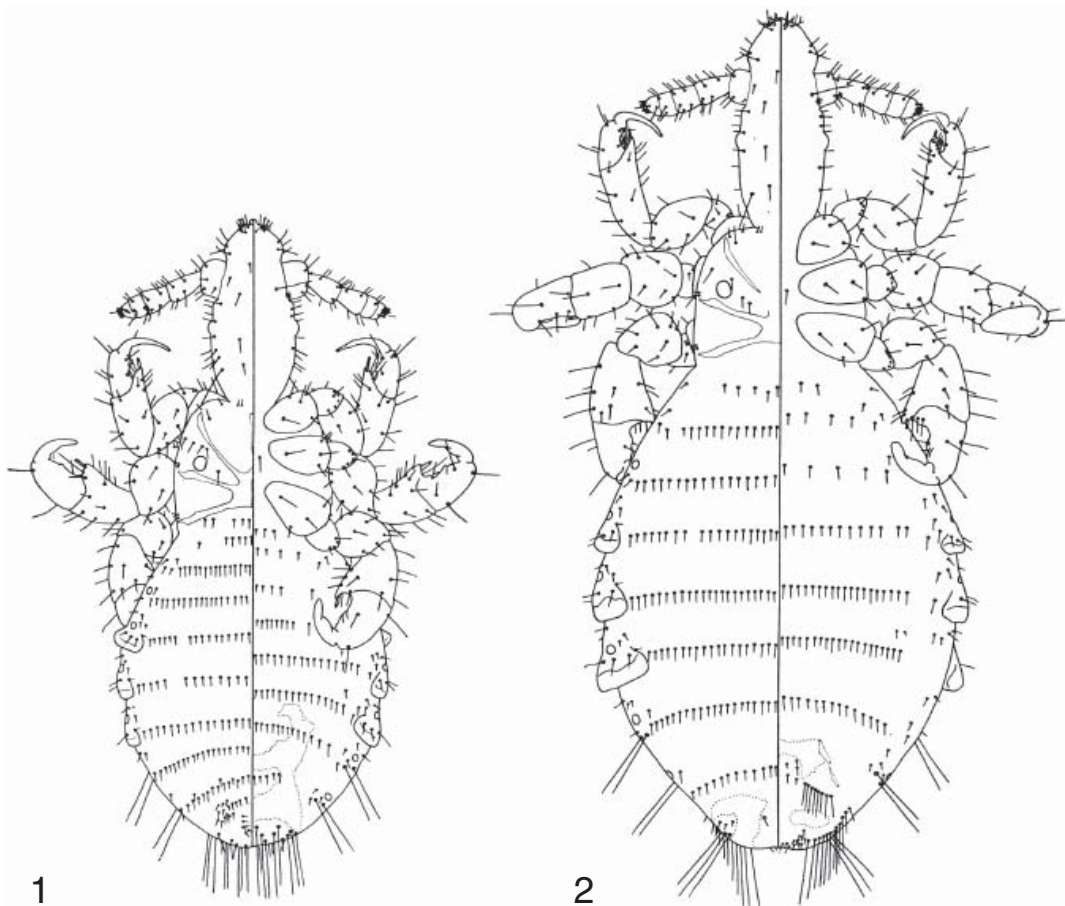
Fig.4. *Pedicinus* (*Neopedicinus*) ancoratus Ferris, 1934 ex *Trachypithecus cristatus* (Raffles) from Pulo Sebang, East-Sumatra. 4-1: Male (holotype); 4-2: female (allotypoid) after Kuhn & Ludwig,1967: 184).

Table. 1. Distribution of the *Pedicinus* (*Neopedicinus*) *ancoratus* species group. References: 1 - Kuhn & Ludwig, 1967; 2 - Durden & Musser, 1994a, fide Ferris, 1934; 3 - Mey, 1994. (*Records on *Hylobates leucogenys* and *H. siki* due to anthromorphic contaminations; see Mey, 1994).

Pedicinus species	Type host	Other hosts	Geographical distribution	References
P. ancoratus Ferris, 1934	*Trachypithecus cristatus* (Raffles, 1821)		Sumatra, some islands in the Riau Archipelago, Borneo, western coastal strip of peninsula Malaysia	1, 2
		T. auratus (E. Geoffroy, 1812)	Java, Bali, Lombok	2
		T. francoisi (Pousargues, 1898)	S China, N Vietnam	1, 2
		Presbytis rubicunda (Müller, 1838)	Borneo, Karimata Islands	1, 2
		Semnopithecus entellus (Dufresne, 1797)	India, Pakistan	1, 2
P. tongkinensis Mey, 1994	*Pygathrix nemaeus* (Linnaeus, 1771)	unknown*	Vietnam, Laos, Cambodia	3
P. atratulus n. sp.	*Pygathrix nigripes* (Milne-Edwards, 1871)	unknown	Vietnam, Cambodia	this paper
P. curtipenitus n. sp.	*Pygathrix cinerea* Nadler, 1997	unknown	Vietnam	this paper
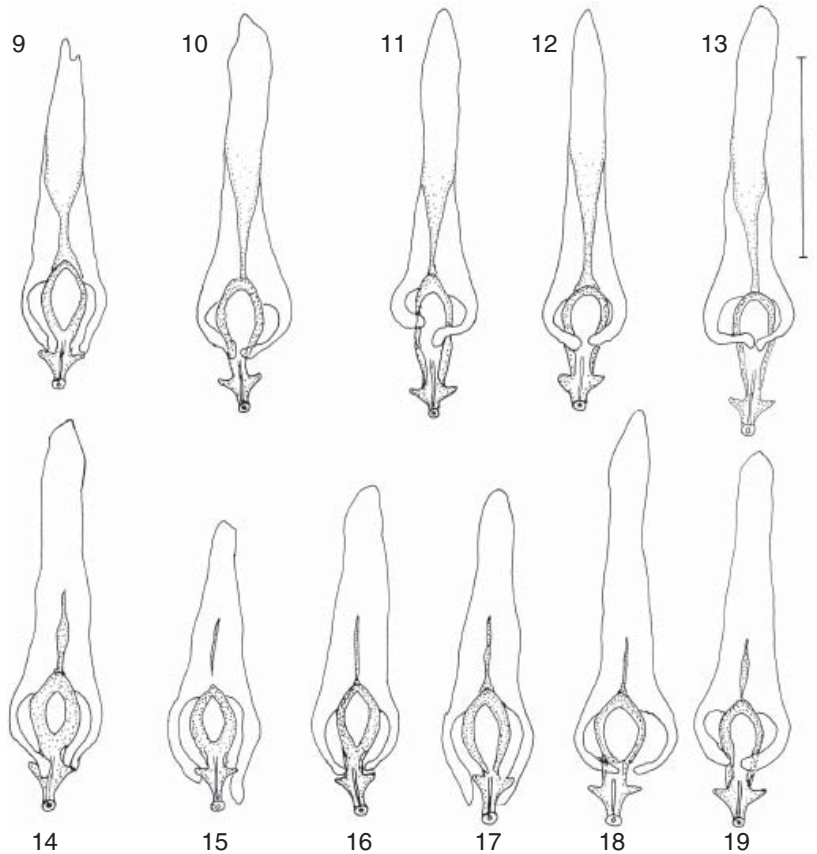
Fig.5. *Pedicinus* spp., penis. Scale 0.1 mm.
  5- 9 to 5-13: *P.* (*Neopedicinus*) *atratulus* n. sp. (5-9: M. 4527. m; 5-10: 4527. f; 5-11: 4527. h; 5-12: 4527. c; 5-13: 4527. b.)
  5-14 to 5-17: *P.* (*Neopedicinus*) *curtipenitus* n. sp. (5-14: holotype; 5-15: M. 5943; 5-16: 5943. a; 5-17: 5943. c.)
  5-18 and 5-19: *P.* (*Neopedicinus*) *tongkinensis* Mey (5-18: M. 4225. c; 5-19: 4225. b.)

In their revision of *Pedicinus*, Kuhn & Ludwig (1967) do not differentiate any species groups, but instead only the higher category of subgenera (see above). They divide some species (like *P. pictus*) into subspecies, although these differ clearly from each other, particularly in their genital morphology. However, such differences, which mostly arise in geographic-hospitalic isolation, are strong indications for the existence of reproductive isolation, which can only be the case when separate species are involved. If two reproducing populations of *Pedicinus* are found together on the same host species or host individual then they are of two distinct species.* Perhaps this was the reason why already Ledger (1980) advocated treating the forms of African *P. pictus* in particular as species in their own right. While Durden & Musser (1994a) pointed this out, in their own Anoplura checklist they consistently synonymized all subspecies (with the exception of *Pediculus humanus humanus* and *P. h. capitis*!). The conclusion to be drawn would seem to be that there are no subspecies in the Anoplura. But it is surely more correct to say that Durden & Musser (1994a, b) make no, or only very limited use of this infraspecific category with regard to Anoplura (with the one exception!). Whether Anoplura species really do tend not to be polytypic (or hardly so) is a question that should remain in the focus of systematic and taxonomic interest. My experience, however, indicates that this is not the case.

Results

1. *Pedicinus* (*Neopedicinus*) *atratulus* nov. spec.

Fig. 5-9 to 5-13; 6-3; 6-5; 7-6; 8-24 to 8-28; 9-32 to 9-37; Tables 1 to 3

Type host: *Pygathrix nigripes* (Milne-Edwards, 1871)

Material

30 males, 20 females, 21 larvae (slides M. 4227. a-h, j-s) from one freshly dead host individual, 13. 2. 2001 EPRC, Cuc Phuong National Park, Vietnam, leg. T. Nadler.

Holotype, male (M. 4527. a), allotypoid (M. 4527. o, above) and paratypes in NMR.

Description

Habitus very similar to *P. ancoratus* Ferris (Fig. 4-1). Head length and total length as in Table 2 (males) and Table 3 (females).

Sclerotization of freshly dead or dry-stored individuals black-brown, light brown following maceration in potassium lye. Contrasted with the brownish color in *Pedicinus tongkinensis* ex *Pygathrix nemaeus* and *P. curtipenitus* ex *Pygathrix cinerea* this difference in the natural body coloration is very striking.

The pigmentation of paratergal plate iv, which protrudes scale-like on both sides (Fig. 6-3 and 6-5), is different in males and females after maceration. In females (n = 15) the paratergalia iv (see Fig. 6-5) are slightly brownish on both sides; in only one individual were they opaque on one side (colorless), and on the other side slightly brownish. In the clearly smaller male (n = 15) left and right paratergalia iv are mostly opaque, in the larvae (n = 11) always so. Only in one male was paratergal plate iv opaque on one side but on the other brownish, while in the other 10 males this weak coloration was present on both sides.

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* Hence it is unacceptable to regard the human body louse and head louse, which differ only very slightly genetically and in their morphological structure but live on the same host, as subspecies of a single species. *Pediculus humanus* Linnaeus and *Pediculus capitis* Degeer are quite clearly two (biological) species.

Table. 2. Body dimensions (mm) and number of subgenital plate setae (isolated bristles of hypandrium, "Inselborsten") of males of *Pediculus* spp. ex *Pygathrix* spp. (* n = 19; ** n = 20).

	Pediculus atratulus n. sp. (n = 30)			*Pediculus curtipenitus* n. sp. (n = 8)			*Pedicinus tongkinensis* Mey (n = 21)		
	holotype	x	variation (min.-max.)	holotype	x	variation (min.-max.)	holotype	x	variation (min.-max.)
total length	1.81	1,649	C1.47 - 1.99	1.75	1,693	1.60 - 1.75	1.72	1,578	1.47 - 1.72*
head length	0.56	0.532	0.50 - 0.57	0.56	0.542	0.53 - 0.56	0.51	0.516	0.47 - 0.54**
penis length	0.205	0.184	0.160 - 0.205	0.186	0.165	0.148 - 0.186	0.194	0.187	0.171 - 0.211
penis width	0.046	0.046	0.046 - 0.051	0.046	0.048	0.046 - 0.051	0.057	0.051	0.046 - 0.057
subgenital plate setae	10	9.1	07 - 12	11	10.88	09 - 13	8	7.62	06 - 10

Table. 3. Body dimensions (mm) and number of subgenital plate setae (isolated bristles of hypogynium, "Inselborsten") of females of *Pediculus* spp. ex *Pygathrix* spp.

	Pediculus atratulus n. sp. (n = 30)			*Pediculus curtipenitus* n. sp. (n = 8)			*Pedicinus tongkinensis* Mey (n = 21)		
	holotype	x	variation (min.-max.)	holotype	x	variation (min.-max.)	holotype	x	variation (min.-max.)
total length	2.14	2,115	1.84 - 2.37	2.2	2	1.84 - 2.50	2.34	2	1.78 - 2.34
head length	0.62	0.604	0.57 - 0.65	0.63	0.604	0.57 - 0.63	0.6	0.605	0.57 - 0.65
subgenital plate setae	7	7.11	05 - 09	9	7.25	05 - 09	8	8.83	07 - 13

The variable form of the hypandrium is illustrated in Fig. 8-24 to 8-28, and the number of its isolated bristles shown in Table 2. Similarly, for the hypogynium see Fig. 9-32 to 9-37, and Table 3. The male genital apparatus is shown in Fig. 7-6, and the penis in Fig. 5-9 to 5-13. The v-shaped pigmented area in the cranial part of the penis is prominent.

Differential diagnosis

The taxa in the *ancoratus* species group can be differentiated by combinations of the following characters: body coloration, size and pigmentation of the paratergalia on abdominal segment iv, number of isolated bristles on the subgenital plates (hypandrium, hypogynium), form of the subgenital plates, and structures of the genital apparatus, the penis in particular. There appear to be no striking differences between the species in the ancoratus group in length (0.41 - 0.45 mm) and width (0.15 - 0.17 mm) of the male genital apparatus.

In contrast to the light brown *ancoratus*, *tongkinensis*, and *curtipenitus* n. sp., in *atratulus* n. sp. the sclerotizations are black-brown; freshly dead and dry-stored adults and larvae (!) even appear to be almost completely blackish in color.

The great majority of *atratulus* n. sp. males possess an opaque, relatively small paratergum on each side of abdominal segment iv (Fig. 6-3). Despite the lighter body coloration of *P. ancoratus*,
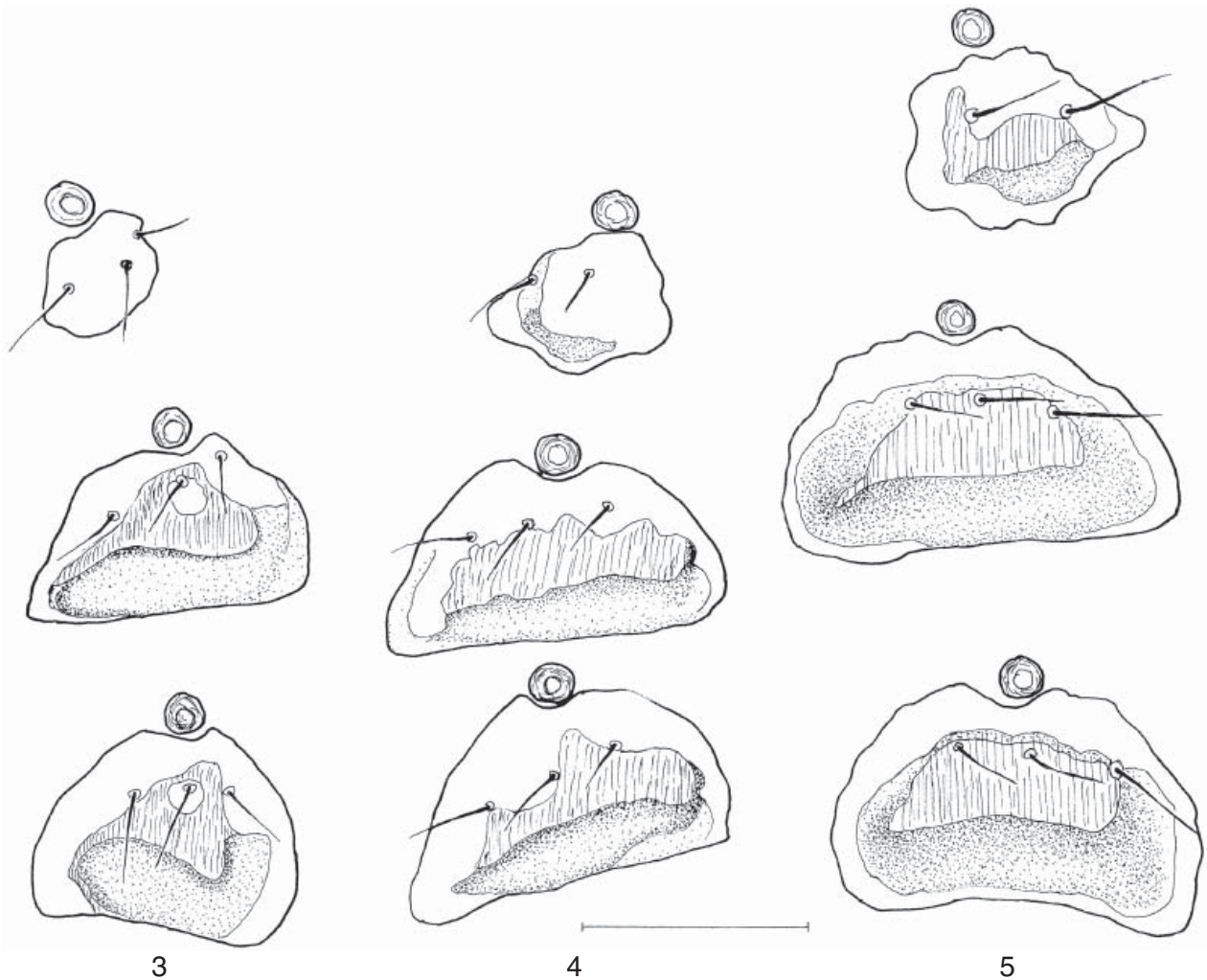
Fig.6. *Pedicinus* spp., paratergalia iv – vi. Scale 0.1 mm. E. Mey del. **6-3:** *P.* (*Neopedicinus*) *atratulus* n. sp., male (M. 4527. h). **6-4:** *P.* (*Neopedicinus*) *curtipenitus* n. sp., male (M. 5943. b). **6-5:** *P.* (*Neopedicinus*) *atratulus* n. sp., female (M. 4527. h).

tongkinensis, and *curtipenitus* n. sp. (even if altered by the mounting process) their patergalia iv are never opaque in the adult animal.

The mean number of isolated bristles ("Inselborsten") differs between *atratulus* n. sp., *curtipenitus* n. sp., and *tongkinensis* in both sexes (Tables 2 and 3). While *atratulus* n. sp. and *curtipenitus* n. sp. males have on average around 10 (9-13), in *tongkinensis* this figure is 8 (6-10) (Table 2). *Ancoratus* too never has more than 10 isolated bristles (Kuhn & Ludwig, 1967). In the females of all species these bristle ratios are reversed. *P. tongkinensis* has the most, with 7-13, and *atratulus* n. sp.and *curtipenitus* n. sp. have only 5-9 (Table 3).

Despite the considerable variability in the form of the hypandrium, it is striking that while its cranial, arm-like extensions in *atratulus* n. sp. and *tongkinensis* are well developed on both sides (Fig. 8-24 to 8-31), in *curtipenitus* n. sp. they are always strongly reduced on one side only and their weakly pigmented, ragged looking contours are hardly visible (Fig. 8-20 to 8-23).

The variablity in the form of the hypogynium in *atratulus* n. sp. and *curtipenitus* n. sp. is shown in Fig. 9-32 to 9-43 . A very similar diversity can be seen in *tongkinensis* and probably also in the *ancoratus* group. Hence it is difficult to regard this character as a diagnostic species trait within the *ancoratus* group. However, one very interesting fact is that the presence of a lateral-caudal sclerite strip in some (apparently only adults) *P. ancoratus* females could not be confirmed in a single individual of the other three species examined.
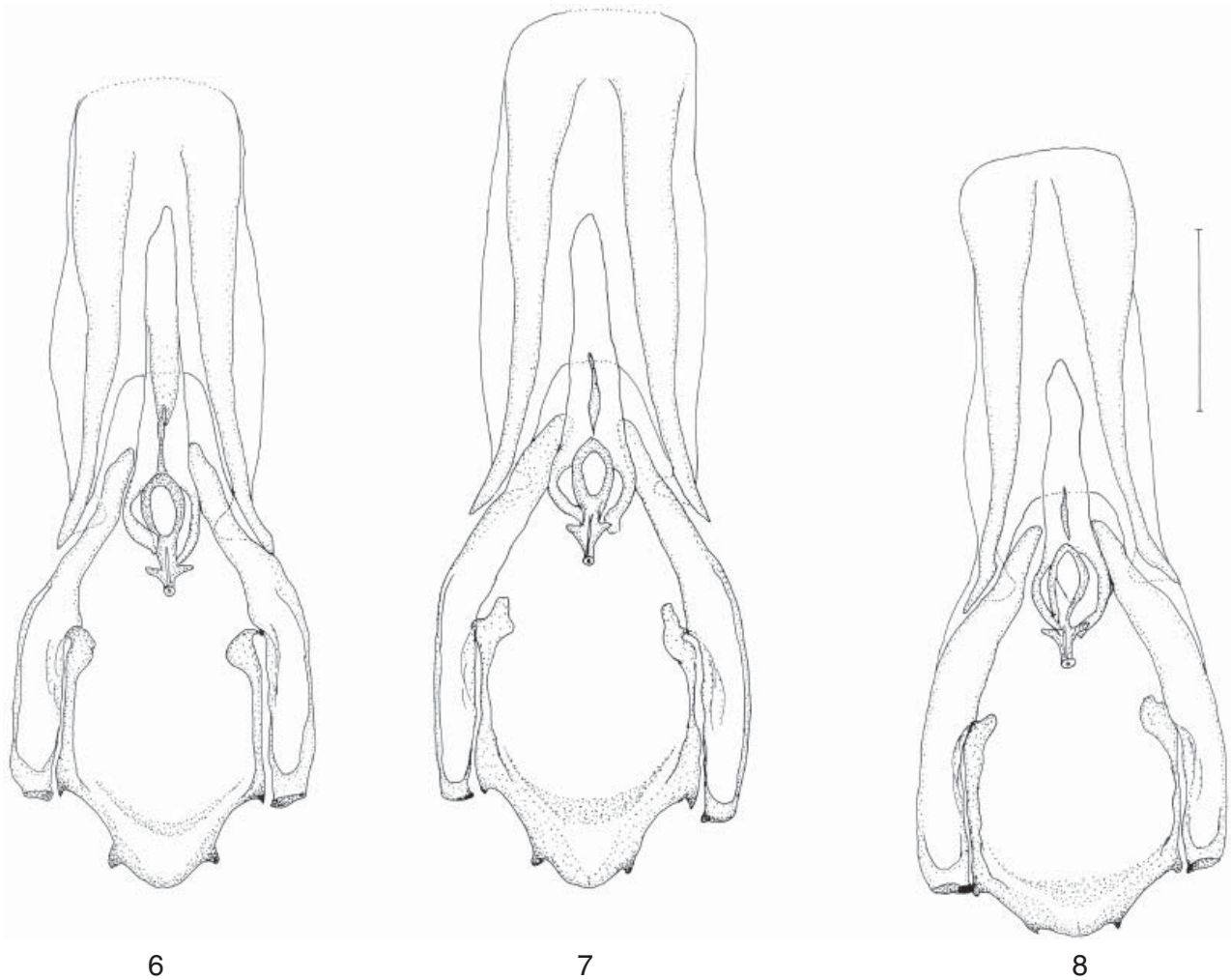
Fig.7. *Pedicinus* spp., males, genital apparatus. Scale 0.1 mm. **7-6:** *P.* (*Neopedicinus*) *atratulus* n. sp., holotype. **7-7 and 7-8:** *P.* (*N.*) *curtipenitus* n. sp. (6-7: holotype; 6-8: paratypoid M. 5943. a.)

In the structures of the male genital apparatus, especially the penis, all species in the ancoratus group show their own peculiarities. With an average length of 0.17 mm, *P. curtipenitus* n. sp. has the shortest penis. The width is the same as in *atratulus* n. sp. but it is greater in *tongkinensis*. *P. atralatus* n. sp. and *tongkinensis* (and presumably also *ancoratus*) do not differ in penis length (Table 2, Fig. 5-9 to 5-19). In its cranial section, the penis of *atratulus* n. sp. has a darkly pigmented v-shaped area, which is lacking in all other species of the *ancoratus* group (Figs. 5-9 to 5-13). The penis of *P. ancoratus* – according to Kuhn & Ludwig (1967; Fig. 34) – appears to be very similar in form and length to that of *curtipenitus* n. sp. On the whole there seem to be very slight differences between the species in the form of the paramera and the pseudopenis, although it cannot be completely excluded that they are an artifact of the preservation process (Fig. 7-6 to 7-8).

In the bristle pattern of the abdominal segments (especially segment v), I could discern no consistent differences between all the species in the ancoratus group. Nevertheless, this important character, which can prove its usefulness only in very carefully preserved individuals, needs to be borne in mind.

Derivatio nominis

From the blackish body coloration (= Lat. atratulus) that is only preserved on the sclerotizations following maceration in potassium lye.
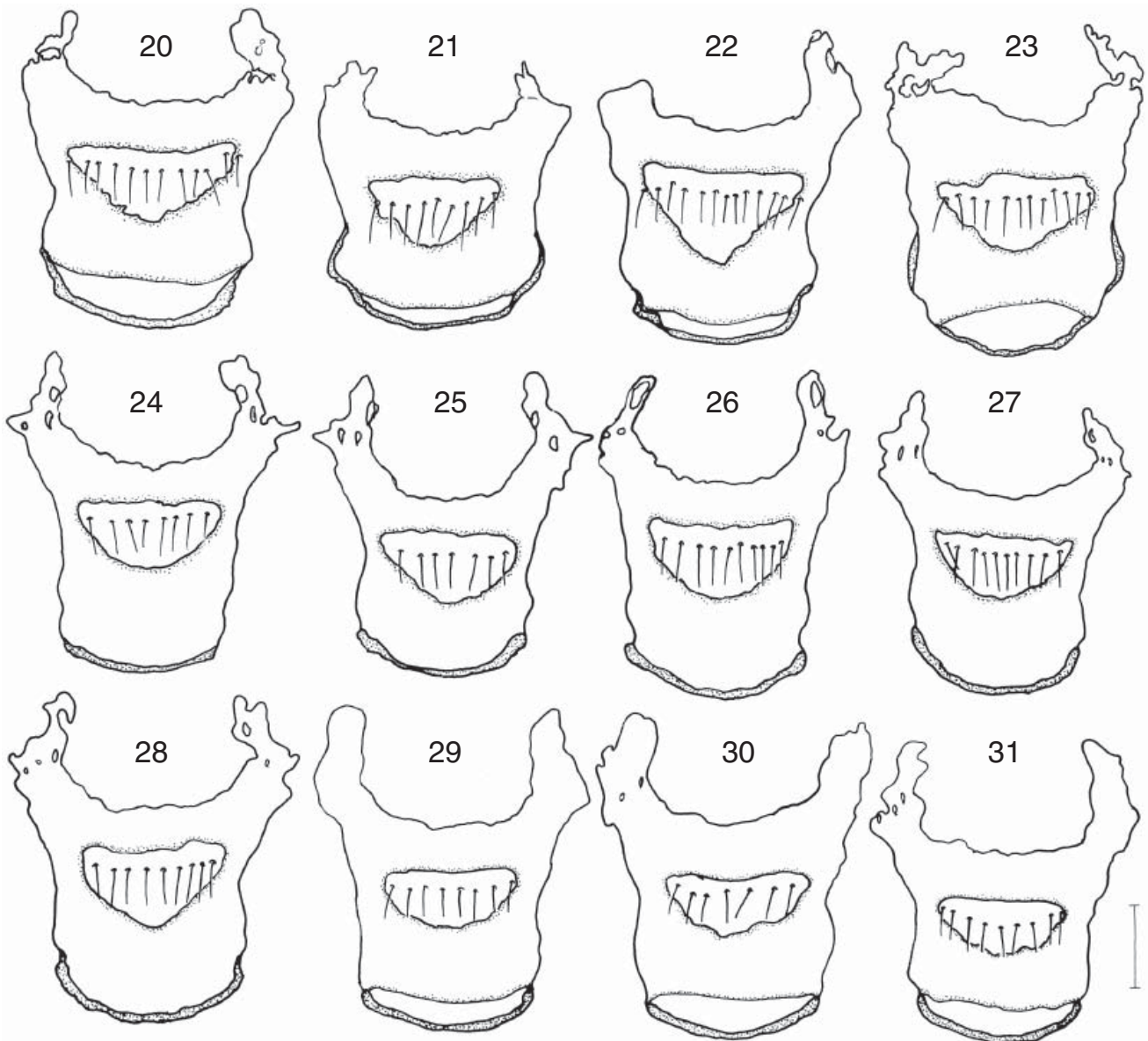
Fig.8. *Pedicinus* spp., hypandrium with isolated bristles ("Inselborsten"). Scale 0.1 mm.
8-20 to 8-23: *P.* (*Neopedicinus*) *curtipenitus* n. sp. (8-20: M. 5943. c; 8-21/22: 5943. a; 8-23: 5943. b).
8-24 to 8-28: *P.* (*Neopedicinus*) *atratulus* n. sp. (8-24/25: M. 4527. b; 8-26: 4527. a; 8-27: 4527. m; 8-28: 4527. f).
8-29 to 8-31: *P.* (*Neopedicinus*) *tongkinensis* Mey (8-29: M. 4225. b; 8-30: 4225. d; 8-31: 4225. b).

2. *Pedicinus* (*Neopedicinus*) *curtipenitus* nov. spec.

Fig. 5-14 to 5-17; 6-4; 7-7 and 7-8; 8-20 to 8-23; 9-38 to 9-43; Tables 1 - 3

Type host: *Pygathrix cinerea* Nadler, 1997 (= *Pygathrix nemaeus cinereus* Nadler, 1997)

Material

8 males, 15 females, 3 larvae from four freshly dead host individuals. **1:** 2 females, 3 larvae (slide M. 4571.), 7.9. 2000, EPRC, Cuc Phuong National Park, Vietnam. **2:** 2 males, 1 female, 2 larvae (slides M. 5785. a-c), March 2004, EPRC, Cuc Phuong National Park, Vietnam. **3:** 1 female (slide M. 5974.), December 2006, Phu Cat District, Quang Binh Province, Vietnam. **4:** 6 males, 13 females, 1 larva (slides M. 5943. a-g), 2009, EPRC, Cuc Phuong National Park, Vietnam, leg. T. Nadler.

Holotype, male (M. 4785. c), allotypoid (M. 5943. e, left) and paratypes in NMR.
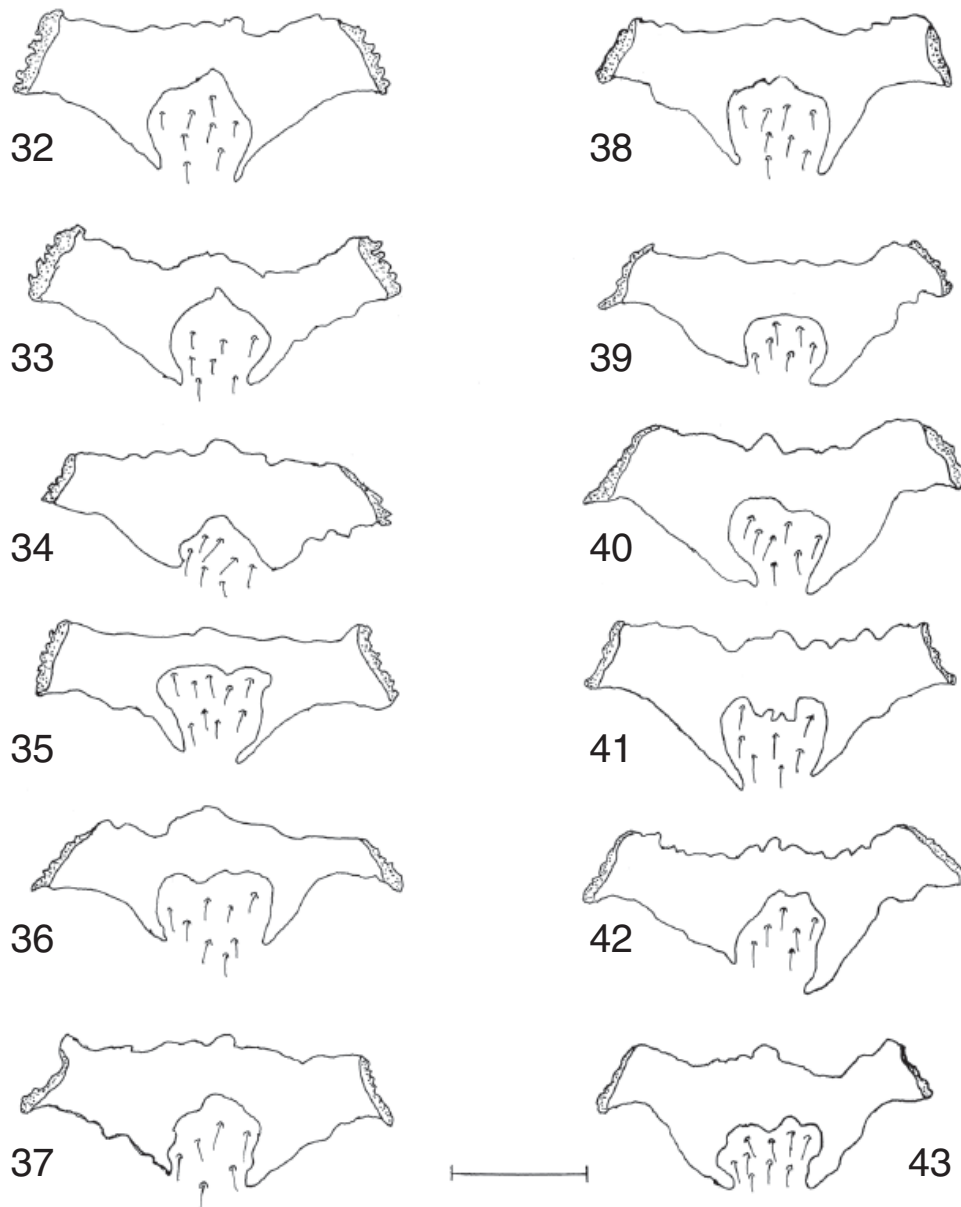
Fig.9. *Pedicinus* spp., hypogynium with isolated bristles ("Inselborsten"). Scale 0.1 mm.
9-32 to 9-37: *P.* (*Neopedicinus*) *atratulus* n. sp. (9-32: M. 4527. a; 9-33: 4527. d; 9-34: 4527. b; 9-35: 4527. e; 9-36: 4527. c; 9-37: 4527. c).
9-38 to 9-43: *P.* (*Neopedicinus*) *curtipenitus* n. sp. (9-38: M. 4571.; 9-39/40: 5943. b; 9-41: 5943. d; 9-42...43: 5943. e).

Description

Habitus very similar to *P. ancoratus* Ferris (see Fig. 4-1). Body coloration light brown. Head length and total length as in Table 2 (males) and Table 3 (females).

Paratergalia v-vii as in Fig. 6-4. Hypandrium and hypogynium see Fig. 8-20 to 8- 23 resp. 9-38 to 9-43. Bristle pattern of the subgenital plates as in Tables 2 and 3. Genital apparatus (Fig. 6-4) with relatively short penis (Fig. 5-14 to 5-17).

Differential diagnosis

See *P. atratulus* n. sp.

Derivatio nominis

Based on the relatively short penis, a Latin combination from curtus (= shortened) and penitus (= possessing a penis).

3. *Pedicinus* (*Neopedicinus*) *tongkinensis* Mey, 1994 [new status]

Fig. 5-18 and 5-19, 8-29 to 8-31, Tables 1to 3

Type host: *Pygathrix nemaeus* (Linnaeus, 1771) [monotypic!]

Material

(here new records since 1993 listed only; see Mey, 1994: 83). 8 males, 18 females, 3 larvae from two freshly dead host individuals. 1: 8 males, 12 females, and 3 larvae (slides M. 4225. a-d) ex one dead *Pygathrix nemaeus*, autumn 1997, EPRC, Cuc Phuong National Park, Vietnam. 2: 6 females (slides M. 4488. a-b) ex one dead *Pygathrix nemaeus* (EPRC 6-27), Cuc Phuong National Park, Vietnam, leg. T. Nadler.

P. tongkinensis was introduced into the scientific literature as a subspecies of *P. ancoratus* Ferris. However, in a comparison of morphological characters with *P. atratulus* n. sp. and *P. curtipenitus* n. sp. in particular, differences became apparent (see Fig. 5-9 to 5-19, 8-29 to 8-31, Tables 2 and 3, and the differential diagnosis of *P. atratulus* n. sp.) that would appear to justify its being treated here as a full species.

Discussion

According to molecular genetic analysis, *Pygathrix nigripes* is an older species than the species pair *P. nemaeus* / *P. cinerea* (Roos & Nadler, 2001; Roos, 2003). All three douc langurs are host to their own species of *Pedicinus*, which resemble each other closely in habitus and morphology and almost certainly share a common ancestor. To what extent this reflects the phylogenesis of their hosts cannot presently be ascertained from the available morphological findings. The study of additional *Pedicinus* taxa would be necessary, in particular those living on Asian colobines, in which less than 15% of an estimated 44 species (Duff & Lawson, 2004) have been examined for ectoparasites. Genital structures, paratergalia, isolated bristles, and also body coloration in *P. atratulus* n. sp., *P. curtipenitus* n. sp., and *P. tongkinensis* all show differences, which would clearly be useful in a later phylogenetic character analysis. From the parasitophyletic viewpoint however, these *Pedicinus* species supply us with excellent evidence that their hosts are valid species and not subspecies as was earlier thought.

In this connection, one noteworthy fact is that *Pygathrix nemaeus* and *P. cinerea*, as well as *P. cinerea* and *P. nigripes*, occur parapatrically and that there are occasional records of hybridization between them (Nadler et al., 2003). Therefore in those contact zones it is clear that a switch of host by *tongkinensis* and *curtipenitus* on the one hand, and by *curtipenitus* and *atratulus* on the other, theoretically cannot be excluded. However evidence of two *Pedicinus* (*Neopedicinus*) species living together permanently on one *Pygathrix* species would be extremely unlikely. Whether these *Pedicinus* species ever mate with each other on contact thus creating a mixed population remains unknown.

What is striking in the currently known hospitalic distribution of the *ancoratus* species group is that one species is polyxenous (= on more than one host) while the other three are monoxenous (= on one host only) (Table 1). In my opinion it must be doubted whether this supposed geographic-hospitalic distribution of *Pedicinus ancoratus* agrees with the facts. The reported cases of polyxeny are probably not even instances of secondary infestation but rather of so-called stragglers.

Among the many *Pedicinus atratulus* n. sp. individuals collected from a heavily infested black-

shanked douc langur was an immature female *Pedicinus* (*Parapedicinus*) species (specimen M. 4527. i). Perhaps this record is traceable to a contamination of collected material in the primate center.

In the light of this study, I would like to appeal to all interested primatologists to give some of their attention also to the lice living on primates, and to carefully collect such material (of known provenance!) for use in phthirapterological research.

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Successful cataract removal, and lens replacement on a rescued yellow-cheeked gibbon (*Nomascus gabriellae*)

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Key words: Yellow-cheeked gibbon, cataract surgery, phaco-emulsification, Dao Tien Endangered Primate Species Centre, Vietnam

Summary

A young female yellow-cheeked gibbon (*Nomascus gabriellae*), rescued from the illegal pet trade as an infant, has successfully undergone cataract surgery and lens replacement by Ho Chi Minh eye surgeons in Vietnam. After checking the retina in both eyes and calculating the required power of the replacement lenses, the cataract lenses were removed using phaco-emulsification, and new monofocal lenses fitted. The young gibbon (Mika) has adapted well to sight and lives with other gibbons in the Dao Tien Endangered Primate Species Centre in Cat Tien National Park, South Vietnam.

This is an important step for improving animal welfare standards in Vietnam and throughout Southeast Asia.

Cắt bỏ bệnh đục nhân mắt thành công và thay thủy tinh thể trên cá thể vượn má hung (*Nomascus gabriellae*)

Tóm tắt

Một cá thể non vượn má hung (*Nomascus gabriellae*) cái được cứu hộ từ buôn bán động vật hoang dã trái phép. Con vượn non này đã trải qua phẫu thuật bệnh đục nhân mắt và thay thủy tinh thể bởi các bác sĩ phẫu thuật mắt TP.Hồ Chí Minh tại Việt Nam. Sau khi kiểm tra võng mạc của cả hai mắt và tính toán khả năng yêu cầu của việc thay thế thủy tinh thể, thủy tinh thể đục nhân mắt được cắt bỏ sử dụng phaco-emulsification và thủy tinh thể mới được lắp vào. Cá thể vượn non (có tên Mika) đã thích nghi tốt với khả năng nhìn và cuộc sống với các cá thể vượn khác tại Trung tâm Cứu hộ các loài Linh trưởng Nguy cấp Đảo Tiên tại Vườn Quốc gia Cát Tiên, Nam Việt Nam.

Đây là một bước quan trọng nhằm cải thiện tiêu chuẩn chăm sóc động vật hoang dã tại Việt Nam và trên toàn khu vực Đông Nam Á.

Introduction

Gibbons (*Hylobatidae*) are distributed from north-east India and Bangladesh in the west, and Yunnan and the Hainan Island in the north, through Burma, Laos, Vietnam, Cambodia, Thailand,

and Malaysia and across Indonesia (Sumatra, Borneo and Java). With high adaptive radiation and speciation they have become the most successful ape in terms of the number of species and their distribution throughout South-east Asia.

In terms of risk of extinction, 86% of all gibbon taxa have become more endangered within the last three to six years (Geissmann, 2007). Certain gibbon species are the most endangered apes on earth (e.g. *Nomascus nasutus*; *N. hainanus*), due to loss of habitat, hunting for meat, Chinese medicine and the national and international illegal pet trade.

As a consequence, rescue centers located throughout Southeast Asia are overwhelmed with confiscated gibbons, trying to care and rehabilitate sometimes mentally and physically damaged individuals. The directors of the new Dao Tien Endangered Primate Species Centre in Cat Tien National Park, South Vietnam, have come across many gibbons with severe malnutrition and lack of social skills, but found most to possess a very strong innate ability to recover mentally and physically, if given the opportunity.

Animal welfare is becoming important in many Asian nations. The International Fund for Animal Welfare (IFAW) asked people in China, South Korea and Vietnam about their views on the treatment of animals; 90% believed "we have a moral duty to minimize suffering." Further still, the vast majority of those questioned would like to see legislation to protect animals (BBC NEWS, 2005). There is no animal welfare legislation in Vietnam, although increased awareness and support.

Background to the young female gibbon "Mika"

Mika, a young female gibbon estimated to be born in 2003, was illegally taken from the wild as an infant and taken to market to be sold in the illegal pet trade in Ho Chi Minh City. When rescued in 2005 the cage in which she was kept was welded closed, so she had most likely not left the cage for many months, unable to move, just sit on her legs. When the young gibbon was released from the cage she appeared paralyzed, with little muscle use in her legs. The bones in Mika's legs were seriously deformed, with 45-degree bends on the lower legs. This has probably been caused by the constricted movement in her small cage, as well as metabolic bone disease due to an unbalanced diet and lack of UVB exposure. Juvenile cataracts (clouding of the lens that gradually affects visual quality) were visible in both eyes, but she still appeared to have considerable vision. The gibbon was housed with other young gibbons for social company. Slowly she regained the use in her legs over the next 2 years.

By August 2008 when the Managers of Dao Tien first saw the gibbon, she was just reaching the age of sexual maturity and turning from black to blonde in color. The cataracts were very dense and the gibbon had no remaining sight (Fig. 1).

Background to cataract

Possible causes for cataract in early childhood are hereditary enzyme defects, severe trauma to the eye, intra-ocular inflammation, excessive ultraviolet-light exposure, poor diet, short but severe period(s) of dehydration, diabetes or the use of certain drugs. Not much is known about cataract in gibbons. Three cases of spontaneous cataracts have been investigated in a colony of vervet monkeys (*Chlorocebus aethiops*). Clinical chemistry gave a hint that calcium might be a key factor in the development of these cataracts: in both cases of the juvenile cataracts, the calcium content in the serum and in the aqueous humor was clearly decreased in the affected babies (Plesker et

Fig.1. Mika pre-surgery. Photo: Marina Kenyon.

al., 2004). While cataracts in captive-bred vervet monkeys starting at 6-8 months of age were found to have a probable genetic origin (Villiers et al., 2001).

Cataract removal in non-human primates has been successful in great apes. In 2004 a rescued chimpanzee at the Sannaga-Yong Chimpanzee Rescue Centre, Cameroon, West-central Africa was successfully operated on by an American medical ophthalmologist (Nichols, 2005). May 16th, 2007, successful cataract surgery was performed on a 20-year-old Orangutan, in Malaysia's Matang Wildlife Centre, after cataracts formed after he bit through an electric cable (Anonym, 2008).

In this case we wanted to remove cataracts from a small ape, a gibbon and replace the lens.

Materials and Methods

During health checks between August and November 2008, Mika was physically examined; blood and urine were tested repeatedly to rule out diabetes and other diseases. On November 29th 2008 Doctors Tien Phi Duy and Tran Huy Hoang from the Community Eye Department, Ho Chi Minh City Eye Hospital performed cataract surgery on Mika. This was the first time the doctors had performed this surgery on a non-human primate. After consultation with Dr Tran Hai Yen (Ho Chi Minh City Eye Hospital) it was agreed that the surgery could go ahead, using the training facilities in the hospital. Anaesthesia equipment was provided by the Endangered Asian Species Trust (EAST), sponsored by Robert Taylor, under veterinary supervision of Monkey World UK specialist primate veterinarian Femke van den Bos.

Before the surgery could take place, the eyes needed to be examined to check if the retina was still intact. If the retina would have been damaged, changing the lens would not have been useful

to regain sight. The left eye appeared to have slight retinal damage, and the retina in the right eye was completely intact. This was confirmed during the surgery when the cataracts had been removed allowing the retina to be seen through the operating microscope.

The corneal curvatures (hence refractive power) were measured with a handheld keratometer. The antero-posterior length of the eyeballs were taken using an a scan sonography machine. Both machines were factory-calibrated for use on human eyes, and the lenses approved by US FDA for human use as well. The readings were then used to calculate the power of intraocular lenses to be implanted. As it turned out, Mika's right eye needed a +27.0 diopter lens, and the left one a +29.0 diopter lens. The lens powers were calculated to return Mika's right eye to emmetropic status and render her left eye myopic. This was intended to enable her to see near objects with her left eye, and far objects with her right eye. The lenses she received were monofocal, which should enable her right eye to see well in the distance, and her left eye to see better objects nearer to her.

The surgical technique used is called phacoemulsification. This is the standard procedure for cataract removal in the US and other developed countries, which involves the use of a tiny tube inserted through a small (3 mm or less) incision into the eye to emulsify and then suck out the cataractous crystalline lens (Fig. 2). A clear, artificial intraocular lens needs to be placed in the position of the removed cataract to restore the normal refraction and therefore vision. To be implanted through such a small opening, the artificial lens must be foldable; three-piece foldable lenses (Sensar, manufactured by Allergan, USA) were used. As Mika had white cataract, trypan blue dye was used to stain the anterior lens capsule to assist with the opening of this capsule so that the lens material could be engaged with the phaco tube, leaving the capsular bag intact for lens replacement.
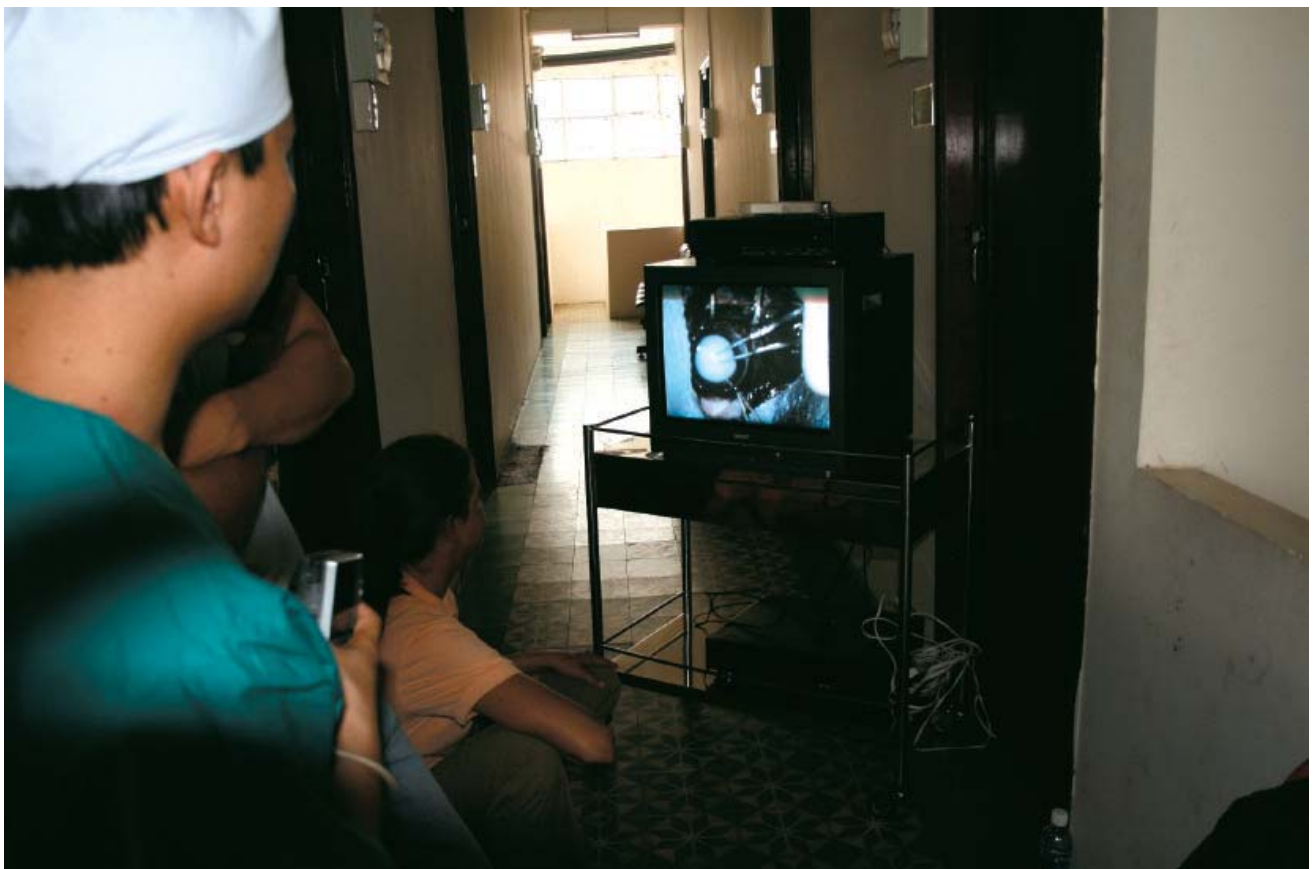

Fig.2. Phaco-emulsification of the eye. Photo: Marina Kenyon.

In human beings, white cataracts in a child's eyes are almost always congenital in origin unless there are other known factors such as drug use or trauma. According to the surgeon, Mika's cataract felt and reacted like pediatric cataract but human eyes with white congenital cataract operated as late in life as were Mika's usually do not regain good eyesight, as did Mika. This case could have been a late onset congenital cataract, but due to her unknown history in captivity, pathological causes cannot be ruled out.

After surgery

After a great debate about how to stop Mika from rubbing her eyes after the surgery, the general consensus was that there was no realistic way to prevent her but, as the surgery should not leave the eyes uncomfortable, the frequency of eye rubbing should be at low/normal levels. As a precaution Mika was placed on pain relief, 0.1mg/kg Meloxicam once a day just to ensure she had minimal reason to touch her eye. She was also given eye drops every 2 hours in the first week, and reduced weekly, for a total of 4 weeks to help protect against infection and inflammation. As Mika was used to being handled due to her blindness, she was very compliant and when given food she would turn her face up as gibbons do, allowing eye drops to be administered. After cataract surgery the eyes might be sensitive to light so Mika was placed in a dull-light room with no direct sunlight for 3 days.

Results and Discussion

By December 20th 2008, it was very clear that Mika had gained good vision in her right eye, but limited vision in her left eye, which was expected due to retinal damage from the extended period of the cataract and the intentionally induced myopia. There is debate about the psychological affect that the sudden acquirement of vision can have on an animal. This has been used as a reason to justify not operating in similar cases. Mika appeared to take everything in her stride and seems even happier with her social group. Six months on from surgery Mika has gained condition and now behaves like a dominant adult female (Fig. 3). The next stage for Mika is to be rehabilitated into trees.

The collaboration between different organizations and fields of expertise has not only transformed Mika's life but, demonstrated a willingness to improve animal welfare in South-east Asia, with young professionals possessing the expertise and belief to make a difference (Fig. 4). Specialist wild animal eye clinics have been suggested as a way to improve animal welfare in Vietnam, if found necessary.

Fig.3. Mika three months after surgery. Photo: Marina Kenyon.

Fig.4. The surgical team. Photo: Marina Kenyon.

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Frankfurt Zoological Society: "Vietnam Primate Conservation Program" and the Endangered Primate Rescue Center, Vietnam – Report 2009

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Summary

In 2009, the *Vietnam Primate Conservation Program* of Frankfurt Zoological Society celebrates its 17th year. The project supports the conservation of highly endangered and particularly Vietnamese endemic primates through habitat protection, captive breeding and reintroduction and education. The Endangered Primate Rescue Center provides housing for confiscated individuals of endangered primate species, supports law enforcement by the Forest Protection Authorities, and has established breeding programs of highly endangered species to support decreased wild populations through the reintroduction of captive-bred animals.

Since the establishment of the Van Long Nature Reserve in 2001, FZS continues to support protection activities by paying and training guards, providing equipment, organizing meetings with communes, and working in close cooperation with local authorities of the Reserve's Management Board.

During the year, monitoring for the Delacour's langur continued in four subpopulations. All four populations showed a dramatic decline. During the last five years, two subpopulations were eradicated.

On Hon Heo Peninsula, Khanh Hoa Province, the study and data collection on black-shanked douc langurs continued. The data should provide basic information for the application of protected area status there.

At the end of 2009, the Endangered Primate Rescue Center (EPRC) housed 148 primates, 115 langurs, 19 gibbons, and 14 lorises. In cooperation with Forest Protection Authorities, 7 langurs and 9 lorises were confiscated; 2 lorises were donated from private keeping after the owner was made aware about the illegality. Five langurs, 3 douc langurs and 1 gibbon were born at the center. Eighteen primates died, including 3 stillbirths and 2 newly confiscated grey-shanked douc langurs with heavy injuries. In October, 11 pygmy lorises were released into Cuc Phuong National Park. The EPRC acts as an important education facility for the public and as a training ground for students. Students of the University of Forestry, Xuan Mai, visit the Center regularly during training courses to get information about wildlife and to be trained in wildlife identification, especially primates.

Captive-bred Hatinh langurs that were transferred to Phong Nha-Ke Bang National Park in 2007 are still kept in the semi-wild enclosure. The release of the animals with GPS-radio collars for monitoring is planned for 2010.

In January, a conference titled "Conservation of Primates in Danang" was organized in cooperation with Danang University.

Báo cáo năm 2009 - Hội Động vật học Frankfurt "Chương trình Bảo tồn Linh trưởng Việt Nam" và Trung tâm Cứu hộ Linh trưởng Nguy cấp

Tóm tắt

Chương trình Bảo tôn Linh trưởng Việt Nam của Hội Động vật học Frankfurt hoạt động đến năm 2009 là năm thứ 17. Mục tiêu của dự án nhằm hỗ trợ bảo tồn những loài thú linh trưởng nguy cấp cao và đặc biệt là những loài đặc hữu của Việt Nam thông qua các hoạt động bảo vệ môi trường sống, chăm giữ động vật trong điều kiện nuôi nhốt và tái hòa nhập thú linh trưởng trở về tự nhiên. Trung tâm Cứu hộ Linh trưởng Nguy cấp là cơ sở chăm giữ những cá thể của những loài thú linh trưởng nguy cấp cao từ buôn bán vận chuyển động vật hoang dã trái phép nhằm hỗ trợ tăng cường thực thi pháp luật cho lực lượng Kiểm lâm và đồng thời thiết lập chương trình cho sinh sản một số loài nguy cấp cao để tăng viện số lượng cho loài còn trong tự nhiên.

Khu bảo tồn đất ngập nước Vân Long được thành lập từ năm 2001, FZS vẫn duy trì hỗ trợ cho nhiều hoạt động như chi phí phụ cấp hàng tháng, cung cấp trang thiết bị và thường niên tập huấn nâng cao năng lực bảo vệ rừng cho nhân viên bảo vệ, tổ chức hội nghị bảo vệ rừng cùng chính quyền cơ sở cấp xã, hợp tác chặt chẽ cùng Ban quản lý Khu bảo tồn. Trong năm đã thực hiện tái điều tra lại bốn bây đàn voọc mông trắng, kết quả cho thấy sự giảm sút mạnh số lượng của loài Trong năm năm vừa qua đã có hai đàn bị xóa sổ bởi những tác động tiêu cực của con người.

Trên báo đảo Hòn Hèo thuộc tỉnh Khánh Hòa, nghiên cứu về loài voọc chà vá chân đen vẫn tiếp tục thực hiện để thụ thập các dữ liệu về loài, các dữ liệu sẽ là những thông tin cơ bản về hiện trạng bảo vệ của loài trong khu vực.

Đến cuối năm 2009, EPRC chăm giữ 148 cá thể linh trưởng bảo gồm 115 cá thể voọc, 19 cá thể vượn, 14 cá thể cu li. Phối kết hợp cùng lực lượng Kiểm lâm, EPRC đã tiếp nhận cứu hộ 7 cá thể voọc, 9 cá thể cu li, 2 cá thể culi được khách du lịch đưa tới. Sinh sản có 5 cá thể voọc, 3 cá thể chà vá và 1 cá thể vượn. Số lượng tử vong có 18 cá thể, trong đó có 3 cá thể sau khi sinh, 2 cá thể chà vá chân xám bị thương quá nặng. Trong tháng 10 đã hòa nhập vào rừng Cúc Phương 11 cá thể culi nhỏ.

EPRC cũng là nơi thực hiện nhiệm vụ tuyên truyền giáo dục cho du khách và cũng là cơ sở cho sinh viên thăm quan và học tập trong thời gian làm thực tập. Sinh viên đến từ nhiều trường Đại học như Đại học Lâm nghiệp Xuân Mai. Các em sinh viên đã được tiếp nhận nhiều thông tin sinh học, hiện trạng bảo tồn về động vật hoang dã nói chung và linh trưởng nói riêng, qua đó định hướng chuyên nghành sinh học và bảo tồn động vật hoang dã cho các em.

Chương trình tái hòa nhập linh trưởng vào tự nhiên tại Vườn Quốc gia Phong Nha – Kẻ Bàng tiếp tục duy trì quan sát động vật trong khu bán hoang dã và tiến tới thả lại vào tự nhiên có gắn thiết bị định vị GPS nhằm giám sát động vật sau khi thả.

Trong tháng 1 năm 2009 đã hợp tác với Đại học Đà Nẵng tổ chức thành công Hội thảo Bảo tồn Linh trưởng tại thành phố Đà Nẵng.

Tạp chí Linh trưởng thường kỳ trong năm 2009 cũng đã được xuất bản với nhiều bài báo khoa

học về điều tra, nghiên cứu, bảo tồn linh trưởng của Việt Nam.

Đồng tài trợ với ngân sách của Hội Động vật học Frankfurt là các tổ chức: Viện Nghiên cứu Linh trưởng Châu Âu, CHLB Đức; Liên đoàn Bảo tồn Linh trưởng Quốc tế; Tổ chức Arcus Foundation, Hoa Kỳ; Vườn thú Leipzig, CHLB Đức; Tố chức Bảo tồn Loài và Quần thể; CHLB Đức; Hội các Vườn thú Virginia, Hoa Kỳ và nhiều cá nhân khác.

Introduction

In 2009, the *Vietnam Primate Conservation Program* of Frankfurt Zoological Society (FZS) celebrates its 17th year. The project supports the conservation of highly endangered and particularly Vietnamese endemic primates through habitat protection, captive breeding, reintroduction and education. The Endangered Primate Rescue Center provides housing for confiscated individuals of endangered primate species, supports law enforcement by Forest Protection Authorities, and has established breeding programs of highly endangered species to support decreased wild populations through the reintroduction of captive bred animals.

Habitat protection at Van Long Nature Reserve

Van Long Nature Reserve holds the largest and most probably the only viable population of the "Critically Endangered" Delacour's langur (*Trachypithecus delacouri*). Since establishment of the nature reserve in 2001, FZS continues to support protection activities by paying and training of guards, providing equipment, organizing meetings with communes, and working in close cooperation with local authorities and the Management Board of the reserve.

In 2009, the number of guards increased from 20 to 24 villagers. Four additional villagers were employed to enforce protection in an area which is planned for extension of the reserve. The reserve, currently 3,000 ha, is planned to extend an additional 4,000 ha.

Fig.1. Guards of Van Long Nature Reserve receive a reward for active protection work. Photo: Nguyen Thi Thu Hien.

Fig.2. A Delacour's langur group close to a cement factory in an area which is designated for limestone quarrying. Photo: Le Van Dung.

Primate surveys

During the year, monitoring for the Delacour's langur continued in four subpopulations (Kim Bang District, Ha Nam Province; Hoa Lu District, Ninh Binh Province; Ha Trung District, Thanh Hoa Province; Lac Thuy District, Hoa Binh Province). All four populations showed a dramatic decline. During the last five years two subpopulations were eradicated (Ngoc Son-Ngo Luong Nature Reserve, Hoa Binh Province; Thach Thanh District; Thanh Hoa Province). The surveys were carried out to trace populations which could be rescued through a translocation project into a save area. Some populations are under pressure through limestone quarrying for cement production (Fig. 2).

The monitoring of the Delacour's langur population in Van Long Nature Reserve continued and shows - as the only exception of all known populations – a steady increase.

The FZS biologist Nguyen Ai Tam continued the study of and data collection on black-shanked douc langurs on Hon Heo Peninsula, Khanh Hoa Province, South Vietnam (Fig. 3). The data should provide basic information for the application of protected area status On Hon Heo. The study was organized in close cooperation with the Forest Inventory and Planning Institute, Hanoi. Severe impact to the area through illegal logging, conversion of forest into agricultural land, trapping, and hunting were recorded (Fig. 4). The black-shanked douc langur population is under threat due to hunting (Fig. 6).

Endangered Primate Rescue Center

Staff

During the year there have been some personnel changes in the Vietnamese staff but the EPRC continues to employ 20 Vietnamese animal keepers. In January, animal keeper Timo Gessner arrived from Leipzig Zoo, Germany and continued the already long lasting cooperation with Leipzig Zoo. He

Fig.3. Hon Heo Peninsula, Khanh Hoa Province with a population of the endangered black shanked douc langurs (*Pygathrix nigripes*).
Photo: Tilo Nadler.

Fig.4. Large forest areas on the peninsula become continuously converted into agricultural land. Photo: Tilo Nadler.

Fig.5. Black-shanked douc langurs (*Pygathrix nigripes*) on Hon Heo Peninsula. Photo: Tilo Nadler.

took over the supervisor position from Kelly Blakemore, animal keeper from California, who was leaving in April. Denny Lohse, another animal keeper from Leipzig Zoo, arrived in September to replace Timo Gessner with a planned time overlap until the end of the year. But in November Timo Gessner had a dramatic accident in a rocky area of Cuc Phuong National Park and had to return to Germany.

The support by Leipzig Zoo in providing the EPRC with experienced animal keepering personnel is invaluable in maintaining high quality animal keeping and in training of the Vietnamese keepers.

Fig.6. Poached black-shanked douc langurs (*Pygathrix nigripes*) on Hon Heo Peninsula. Photo: Vo Van Tao.

Primates housed at the EPRC

At the end of 2009, the EPRC housed 148 primates, 115 langurs, 19 gibbons, and 14 lorises. In cooperation with Forest Protection Authorities, 7 langurs and 9 lorises were confiscated and 2 lorises were donated from private keeping after the owner was made aware about the illegality. Five langurs, 3 douc langurs and 1 gibbon were born at the center. 18 primates died, including 3 stillbirths and 2 new confiscated grey-shanked douc langurs with heavy injuries.

In October, 11 pygmy lorises were released into Cuc Phuong National Park (Fig. 7 and 8).

Fig.7. Release of pygmy lorises (*Nycticebus pygmaeus*) in Cuc Phuong National Park. Photo: Tilo Nadler.

Fig.8. Released pygmy loris (*Nycticebus pygmaeus*). Photo: Tilo Nadler.

Education

The EPRC acts as an important education facility for the public and as a training ground for students. Students of the University of Forestry, Xuan Mai regularly visit the Center during training courses to get information about wildlife and to be trained in wildlife identification, especially primates. Study tours by students of the UN-International School in Hanoi and the German School in Beijing, China have been a tradition for several years now.

About 7,000 visitors to the EPRC were recorded during the year.

Cooperation with Authorities to combat poaching and illegal wildlife trade

The project staff worked together with Forest Protection Authorities and the Vietnamese organization Education for Nature (ENV) to confiscate 16 primates. Langurs, confiscated in southern provinces, are transported by car or by air to the EPRC. The transport is very costly but supports the motivation of the rangers. Without the possibility of a placement the confiscation of animals will stop.

Project staff attended a criminal court case against two poachers who killed two black-shanked douc langurs at the FZS study site on Hon Heo Peninsula, Khanh Hoa Province (Fig. 8). The court sentenced the two poachers to a high punishment of 24 and 30 months of jail time, respectively. Such a high punishment is still a rare exception but shows an increasing awareness about the value of threatened and endangered wildlife.

Fig.9. A criminal court sentenced the two poachers of black-shanked douc langurs (Fig. 6) to a high punishment of 24 and 30 month of jail time, respectively. Photo: Nguyen Ai Tam.

Reintroduction project in Phong Nha-Ke Bang National Park

In September, Pascal Fust took over the management of the reintroduction project from Bernhard Forster. Despite increased efforts to habituate the captive bred Hatinh langurs (which were transferred from the EPRC in September 2007) on the large (20 ha) semi-wild enclosure, it was not yet possible to catch the animals again for the planned final release into the national park.

A release site inside the national park has already been designated and intensified ranger patrols continue to be carried out there. The released, collared langurs should be monitored by radio telemetry to gather information about the success of the reintroduction and possible interactions with the wild population.

Primate conference

In January, a conference "Conservation of Primates in Danang" was organized in cooperation

with Danang University. Participants in the conference included leaders from Danang City, teachers from Danang University, and also primatologists. As one of the largest cities in Vietnam, Danang has an exceptional and unique environment of protected areas with parts of primary forest close to the city. These protected areas hold red-shanked douc langurs and several other primate species as well. The conference should raise awareness for decision makers about the value of these areas and support for primate research activities.

Fig.10. Participants on the primate conference in Danang. Photo: Nguyen Ai Tam.

Fig.11. Signing ceremony of a document for cooperation about primate research and primate protection in Danang between Frankfurt Zoological Society, Departments of the Danangs People's Committee and Danang University. Photo: Nguyen Thi Thu Hien.

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We would like to thank all who support our work. We are grateful for this support and try to use our funds economically.

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

The Vietnamese Journal of Primatology was issued in 2009 with 10 scientific articles. The Journal can be ordered at the EPRC but is also available on the website of the IUCN / Primate Specialist Group. A checklist Birds of Cuc Phuong National Park was published which also includes a set of color post cards.

A number of scientific and popular articles were published:

Fig.12. Publication of "Birds of Cuc Phuong National Park – a checklist".

Bernstein RM, **Nadler T**, **Brown JL** and **Fourie NH** (2009): Variation in fecal glucocorticoid concentrations in captive red-shanked douc langurs (*Pygathrix nemaeus*) Vietnamese J Primatol. (1) 3, 65-74.

Brockman DK, **Harrison RO** and **Nadler T** (2009): An assessment of Agent Orange exposure in douc langurs (*Pygathrix*) at the Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam. Vietnamese J Primatol. (1) 3, 45-64.

Carbone L, **Mootnick AR**, **Nadler T**, **Moisson P**, **Ryder O**, **Roos C** & **de Jong PJ** (2009): A Chromosomal Inversion Unique to the Northern White-cheeked Gibbon. PLoS ONE 4, e4999.

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Nadler T (2009): Hybridisation between Colobine Genera (*Trachypithecus* x *Pygathrix*) a case study under semi-wild conditions. Presentation on the Symposium "Hybridisation in Primates" German Primate Center, Goettingen, October 7-10, 2009.

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Nadler T & **Wicker F** (2009): Birds of Cuc Phuong National Park – a checklist. Frankfurt Zoological Society.

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Nam Phuong (2009): Langur family. Phu nu 68, 12. (In Vietnamese)

Torr J (2009): No place to hide. Discovery Channel Magazine. September 2009, 86-91.
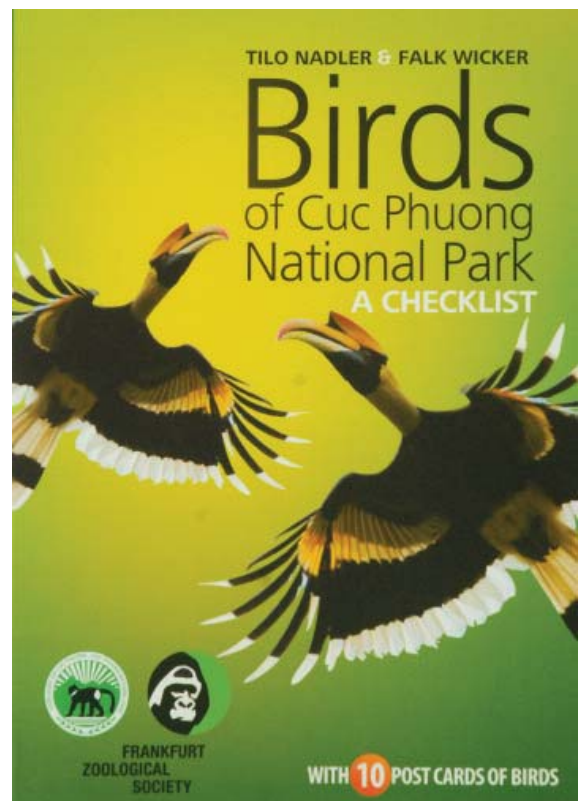
Appendix

Register of primates at the EPRC 2009 - (up to date 31.12. 2009)

(*species or subspecies only held in EPRC anywhere 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
1-03	17.5.94	F	ad.	wild	wild	confiscated	† 11.8.09
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
1-08	16.8.99	F	16.8.99	1-01	1-03	born EPRC	† 9.9.09
1-09	3.4.01	F	3.4.01	1-01	1-03	born EPRC	EPRC
1-10	4.6.01	M	4.6.01	1-02	1-05	born EPRC	EPRC
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	EPRC
1-21	29.7.08	F	29.7.08	1-07	1-13	born EPRC	EPRC
1-22	27.4.09	F	27.4.09	1-04	1-08	born EPRC	† 13.9.09
Hatinh langur *Trachypithecus* [*laotum*] *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
2-15	15.10.97	M	1995	wild	wild	from tourists	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
2-21	11.3.98	M	11.3.98	2-01	2-04	born EPRC	† 17.10.09
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	EPRC
2-26	20.11.00	M	20.11.00	2-15	2-11	born EPRC	EPRC
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	EPRC

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	?	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
2-61	24.4.09	M	24.4.09	2-01	2-09	born EPRC	† 7.6.09
2-62	May 09	M	May 09	2-12	2-05	born EPRC	EPRC
2-63	4.6.09	F	4.6.09	2-15	2-20	born EPRC	EPRC

Black langur *Trachypithecus* [*laotum*] *hatinhensis* morph "*ebenus*" (*)

| 14-01 | 12.1.98 | M | 1996 | wild | wild | from tourists | EPRC |

Laos langur *Trachypithecus* [*laotum*] *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 (Golden-headed langur) *Trachypithecus* [*poliocephalus*] *poliocephalus* (*)

15-01	8.11.98	F	1998	wild	wild	confiscated	EPRC
15-04	2.6.03	M	2.6.03	15-02	15-01	born EPRC	EPRC
15-05	10.6.09	F	10.6.09	15-04	15-01	stillbirth EPRC	† 10.6.09

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 |

Red-shanked douc langur x Hatinh langur *P. nemaeus* x *T. laotum 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	EPRC
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
6-30	6.6.01	F	6.6.01	6-06	6-02	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	EPRC
6-36	28.6.04	M	ad.	wild	wild	confiscated	† 17.12.09
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
6-52	14.9.07	M	2003	wild	wild	confiscated	† 19.11.09
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	EPRC
6-58	27.3.08	F	27.3.08	6-16	6-32	born EPRC	EPRC
6-59	1.4.08	M	1.4.08	6-16	6-38	born EPRC	† 14.5.09
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	EPRC
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	confiscated	EPRC

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

7-01	31.8.95	M	1992	wild	wild	confiscated	EPRC
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
7-31	5.3.06	M	5.3.06	7-04	7-13	born EPRC	EPRC
7-34	19.10.06	F	2000	wild	wild	confiscated	EPRC
7-35	3.11.06	F	ad.	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
7-41	5.2.08	F	5.2.08	7-04	7-08	born EPRC	† 13.5.09
7-43	5.5.08	M	5.5.08	7-01	7-11	born EPRC	EPRC
7-44	24.8.08	F	2007	wild	wild	confiscated	† 22.4.09
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
7-50	26.8.09	M	2008	wild	wild	confiscated	† 27.8.09
7-51	20.10.09	M	2007	wild	wild	confiscated	† 4.11.09

Black-shanked douc langur *Pygathrix nigripes*

| 13-05 | 15.3.01 | M | 1996 | wild | wild | confiscated | EPRC |

White-cheeked gibbon *Nomascus leucogenys leucogenys*

8-01	30.9.94	F	1993	wild	wild	from foreigner	EPRC
8-02	30.9.94	F	1994	wild	wild	from foreigner	† 6.9.09
8-03	28.5.02	M	1999	wild	wild	confiscated	EPRC
8-08	19.11.04	F	2001	wild	wild	confiscated	EPRC

Southern white-cheeked gibbon *Nomascus leucogenys 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
9-07	30.10.96	M	1996	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
9-10	10.3.00	M	1999	wild	wild	confiscated	† 24.10.09
9-11	25.7.02	F	25.7.02	9-03	9-06	born EPRC	EPRC
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
9-14	30.12.07	M	30.12.07	9-07	9-06	born EPRC	† 11.10.09
9-15	15.7.09	M	15.7.09	9-05	9-02	born EPRC	EPRC

Yellow-cheeked crested gibbon *Nomascus gabriellae*

10-02	6.2.97	F	1994	wild	wild	confiscated	EPRC
10-04	3.6.01	F	1997	wild	wild	confiscated	EPRC
10-05	11.6.04	F	2001	wild	wild	confiscated	EPRC
10-06	21.5.04	F	2003	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

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	F	22.2.01	12-09	12-04	born EPRC	EPRC
12-69	24.2.06	F	2/2005	wild	wild	confiscated	† 29.10.09
12-70	24.2.06	F	ad.	wild	wild	confiscated	EPRC
12-72	24.2.06	F	ad.	wild	wild	confiscated	EPRC
12-78	15.3.06	F	ad.	wild	wild	confiscated	released 26.10.09
12-86	17.5.07	F	ad.	wild	wild	confiscated	released 26.10.09
12-88	17.5.07	F	ad.	wild	wild	confiscated	EPRC
12-94	28.10.07	M	ad.	wild	wild	confiscated	released 26.10.09
12-96	11.1.08	M	ad.	wild	wild	confiscated	released 26.10.09
12-97	12.4.08	F	ad.	wild	wild	confiscated	EPRC
12-98	5.12.08	F	ad.	wild	wild	confiscated	† 27.8.09
12-99	7.1.09	F	ad.	wild	wild	confiscated	EPRC
12-100	14.3.09	F	ad.	wild	wild	confiscated	EPRC
12-101	Febr.09	M	2/2009	wild	12-98	born EPRC	EPRC
12-102	Febr.09	F	2/2009	wild	12-99	born EPRC	EPRC
12-103	Febr.09	M	2/2009	wild	12-99	born EPRC	EPRC
12-104	27.5.09	M	2/2009	wild	wild	confiscated	released 26.10.09
12-105	27.5.09	F	2/2009	wild	wild	confiscated	released 26.10.09
12-106	28.5.09	M	ad.	wild	wild	from tourists	released 26.10.09
12-107	18.7.09	M	ad.	wild	wild	confiscated	released 26.10.09
12-108	18.7.09	M	ad.	wild	wild	confiscated	released 26.10.09
12-109	18.7.09	F	ad.	wild	wild	confiscated	released 26.10.09
12-110	6.8.09	M	2008	wild	wild	from private	EPRC
12-111	18.9.09	F	ad.	wild	wild	confiscated	released 26.10.09

INSTRUCTIONS FOR CONTRIBUTORS

The **Vietnamese Journal of Primatology** welcomes manuscripts from all areas related to the conservation and research of non-human primate taxa which occur in Vietnam and the neighboring countries of Cambodia, China and Laos. The journal publishes both original research papers and review articles. Original papers may be published as standard research articles or as short communications.

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Endangered Primate Rescue Center	German Primate Center
Vietnam	Germany
Email: t.nadler@mail.hut.edu.vn	Email: croos@dpz.eu

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The first page of the manuscript should include the complete title of the paper, the authors' names, an abstract and key words. The complete postal addresses, e-mails and affiliated institutions of the authors must be given at the bottom of the title page.
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Papers published in periodicals
Dao Van Tien (1989): On the trends of the evolutionary radiation on the Tonkin Leaf monkey (*Presbytis francoisi*) (Primates: Cercopithecidae). J. of Human Evolution 4, 501-507.
Fooden J (1996): Zoogeography of Vietnamese Primates. Int. J. Primatol. 17, 845-899.

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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