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…with the description of a new primate species

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Cover: Short-tailed langur (*Trachypithecus brevicaudus*). Photo: Tilo Nadler.

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# A new primate species from Laos – genus *Trachypithecus*

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**Keywords:** new primate species, short-tailed langur, *Trachypithecus brevicaudus*

**Summary**

The occurrence of langurs in Laos that cannot be definitively assigned to a specific species is mentioned in the scientific literature. Interviews with residents and hunters in Bolikhamxai Province also suggested this. Two photographs taken by a staff member of the Saola Foundation reinforced the suspicion that a previously undescribed primate species exists.

During several surveys in Bolikhamxai Province, photographs of langurs were taken. Analysis of the photographs reveals significant differences in tail length and thickness compared to the two known southern species of so-called limestone langurs: the Hatinh langur (*Trachypithecus hatinhensis*) and the Lao langur (*T. laotum*). Although no type specimen or genetic samples exist to confirm its differentiation from the known species, we consider the available evidence sufficient to describe this langur as a new species. We name it the short-tailed langur (*Trachypithecus brevicaudus*).

# Một loài linh trưởng mới ở Lào – chi *Trachypithecus*

**Tóm tắt**

Sự xuất hiện của đàn voọc ở Lào mà không thể xác định chắc chắn thuộc loài nào đã được đề cập trong tài liệu khoa học. Các cuộc phỏng vấn với người dân và thợ săn ở tỉnh Bolikhamxai cũng cho thấy điều này. Hai bức ảnh do một nhân viên của Quỹ Bảo tồn Saola chụp đã củng cố thêm nghi ngờ về sự tồn tại của một loài linh trưởng chưa được mô tả trước đây.

Trong một số cuộc khảo sát ở tỉnh Bolikhamxai, ảnh chụp loài voọc này đã được ghi lại. Phân tích các bức ảnh cho thấy sự khác biệt đáng kể về chiều dài và độ dày đuôi so với hai loài voọc đá vôi ở phía Nam: Voọc Hatinh (*Trachypithecus hatinhensis*) và voọc Lào (*T. laotum*). Mặc dù không có mẫu vật điển hình hoặc mẫu di truyền nào tồn tại để xác nhận sự khác biệt của nó với các loài đã biết, nhóm khảo sát chúng tôi cho rằng bằng chứng hiện có đủ để mô tả loài voọc này là một loài mới. Chúng tôi đặt tên cho nó là voọc đuôi ngắn (*Trachypithecus brevicaudus*).

## Introduction

The systematics and distribution of primates in Indochina remained unclear until very recently. Over the last three decades, significant progress has been made through more intensive fieldwork by institutes, universities, and especially NGOs, as well as the application of genetic methods. Genetic studies have led to a clarification of the taxonomic position of primates and thus to a stable systematics upon which conservation activities can be planned and carried out. These studies confirmed the status of the *Trachypithecus* species, of which the species of the so-called *francoisi*-group are also known as limestone langurs.

This group includes the four species with a northern distribution, Francois' langur (*T. francoisi*), white-headed langur (*T. leucocephalus*), Cat Ba langur (*T. poliocephalus*), Delacour's langur (*T. delacouri*) and two southern species, Hatinh langur (*T. hatinhensis*) with two color morphs and Lao langur (*T. laotum*) (Roos et al. 2001; Roos 2003; 2004; Osterholz et al. 2008). Another clarification

was the separation of the silvered langurs into two species, the Annamese silvered langur (*T. annamensis*) and the Indochinese silvered langur (*T. germaini*) (Roos et al. 2008), the splitting of the black gibbons into a western and an eastern species (*Nomascus concolor* and *N. nasutus*) (Roos 2004; Roos et al. 2007), and most recently the splitting of the pygmy loris into a northern and a southern species (*Xanthonycticebus intermedius* and *X. pygmaeus*) (Blair et al. 2023).

Of particular importance was the genetic confirmation of the newly discovered primate species in Vietnam: the grey-shanked douc langur (Nadler 1997; Roos & Nadler 2001) and the Annamese gibbon (Van Ngoc Thinh et al. 2010a; 2010b; 2010c; 2011). These discoveries also demonstrate that surprises can still occur even among primates that are now relatively well-studied.

Older reports (Boonratana 1998; Robichaud 1998; Steinmetz 1998; Duckworth et al. 1999; Evans et al. 2000; Duckworth et al. 2010) mention sporadic observations of phenotypically distinct langurs in central Laos: completely black, black with a white beard, and black with a white head. However, the taxonomic classification of the observed individuals was unclear, and they were mostly placed *sensu lato* with François langurs. Duckworth et al. (1999) mention that, according to information from locals, undocumented forms may still exist in some areas - without specifying them.

A photograph of a black langur, taken by a staff member of the Saola Foundation, with a tail length and thickness that differed significantly from those of known langurs, raised the suspicion that the existence of a previously unknown form might be confirmed. These suspicions, based on the photograph, were presented by the Saola Foundation at the EAZA Conservation Forum 2022 in Zagreb and at the EAZA Annual Conference 2023 in Helsinki. However, conclusive evidence was still lacking.

To date, the occurrence of 20 primate species in Laos has been documented: 5 macaque species, 6 colobine species, 6 gibbon species, and 3 loris species. The colobine species include the red-shanked and grey-shanked douc langur (*Pygathrix nemaeus* and *P. cinerea*). The grey-shanked douc langur, whose main distribution area is in Vietnam, occurs only in a very limited area in the far southeast of Laos, within the Dong Amphan National Protected Area. Representatives of the genus *Trachypithecus* include the Indochinese silvered langur and the limestone langurs Hatinh langur, including the black morph *ebenus* and the Lao langur.

**Methods**

For more than 15 years, the first author has conducted numerous primate surveys in Laos, particularly on the distribution of limestone langurs of the genus *Trachypithecus*. In 2025, three surveys were carried out in the limestone areas of Bolikhamxai Province. Surveys in February and May 2025 were interview surveys to obtain information from locals about the occurrence of primates, especially limestone langurs. During a survey in November/December 2025, the first photographs of limestone langurs were taken in the area of the village Na Di. Two further surveys in January and March 2026 yielded observations and photographs of another group of limestone langurs in the area of the village of Khamkouna (Houay Khang).

The habitat of these langurs consists of rugged limestone formations with typical sparse limestone forest. In narrow valleys and gorges, the vegetation and tree cover are often denser. These are often preferred feeding places of langurs (Figs. 1, 2).



**Fig.1.** Typical habitat of the short-tailed langur. Photo: Tilo Nadler.



**Fig.2.** The typical limestone forest consists mainly of thin-trunked trees and bushes. These are the feeding grounds of leaf-eating langurs. Photo: Tilo Nadler.

## Material

The first photograph of a previously undescribed langur was taken on May 1, 2024, by Souksamian Laladeth, a staff member of the Saola Foundation (Figs. 3, 4), and is published on the Saola Foundation website. A series of photographs of langurs was taken by TN on December 2, 2025, in the limestone area surrounding the village of Na Di (Figs. 5, 6). Another series of photographs of a group of limestone langurs was taken in January 2026 in the limestone area surrounding the village of Khamkouna, and it is highly likely that the same group was photographed again in March 2026 (Figs. 7, 8, 9).



**Fig.3.** The first published photo of a short-tailed langur. Photo: Souksamlan Laladeth, Saola Foundation.



**Fig.4.** The same animal during the jump. Photo: Souksamlam Laladeth, Saola Foundation.



**Fig.5.** Male short-tailed langur of a group. Photo: Tilo Nadler.



**Fig.6.** Short-tailed langur of a group. Photo: Tilo Nadler.



**Fig.7.** A group of short-tailed langurs consisting of five adults (four in the photo) and two juveniles, approximately 1.5 to 2 years old. Photo: Tilo Nadler.



**Fig.8.** The langurs eat the buds of the leaves. Photo: Tilo Nadler.



**Fig.9.** One male (in the middle) and two females. As with other limestone langurs, the females are recognizable even from a greater distance by their white pubic patch. Photo: Tilo Nadler.

## Results

The photographs of the langurs show animals that resemble the black morphe *ebenus* of the Hatinh langurs in both appearance and coloration. The striking difference, however, is the significantly shorter and thicker tail. To allow a comparison with known and very likely closely related species, enlarged photographs were measured. For this purpose, photographs were selected that showed the animals as clearly as possible from the side. Since the usual measurement of the head-body length is not possible with an animal lying stretched out, the measurement of the back length – from the neck to the base of the tail – and the tail length was chosen (Fig. 10). When measuring animals of the previously undescribed species with limestone langurs of the southern group, Hatinh langur, including morphe *ebenus* and the Lao langur, the following average results were obtained for the back length to tail length ratio:




**Fig.10.** The back and tail lengths were measured from photographs of six different short-tailed langur individuals and of 20 langurs from the southern limestone langur group. Photos: Tilo Nadler.

For 6 individuals of the previously undescribed form: 1:1.80

For 10 individuals Hatinh langurs: 1:2.14

For 4 individuals Hatinh langurs of morphe *ebenus*: 1:2.10

For 6 individuals Laos langurs: 1:2.18

Despite the inherent uncertainty of the measurement method, the difference in tail length is clearly evident (Figs. 11, 12). Measuring tail thickness would introduce even greater uncertainty, but the difference is visually apparent.

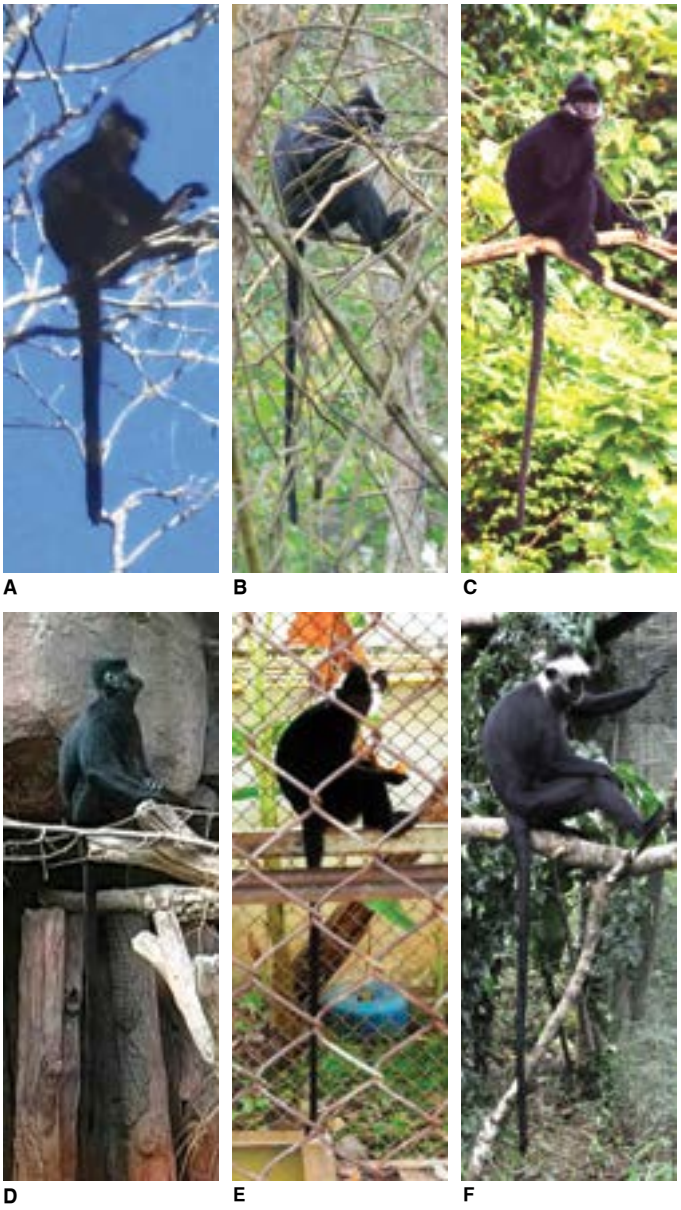



**Fig.11.** Comparison of tail lengths of the limestone langurs of the southern group: A – short-tailed langur, Photo: Tilo Nadler. B and C – Hatinhlangur, Photo: Tilo Nadler. D – Hatinhlangur morphe *ebenus*, Photo: Roland Männel. E – Hatinhlangur morphe *ebenus*, Photo: Tilo Nadler. F – Laoslangur, Photo: Tilo Nadler.

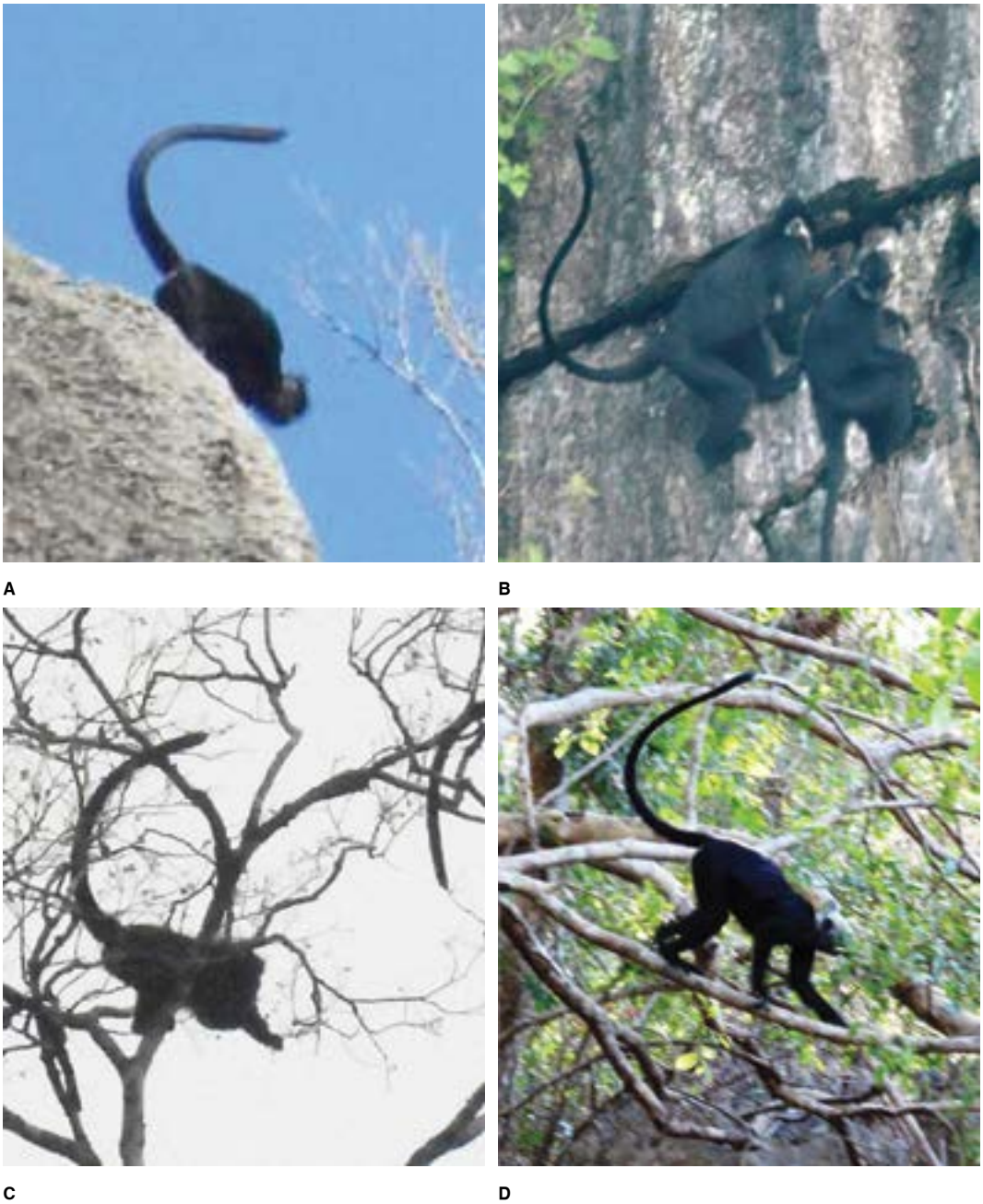


**Fig.12.** The tail, which is held forward over the back and is typical for the southern group of limestone langurs, shows a clear difference in tail length and tail thickness between short-tailed langur (A and C), Hatinhlangur (B) and Laoslangur (D). Photos: Tilo Nadler.

## Discussion

The various photos of animals of this previously unknown form show a clear difference in tail length and thickness compared to known southern limestone langur species. The northern limestone langurs, Francois' langur, white-headed langur, Cat Ba langur, and Delacour's langur, differ from the southern limestone langurs in various morphological characteristics and also in tail thickness,

although the tail length is approximately the same as in the southern group (Nadler 2026; Nadler & Brockman 2014). However, a measurable comparison of tail thickness is difficult, but visually quite noticeable. Delacour's langur, with its long-haired tail, is an exception.

The most reliable and comprehensive measurements of tail length and other body masses probably exist from the Endangered Primate Rescue Center, Vietnam (Nadler & Brockman 2014).

The tail length of Hatinh langurs is 75–95 cm in males, averaging 87.5 cm, and 73–96 cm in females, averaging 84 cm. Given a tail length ratio of 1.80 to 2.14 for the previously undescribed species to Hatinh langurs the tail length of the undescribed species is approximately 11–15 cm shorter, or about 63–80 cm.

This difference is roughly equivalent to the difference in tail length between the *Pygathrix* species red- and black-shanked douc langur (*P. nemaeus* and *nigripes*) (Nadler & Brockman 2014).

Regarding tail thickness, one might also assume that this form is possibly closely related to the Francois langur. However, this is contradicted by the tail length of the Francois' langur, which is approximately 80–90 cm, and quite clearly also by the tail carriage, which unequivocally assigns this form to the southern group of limestone langurs (Fig. 12) (Nadler 2026).

This also raises the question of taxonomic classification, as a species or subspecies of one of the known species. However, the significant difference in tail length and shape leaves little doubt that this form should be granted species status. Based on morphology, behavior and habitat use, there is also no doubt that this form of langur belongs to the southern group of limestone langurs and the genus *Trachypithecus*.

However, the establishment of a new species lacks both a type specimen and a sample for genetic substantiation. In the past, hunting of these langurs was quite intensive. Poppies were cultivated for opium production in the rather inaccessible mountains and their rocky areas. Daily returns of the farmers to the villages in the valley were not possible when working the fields, and therefore supplies were primarily obtained through hunting, with langurs being a relatively common prey. Both poppy cultivation and hunting of now-protected species, including langurs, are punishable offenses, which has led to a widespread cessation of poaching. In particular, the arduous climb into the rocky massifs to reach the langur habitats is disproportionate to a questionable hunting outcome. During the interview surveys, the villagers were also asked about any remaining traces of langurs that might be present. However, according to numerous sources, all such remains, especially bones, were sold long ago to Vietnamese wildlife traders who frequented the villages and acquired such wildlife remains for the production of traditional medicine.

It will certainly be a future problem in the description of newly discovered species, especially larger mammals that existing laws and regulations prevent the collection of voucher specimens from the wild, and even samples for genetic identification are often unavailable.

Against this backdrop, we describe a species here based solely on clear photographic differences from known species. We would like to name this species:

**Short-tailed langur**

*Trachypithecus brevicaudus*

Description

A completely black langur, comparable to the black morph *ebenus* of the Hatinh langur. This species, however, has a tail length of 63–80 cm, on average 11–15 cm shorter than the other southern limestone langurs, the Hatinh langur, including their black morph *ebenus*, and the Lao langur. In contrast, its tail thickness is significantly greater compared to these other species. The tail carriage is similar to that of southern limestone langurs, with the tail held forward over the back (Nadler 2026). We refer to the male animal in Fig. 5 as the "photographic holotype".

Juveniles are born with yellow fur, as is the case with all other limestone langurs. Observations of juveniles with yellowish heads indicate that they also undergo a color change.

## Etymology

The scientific species name *brevicaudus* comes from Latin and means short-tailed, a combination of *brevis*-short and *cauda*-tail. The name thus describes the distinctive morphological characteristic of this species.

## Type Locality

The species has been recorded on two limestone blocks, southeast and east of the district center of Viengthong (Fig. 13). The southeastern block near the village of Na Di 18°18'...18°21'/104°32'...104°36' is considered the type locality and covers an area of approximately 3600 ha. The northeastern limestone block at 18°30'...18°33'/ 104°40'...104°42' covers an area of approximately 3000 ha. The distance between these two limestone blocks is about 20 km, and smaller limestone formations lie between them. Neither area has protected status. The northeastern area borders the Phou Sithone Endangered Species Conservation Area, a provincial protected area of approximately 14,000 hectares, established in 2010.




**Fig.13.** Confirmed occurrences of the short-tailed langur (*Trachypithecus brevicaudus*).

## Habitat

The occurrence of this species is most likely, like that of other limestone langurs, restricted to rugged limestone outcrops. It is also likely that this species uses caves or niches in the rocks as sleeping places.

## Distribution

Due to the limited number of records, it is not possible to make a statement about the overall distribution of this species. However, it is very likely that it has an insular and allopatric distribution among the Hatinh and Lao langur (Fig. 13).

### Threats

Based on reliable information gathered during four surveys in the species' range, hunting pressure appears to be very low. Working in the former opium poppy fields left relatively ample time for hunting. With the still widespread illegal logging, time spent in the forest is used for processing timber, which is more valuable than hunting game, which is difficult to obtain.

The limestone langurs, Lao langur and Hatinh langur found in Laos, including the morph *ebenus*, are listed as 'Endangered' on the IUCN Red List of Threatened Species. The short-tailed langur likely has the same assessments to also be classified as 'Endangered'.

## Acknowledgements

We would like to thank our friends and colleagues who supported our surveys. Our thanks go to Pachou Thao, our excellent guide, Somsack Ladsavong from the Lao Conservation Trust for Wildlife, to Keut Chanthalard, Roland Männel and the many unnamed villagers who provided us with information about the wildlife in their region.

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# The history of existing populations of Delacour's langur (*Trachypithecus delacouri*), their current status, and a conservation strategy for their preservation

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**Keywords:** Delacour's langur, *Trachypithecus delacouri*, status, conservation strategy.

**Summary**

Delacour's langur (*Trachypithecus delacouri*) is one of three endemic primate species in Vietnam. It is classified as 'Critically Endangered' in both the IUCN Red List of Threatened Species and the Vietnam Red Data Book, and listed among the "World's Top 25 Most Endangered Primates".

Vietnam as a country, and in particular the Ninh Binh Province with approximately 95% of all individuals, bears responsibility for the long-term survival of the species. Conservation measures must be developed and established for this purpose.

Frankfurt Zoological Society launched a long-term program in 1993 specifically focused on this species. Extensive survey activities in the following years led to the confirmation of occurrences in 16 isolated areas within a limited region of northern Vietnam. By around 2010, 11 of the 16 existing populations had been eradicated through poaching. Currently, only 5 originally wild populations remain. The Endangered Primate Rescue Center has a captive breeding population, and individuals born in this facility are intended to establish another population at the UNESCO Trang An World Heritage Site. The total population of the species observed and determined through surveys is approximately 400 individuals and is estimated to be around 500 individuals in total.

Threats to the long-term survival of the species include poaching, habitat destruction, and fragmentation.

To ensure the long-term survival of the species, various conservation measures are necessary:

- Areas without protected status where populations of Delacour's langurs exist should urgently be granted protected status.This applies in particular to the second largest population in the Kim Bang karst area and the third largest population in the Yen Mo karst area.
- The two largest populations, in the Van Long Nature Reserve and the Kim Bang karst area, should be connected by a corridor to facilitate genetic exchange and ensure sufficient carrying capacity.
- The area adjacent to the Van Long Nature Reserve in the (former) Lac Thuy District, Phu Tho Province, should be integrated into the nature reserve, either by extending the reserve into the neighboring province or by incorporating the (former) Lac Thuy District into Ninh Binh Province.
- The ongoing establishment of a further reserve population at the UNESCO Trang An World Heritage Site requires the translocation of animals from the wild to reduce inbreeding. The translocation of animals, preferably from the Van Long Nature Reserve, should be planned immediately and carried out with the utmost care.
- Continuing a captive breeding program is only worthwhile if, in particular, male animals from the wild are integrated to reduce inbreeding. Animals from the wild should not be integrated into the

captive population of the EPRC and, moreover, exposed to a high risk of parasite infection, but should instead be released on the islands within the UNESCO Trang An World Heritage Site to strengthen the development of this population.

## Lịch sử của các quần thể voọc mông trắng hiện có (*Trachypithecus delacouri*), hiện trạng của chúng và chiến lược bảo tồn loài

**Tóm tắt**

Voọc mông trắng (*Trachypithecus delacouri*) là một trong ba loài linh trưởng đặc hữu ở Việt Nam. Loài này được xếp loại 'Cực kỳ nguy cấp' trong cả Sách đỏ các loài bị đe dọa của IUCN và Sách đỏ Việt Nam, đồng thời nằm trong danh sách "25 loài linh trưởng nguy cấp nhất thế giới".

Việt Nam nói chung, và đặc biệt là tỉnh Ninh Bình với khoảng 95% tổng số cá thể, có trách nhiệm đảm bảo sự tồn tại lâu dài của loài này. Cần phải xây dựng và thiết lập các biện pháp bảo tồn vì mục đích này.

Năm 1993, Hội Động vật học Frankfurt đã khởi động một chương trình dài hạn quan tâm đặc biệt đến loài này. Các hoạt động khảo sát sâu rộng trong những năm tiếp theo đã dẫn đến việc xác nhận sự hiện diện của loài này tại 16 khu vực biệt lập trong một vùng giới hạn ở miền Bắc Việt Nam. Đến khoảng năm 2010, 11 trong số 16 quần thể hiện có đã bị xóa sổ do săn bắn trộm. Hiện nay, chỉ còn lại 5 quần thể còn trong tự nhiên. Trung tâm Cứu hộ Linh trưởng Nguy cấp có một quần thể nhân giống trong điều kiện nuôi nhốt, và một số cá thể được sinh ra tại cơ sở này dự định sẽ thiết lập một quần thể mới tại Di sản Thế giới Tràng An được UNESCO công nhận. Tổng số cá thể của loài này được quan sát và xác định thông qua các cuộc khảo sát là khoảng 400 cá thể và ước tính tổng số quần thể hiện có là khoảng 500 cá thể.

Các mối đe dọa đối với sự tồn tại lâu dài của loài này bao gồm săn bắt trộm, phá hủy môi trường sống sự phân mảnh môi trường sống.

Để đảm bảo sự tồn tại lâu dài của loài, cần thực hiện nhiều biện pháp bảo tồn khác nhau:

- Những khu vực chưa được bảo vệ nhưng có quần thể voọc mông trắng sinh sống cấp thiết được công nhận là khu bảo tồn thiên nhiên. Điều này cần đặc biệt áp dụng cho quần thể lớn thứ hai ở khu vực đá vôi Kim Bảng và quần thể lớn thứ ba ở khu vực đá vôi Yên Mô.

- Hai quần thể lớn nhất là khu bảo tồn thiên nhiên đất ngập nước Vân Long và Rừng phòng hộ Kim Bàng cần được kết nối bằng hành lang xanh để tạo điều kiện trao đổi gen và đảm bảo đủ sức chứa.

- Khu vực tiếp giáp với Khu bảo tồn thiên nhiên đất ngập nước Vân Long ở xã Lạc Thủy, tỉnh Phú Thọ, nên được sáp nhập vào khu bảo tồn, bằng cách mở rộng khu bảo tồn sang tỉnh giáp ranh hoặc bằng cách sáp nhập toàn xã này vào tỉnh Ninh Bình.

- Việc tiếp tục thiết lập thêm một quần thể dự trữ tại Di sản Thế giới Tràng An được UNESCO công nhận đòi hỏi phải di dời động vật từ tự nhiên để giảm hệ số giao phối cận huyết.

- Việc di dời động vật, tốt nhất là từ Khu bảo tồn thiên nhiên đất ngập nước Vân Long, cấp thiết được lên kế hoạch và thực hiện hết sức cẩn thận.

- Việc tiếp tục chương trình nhân giống nuôi nhốt chỉ có giá trị chỉ khi, đặc biệt, các cá thể đực từ tự nhiên được đưa vào để giảm hệ số cận huyết. Động vật từ tự nhiên không nên đưa vào nhập đàn với quần thể nuôi nhốt của EPRC và hơn nữa, không nên để chúng tiếp xúc với nguy cơ nhiễm ký sinh trùng cao tại đây, mà thay vào đó nên tiếp tục chương trình thả động vật vào một vài hòn đảo trong Di sản Thế giới Tràng An của UNESCO.

## Introduction

Delacour's langur (*Trachypithecus delacouri*) is one of three endemic primate species in Vietnam. It is listed as 'Critically Endangered' in both the IUCN Red List of Threatened Species (Nadler et al. 2020) and the Vietnam Red Data Book (2024). Since the most endangered primates worldwide were classified, Delacour's langurs have been among the "World's Top 25 Most Endangered Primates" (Mittermeier et al. 2000).

Frankfurt Zoological Society launched a long-term program in 1993 specifically focused on this species. Extensive survey activities in the following years led to the confirmation of occurrences in 16 isolated areas within a limited region of northern Vietnam (Baker 1999; Cano & Telleria 2013; Le Thien Duc 2002a; 2002b; 2002c; Le Trong Dat & Do Dang Khoa 2014; Le Trong Dat 2008; Le Trong Dat et al. 2006; Le Trong Dat & Luong Van Hao 2008; Le Van Dung (2008a; 2008b; 2008c; 2009a; 2009b; 2009c; 2009d; 2011; 2014; Luong Van Hao 1999a; 1999b; 1999c). 1999d; 2000a; 2000b; 2000c; 2005; Luong Van Hao & Le Trong Dat 2003; 2008; Nadler 1995a; 1995b; 1996a; 1996b).

The species' status and threats raised concerns about its survival. The project of the Frankfurt Zoological Society focused conservation work on the Van Long area with the largest recorded population. Due to limited personnel and financial resources for conservation activities, uniform protection could not be guaranteed for all existing populations. Consequently, by around 2010, 11 of the 16 existing populations had been eradicated. Currently, only 5 originally wild populations remain. A captive-breeding population exists at the Endangered Primate Rescue Center in Cuc Phuong National Park. As a first step for a rewilding project animals from this captive breeding program were transferred to an island in the UNESCO Trang An World Heritage Landscape Complex.

In recent years, other NGOs active in Vietnam have also begun carrying out conservation and survey work. Fauna & Flora International has worked intensively to protect and safeguard the Kim Bang karst area, which is home to the second-largest population of the species. Several surveys in recent years, some of which utilized drones equipped with thermal imaging cameras, have provided an overview of the remaining populations.

To ensure the long-term survival of the species, a conservation strategy encompassing all existing populations is necessary. Since 95% of all Delacour's langurs are found in Ninh Binh Province, the species can be considered a flagship species of the province and, on this basis, deserves special attention and can make a significant contribution to conservation activities and public education.

## Currently existing populations of Delacour's langur

### Population 1 - Van Long Nature Reserve with Lac Thuy District, Phu Tho Province

21 groups / 176 to 184 individuals and 4 groups / 31 to 38 individuals
Total: 25 groups / 207 to 222 individuals

Upon the discovery of Delacour's langur population and the first surveys conducted by the Frankfurt Zoological Society in the Van Long area in 1993/1994, the population was estimated at approximately 50 individuals. In 2001, the area was granted protected status as the Van Long Nature Reserve. This created the possibility of enforcing strict conservation measures. The establishment of a Community Patrol Unit, consisting of 30 local guards from the surrounding communities, organized and funded by the Frankfurt Zoological Society, supported the Management Board's work in enforcing these strict conservation measures over a period of 15 years (Prosser & Nadler 2017). This also included the adjacent limestone massif in the Lac Thuy District of the neighboring Hoa Binh Province (now Phu Tho Province). While this area does not have protected status, it forms a single population with the langur groups within the nature reserve. To safeguard the population, incorporating the limestone area into the Van Long Nature Reserve would be a significant step. Since protected areas that cross provincial borders pose almost insurmountable administrative problems, incorporating the Lac Thuy District into Ninh Binh Province would be the most suitable solution. Such a regulation has been recommended for more than 10 years. (Nguyen Vinh Thanh 2008; Wojciechowski & Nguyen Hong Chung 2013; Nadler 2015a; Nadler & Roos 2017) (Fig. 1).

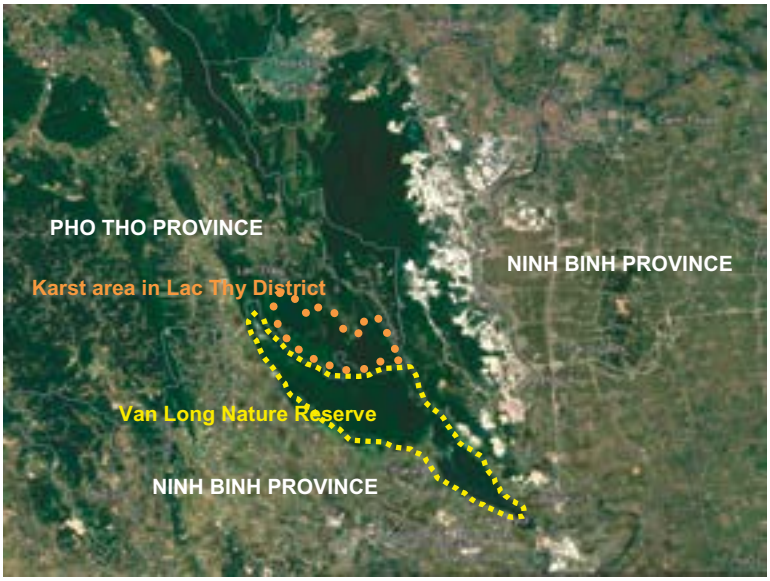



**Fig.1.** Van Long Nature Reserve, together with the karst area in the neighboring Phu Tho Province, is home to the largest population of Delacour's langurs. An administrative merger of the two areas is necessary to ensure the conservation of this population.

With the strict enforcement of protection for the area and the langurs, population growth increased rapidly. A 2018 survey identified 21 groups with 176 to 184 individuals within the nature reserve and 4 groups with 31 to 38 individuals in the adjacent area of the neighboring province, resulting in a total population of 25 groups with 207 to 222 individuals (Nguyen Van Linh et al. 2019). A 2023 survey using a drone identified 28 groups with a total of 179 individuals. However, this survey did not cover the entire area. Whether a mathematical model-based estimate of 44 groups with a total of 308 individuals is realistic remains questionable (Trinh Dinh Hoang 2025). It would represent an unexplained increase in the population growth to date (Fig. 2). In contrast to the more stochastic surveys in the Kim Bang karst area, which led to an apparent increase in the population, the surveys in the Van Long Nature Reserve were carried out according to a consistent scheme.

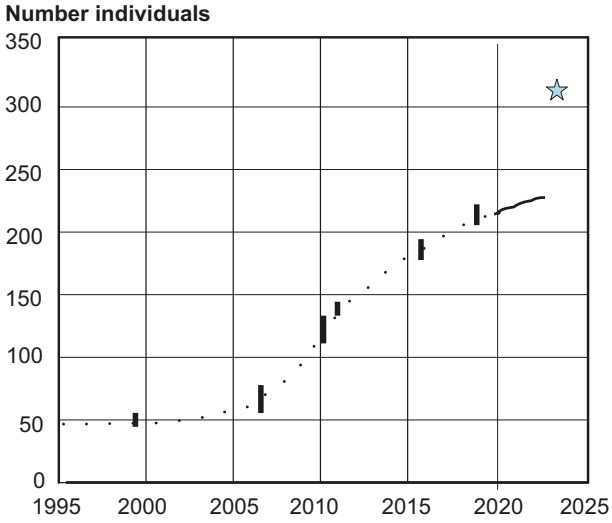



**Fig.2.** The development of the Delacour's langur population in the Van Long Nature Reserve. The black bars mark the survey results in different years. The asterisk marks an unrealistic population estimate.

**Population 2 - Kim Bang karst area**

18 to 20 groups / 120 to 121 individuals

The number of Delacour's langurs in the area has increased steadily over decades, which, however, does not necessarily indicate a population increase, but rather an intensification of survey efforts. While surveys conducted by the Frankfurt Zoological Society in the 1990s and 2013/2014 confirmed only about 20 individuals (Nadler et al. 2003; Le Van Dung 2014), this number had risen to 40 individuals by 2016 (Trinh Dinh Hoang & Le Van Dung 2016). A 2018 survey by the National University of Hanoi in cooperation with the Center for Nature Conservation and Development observed 13 groups comprising with a total of 73 individuals. One estimate, however, is between 82 and 97 individuals (Nguyen Anh Tuan et al. 2021). A 2022 survey using a drone with a thermal imaging camera revealed a population consisting of 16 groups with 104 individuals (Trinh Dinh Hoang et al. 2024). Another ground survey in 2025 using handheld thermal devices increased the number to 18 to 20 groups with 120 to 121 individuals (Nguyen Anh Tuan et al. 2026). This makes the area the second largest population of the species (Fig. 3). However, this population is under extremely high pressure due to habitat loss caused by limestone mining (Fig. 4).

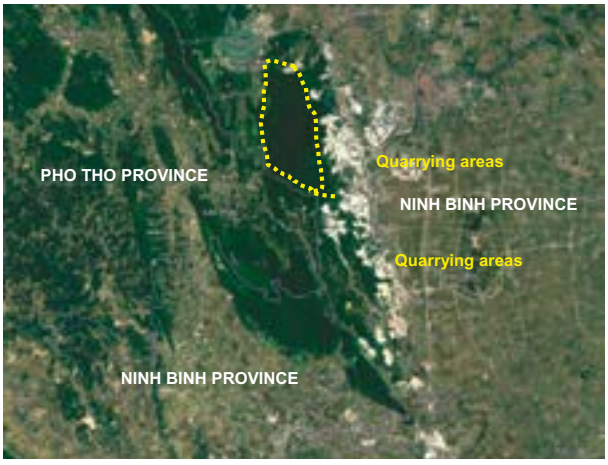



**Fig.3.** The Kim Bang karst area was incorporated into Ninh Binh Province through a territorial reform. Due to limestone quarrying, the area has already lost large portions of its habitat.



**Fig.4.** Extensive habitat destruction due to limestone mining for the cement industry in the Kim Bang karst area. Photo: Phuong Hong.

**Population 3 - Yen Mo karst area**

3 to 4 groups / 32 to 37 individuals

The Yen Mo karst area includes parts of the former districts of Tam Diep, Yen Mo (now Dong Thai), and Trung Son in Ninh Binh Province, and parts of the districts of Bim Son and Nga Trung in Thanh Hoa Province. Surveys conducted by the Frankfurt Zoological Society between 1993 and 1995, and again in 1999, confirmed the presence of Delacour's langur in the area. Approximately 20 individuals were recorded in Ninh Binh Province, and 4 to 5 groups of 14 to 18 individuals were found in Thanh Hoa Province (Baker 1999; Luong Van Hao 1999a; Nadler et al. 2003). In Thanh Hoa Province, a significant portion of the habitat has been destroyed by limestone quarrying for cement production. It can be assumed that no significant population currently exists there, and that individuals that were formerly native to the area likely crossed the provincial border into Ninh Binh Province due to blasting during limestone quarrying (Fig. 5). A 2023 survey, supported by a drone, counted 3 to 4 groups with 32 to 37 individuals (Trinh Dinh Hoang et al. 2024). This is thus known to be the third largest population of the species.

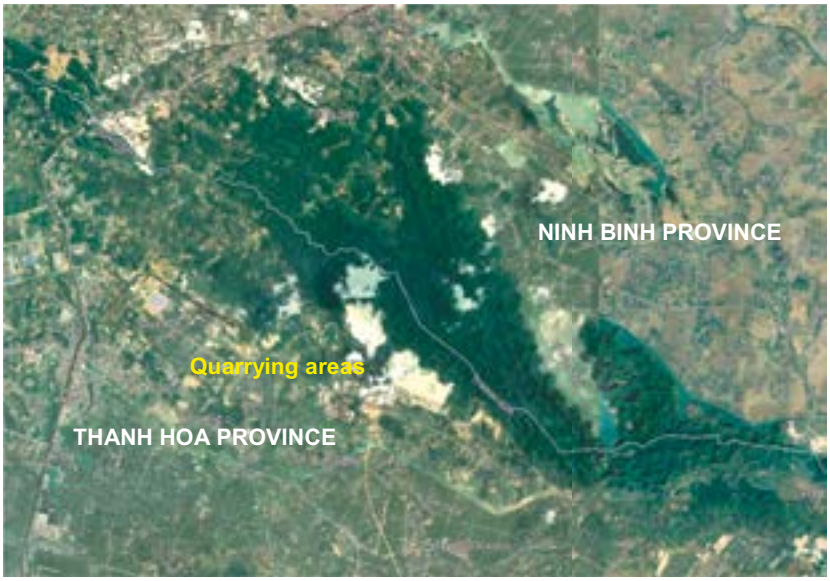



**Fig.5.** The border between Ninh Binh and Thanh Hoa Provinces runs through the Yen Mo karst area. In the Thanh Hoa part, large areas of habitat have already been destroyed by limestone quarrying.

**Population 4 - Huong Son Cultural and Historical Site with Tam Chuc Scenic Landscape and Archaeological Complex**

3 groups / 14 to 15 individuals and 1 group / 2 individuals

Total 4 groups / 16 to 17 individuals

The Huong Son karst area was designated as Cultural and Historical Site in 1993, encompassing 4,355 hectares (Tordoff et al. 2004). At its heart lies the renowned Perfume Pagoda, a Buddhist pilgrimage center that attracts tens of thousands of visitors, particularly around the Lunar New Year. The Tam Chuc Scenic Landscape and Archaeological Complex is a national cultural and spiritual relic site. The complex covers 3,835 hectares, and the limestone area connects to the Huong Son Cultural and Historical Site (Fig. 6).

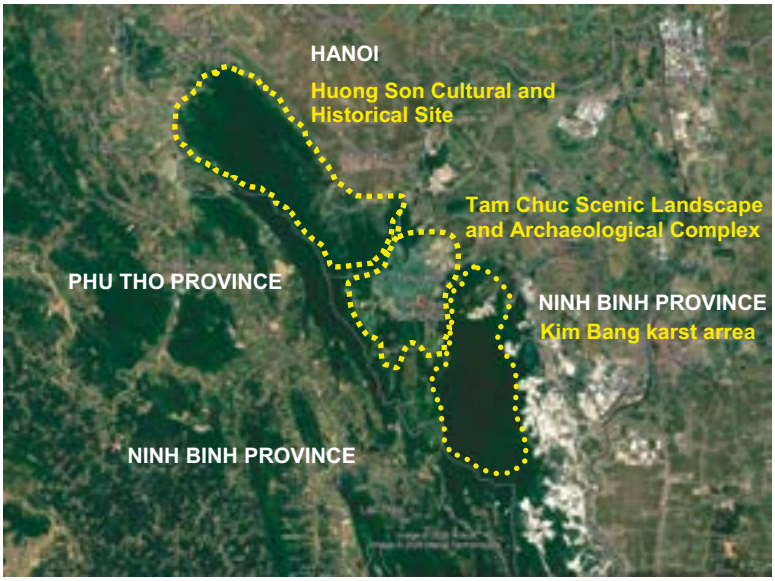



**Fig.6.** The Huong Son Cultural and Historical Site is administratively part of the capital city of Hanoi. However, the remaining population of Delacour's langurs has a connection to the Tam Chuc Scenic Landscape and Archaeological Complex.

The first information regarding the presence of Delacour's langurs was obtained through a survey conducted by the Frankfurt Zoological Society in 1996, but this survey did not provide an overview of the potential number of individuals. A local producer specializing in the production of "monkey balm" received 39 Delacour's langurs, which were killed in the area, between 1990 and 1999 (Nadler et al. 2003). In 2006, the Frankfurt Zoological Society conducted a survey that recorded 6 groups with a total of 27 langurs (Nadler & Luong Van Hao 2006). A 2015/2016 survey by Fauna & Flora International in the Lac Thuy-Huong Son area mentions the observation of a group of 4 individuals, but with the location in Lac Thuy, outside of Huong Son (Trinh Dinh Hoang & Le Van Dung 2016). A 2024 camera trap photograph from the Center for Nature Conservation and Development shows a group of 11 individuals. In a survey conducted by this NGO in 2024/2025, supported by a drone, 3 to 4 groups with 14 to 15 individuals and one group with 2 individuals in the Tam Chuc area were counted (Trinh Dinh Hoang 2025).

**Population 5 - Pu Luong Nature Reserve**

1 to 3 groups / 4 to 9 individuals

Pu Luong is the type locality for the species. Two pelts, which form the basis of the species description, were acquired from local hunters by the Delacour Expedition in February 1930. The occurrence of Delacour's langurs is mentioned in a report by Le (1997). A survey by the Frankfurt Zoological Society was carried out in 1999 to confirm the occurrence. Locals reported frequent occurrences in the 1970s and 1980s, but increasing rarity due to high hunting pressure (Nadler et al. 2003). The 1999 survey resulted in the assumption of 2 to 3 groups of approximately 10 individuals in the southwest part of the nature reserve and 5 to 6 groups of approximately 30 to 35 individuals in the northeast part (Baker 1999; Nadler et al. 2003). Another intensive survey was conducted in 2004 by Fauna & Flora International and the Frankfurt Zoological Society (Nadler et al. 2004). The results showed a further reduction in the population, with a count of 8 groups containing 31 to 38 individuals. A subsequent short interview survey in 2025 by Save Vietnam's Wildlife revealed a count of 1 to 3 groups and 4 to 9 individuals (Trinh Dinh Hoang 2025).

**Population 6 - UNESCO Trang An World Heritage Landscape Complex**

1 group / 8 individuals

Based on the 'Urgent Conservation Action Plan for Primates in Vietnam to 2025, Vision to 2030', confirmed by a Prime Minister's Decision (2017), preparations for establishing a Delacour's langur population at the UNESCO World Heritage Site began in 2020. A survey was conducted in the area to identify a suitable habitat, and a botanical survey ensured that the selected habitat offered sufficient food resources.

Three adult animals (1 male, 2 females) born at the EPRC were transferred to Ngoc Island, which is approximately 2 hectares in size, in August 2020. The animals acclimatized without problems (Nadler et al. 2020). Subsequently, a total of 6 offspring were born to the two females. One offspring did not survive, and the current population consists of 8 langurs (Fig. 7).



**Fig.7.** Ngoc Island was chosen to launch a rewilding program for the Delacour's langurs in the UNESCO Trang An World Heritage Site.

**Population 7 - Captive population at the Endangered Primate Rescue Center**

19 individuals

The captive population at the EPRC in Cuc Phuong National Park originates from 5 individuals (2 males, 3 females) confiscated from poachers or the illegal wildlife trade respectively. A captive population was established with these animals, and a total of 37 offspring were born at the EPRC. Due to the very small number of founders, the inbreeding of the captive population is high.

**Total Delacour's langur population**

According to the most recent survey results, the total Delacour's langur population consists of at least 52 to 61 groups with 386 to 414 individuals, plus 19 captive individuals at the EPRC. The actual number of individuals is very likely higher, as a complete and reliable count of all animals is not achievable with the surveys. A total population of approximately 500 individuals is probable.

## Threats to the long-term existence of Delacour's langurs

### Poaching

Historically, until the 1990s, the threat to populations from poaching was very high, and some populations were subsequently wiped out. Increasing public awareness of the need to protect rare species, more intensive work by rangers and forestry authorities, a drastic reduction in firearms, and significantly higher penalties for violations of conservation laws have considerably reduced poaching of Delacour's langurs. A few isolated incidents, such as the fatal snare trapping of two Delacour's langurs in 2018 and another snare trapping in 2020, which resulted in the release of the animal in the Kim Bang karst area, still require appropriate patrol and protection work, but no longer pose a critical threat to existing populations. This is not comparable to the poaching of many other species, for which the snare trap crisis represents a serious existential threat.

### Habitat destruction

A current threat to the species is primarily habitat loss and population fragmentation. Limestone quarrying for the cement industry has already destroyed large areas of habitat in the karst regions of Kim Bang and Bim Son. The Kim Bang karst area covers approximately 6,000 hectares, of which about 3,100 hectares (52%) have already been destroyed (Fig. 3). The Yen Mo karst area (including the area in Thanh Hoa Province) covers approximately 2,500 hectares, of which about 800 hectares (20%) have been destroyed (Nadler unpubl.). The Kim Bang karst area, with the second-largest population, and the Yen Mo karst area, with the third-largest population, are crucial for the long-term survival of the species.

### Fragmentation

Two of the five remaining wild populations (Pu Luong Nature Reserve and Yen Mo karst area) have likely been separated from each other and the other three populations probably for several centuries. The three populations in the Huong Son Cultural and Historical Site, the Kim Bang karst area, and the Van Long Nature Reserve certainly maintained contact until just a few decades ago. The country's rapid economic development has been accompanied by infrastructure development, settlement growth, and agricultural expansion. New roads bisect areas where settlements and other agricultural land are being built, further increasing habitat separation. The three habitats and populations that were connected decades ago are now isolated for Delacour's langurs.

## Conservation strategy for the species

### Securing existing populations

Although every single population is important given the rarity and threats to the species, the three largest populations (Van Long Nature Reserve, Kim Bang karst area, Yen Mo karst area), comprising a total of 360 to 380 individuals and thus over 90% of the species' total population, should be the focus of conservation efforts. The priority measure is to grant protected status to the Kim Bang and Yen Mo karst area. This would prevent, or at least reduce, further destruction of these areas. However, the establishment of protected status should then be followed by the implementation of a management board and corresponding patrol activities.

### Establishment of corridors

Ensuring panmixia for the long-term genetic stabilization of the species requires connecting the two largest populations (Van Long Nature Reserve and Kim Bang karst area). The historical connection between the two largest populations has been destroyed by deforestation, road construction, and settlement expansion.

A proposed UNESCO World Heritage Site designation as a landscape of biocultural diversity, encompassing the Van Long Nature Reserve, the Kim Bang karst area, and the Tam Chuc Scenic Landscape and Archaeological Complex, would contribute to securing the area with the largest populations of Delacour's langurs (Fig. 8). This requires the establishment of a corridor connecting the

Van Long Nature Reserve with the Kim Bang area. This corridor currently has only minimal remnants of forest. Reforestation of the area is a prerequisite to enable the Delacour's langur populations to connect.

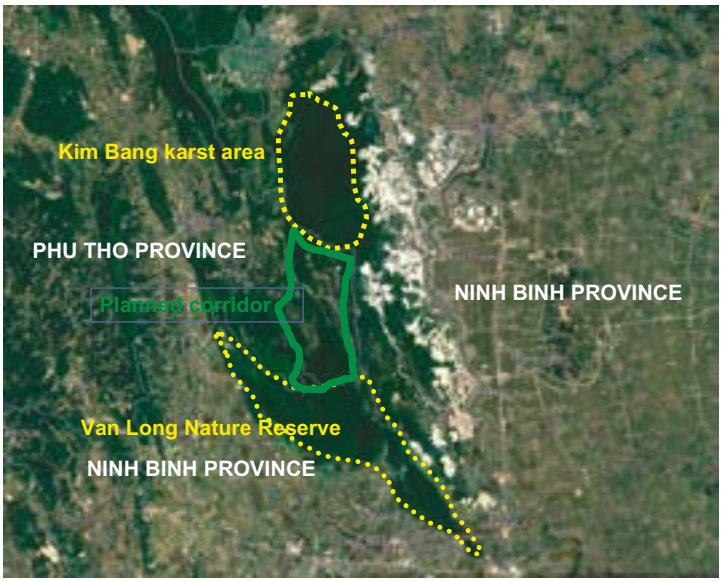



**Fig.8.** A planned corridor between the two largest populations in Van Long Nature Reserve and Kim Bang karst area would enable genetic exchange and provide sufficient carrying capacity for the long-term existence of the species.

The Huong Son Cultural and Historical Site lies outside of Ninh Binh Province and is not included in the UNESCO World Heritage Site concept. However, a residual connection exists between it and the Tam Chuc Scenic Landscape and Archaeological Complex via a limestone forest. Protecting this connection and potential reforestation efforts would secure this corridor and thus integrate the remaining population in the Huong Son Cultural and Historical Site into the overall complex.

Creating corridors to or between the remaining populations in the Yen Mo karst area and the Pu Luong Nature Reserve is not realistic, as the distances are too great and the intervening areas are subject to intensive use.

These isolated populations can, however, serve as reserve populations, provided illegal hunting is prevented. Should the main population (Van Long/Kim Bang/Tam Chuc) be affected by unforeseen circumstances (e.g. disease), these reserve populations could ensure the long-term survival of the species.

At very long intervals (over decades), translocations between these subpopulations could safeguard the genetic diversity of these subpopulations.

### Rewilding - Establishing a new population

The establishment and existence of a reserve population in a safe area was the background for a rewilding/reintroduction project at the UNESCO World Heritage Site Trang. The establishment of a new Delacour's langur population in an area where the species was present until very recently was recommended for the UNESCO Trang An World Heritage Site in the 'Urgent Conservation Action Plan for Primates in Vietnam to 2025, Vision to 2030'. The original population in the area was eradicated around 2000. It is a pilot project – also for other critically endangered langur species – with the possibility to monitor the development of a population that begins with individuals from a captive-breeding program.

Based on, and following intensive preparation, three Delacour's langurs born and raised at the EPRC were released on an island in the UNESCO Trang An World Heritage Landscape Complex. The now high level of safety and the habitat structure make this area the only one of the former populations suitable for this pilot project to establish a new population. However, the genetic diversity of the founders for this population is limited due to the small number of founder animals in the EPRC's captive-breeding population and the inbreeding is high (Fig. 9). To increase genetic diversity, further mating of the animals born and raised in the area with animals from a wild population is necessary.

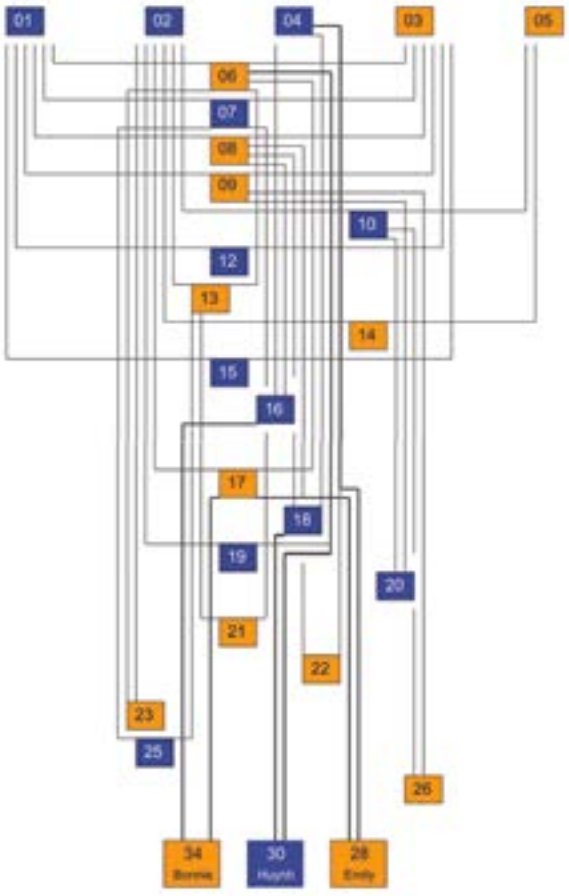



**Fig.9.** The pedigree chart of the captive born Delacour's langurs (Bonnie, Huynh and Emily) transferred to the UNESCO Trang An World Heritage Site. It shows the close kinship and inbreeding of the population at the Endangered Primate Rescue Center (blue - males; orange - females). The animals 01, 02, 03, 04, 05 are the founders of the captive breeding program.

Further establishment of a population in a former habitat, such as Cuc Phuong National Park or Ngoc Son Nature Reserve is currently unacceptable. The number of available captive-born individuals with a relatively high inbreeding necessitates splitting the animals and mating them with wild populations. However, there are not enough male individuals from wild populations available for this without negatively impacting them. Furthermore, splitting is only possible with effective spatial separation, which is offered exclusively by the Trang An World Heritage Site with its islands. Only after stable development of groups on the islands can they be released onto the mainland of the World Heritage Site to ultimately achieve panmixia. Another fundamental requirement is the ability to manage and monitor the individual groups, which is also only possible with controlled husbandry, such as that provided by the islands in the Trang An World Heritage Site.

### Translocation of Individuals

Translocation of individuals to build up the population in the UNESCO Trang An World Heritage Site is necessary to ensure the genetic diversity of the planned future population. It would be sensible to use animals from one of the remaining populations (Huong Son Cultural and Historical Site, Pu Luong Nature Reserve), as the future of these populations is uncertain. Without specific conservation intervention, it is feared that these populations may not have long-term survival, even without hunting pressure. However, it is foreseeable that the administrative hurdles for translocating these animals are very high. The likelihood of approval is certainly higher with the removal and translocation of animals from the Van Long Nature Reserve. The translocation of animals is a major logistical challenge and requires clear and careful planning and execution.

### Captive breeding and maintenance of an ex-situ population

The captive breeding program for Delacour's langurs at the EPRC was initiated in the early 1990s to provide animals for supporting wild populations or for establishing a new population in an area where the species had become extinct. Animals from the captive breeding program were released in two release projects in 2011 and 2012 at the Van Long Nature Reserve (Elser 2013; Agmen 2014; Elser et al. 2015). In 2020, a release project to establish a new population began at the UNESCO Trang An World Heritage Landscape Complex. No further reintroduction programs have been implemented, although breeding has continued. The Delacour's langur population in the EPRC has a very high inbreeding rate due to the small number of founding members, which can lead to inbreeding depression. To avoid a further increase through the continuation of the captive-breeding program, it would be beneficial to release animals into existing wild populations. This could, for example, stabilize the remaining populations in the Yen Mo karst area or the Huong Son Cultural and Historical Site.

Continuing the captive-breeding program at the EPRC is not feasible without the availability of male animals from a wild population to reduce the inbreeding. However, the very limited possibility of obtaining male animals from a wild population should not lead to these animals being housed in the partially necessary cages at the EPRC, thereby tying up additional resources, facilities, food procurement, feeding, and animal care. If male animals are available, they should contribute to the establishment of a new population on the islands within the Trang An World Heritage Site. There, the costs of facility use, food procurement, feeding, and animal care would be eliminated.

Another significant argument against housing wild-caught animals at the EPRC is the high risk of parasitic infection. A large proportion of the animals at the EPRC are infected with echinococci, an infection that can lead to a reduced quality of life and premature death (Plesker et al. 2009; Vo Duy Thanh et al. 2020; Le Thi Lan Anh 2023). An individual taken from the wild must not be exposed to this risk. To avoid increasing inbreeding of the captive population within the EPRC, and also to prevent the infection of male animals taken from the wild, further transfers of animals from the EPRC to islands within the Trang An World Heritage Site would be advisable.

## Conclusions

- Surveys have confirmed approximately 400 individuals of Delacour's langur, and the total population is estimated at around 500.
- Protection status is urgently needed for the Kim Bang and Yen Mo karst area, which houses the second and third-largest populations.
- Delacour's langurs in the karst region of Dong Tam, Lac Thuy District, Phu Tho Province, are part of the largest population in the Van Long Nature Reserve. The inclusion of this population through administrative changes-either extending the Van Long Nature Reserve into Phu Tho Province or integrating Lac Thuy District into Ninh Binh Province-is urgently needed.
- A planned UNESCO World Heritage status for Van Long-Kim Bang-Tam Chuc, with the establishment

of a corridor between the two largest populations and a contact zone with the Huong Son Nature Reserve, would be a crucial contribution to ensuring the long-term survival of the species by providing sufficient carrying capacity in the area.

- The establishment of another population with captive-born individuals and through the translocation of wild individuals in the UNESCO Trang An World Heritage Landscape Complex would serve as an additional reserve population. Since this population is growing on the 2-hectare island and the oldest individuals born there are already 3 to 5 years old, relocation of the animals is necessary this year or next.

- Establishing another population in a former habitat (Cuc Phuong National Park, Ngoc Son Nature Reserve) is not feasible due to the small number of captive-born individuals, the necessary translocation of individuals from a wild population, and the impossibility of managing inside a large habitat.

- Continuing a captive-breeding program is only viable with the integration of wild individuals, due to the minimal number of founder animals and a high inbreeding. However, wild individuals should not be brought into the caged environment of the Endangered Primate Rescue Center, nor should they be exposed to the high risk of parasite infection there. The islands within the UNESCO Trang An World Heritage Site should be used for managing a captive-breeding program.

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# The tail posture in 'limestone langurs', genus *Trachypithecus* and the parallelism with Hanuman langurs of the genus *Semnopithecus*

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**Keywords:** Limestone langurs, *Trachypithecus*, *Semnopithecus*, tail posture.

**Summary**

The long tails of species in the genus *Semnopithecus* on the Indian subcontinent and the limestone langurs of the genus *Trachypithecus* in South China and Indochina serve to provide balance and stability when the animals move. Despite similar requirements and largely undifferentiated habitat structures, the species in both genera display parallel and distinct differences in tail posture.

The eight species in the genus *Semnopithecus* display different tail postures, which can be divided into two types that are geographically separated at approximately 20°N. Four species, the Nepalese gray langur (*Semnopithecus schistaceus*), Kashmir gray langur (*Semnopithecus ajax*), Tarai gray langur (*Semnopithecus hector*), and northern plains gray langur (*Semnopithecus entellus*) represent the northern type with a tail posture curved forward over the back. Four species represent the southern type: the black-footed gray langur (*Semnopithecus hypoleucos*), tufted gray langur (*Semnopithecus priam*), Nilgiri langur (*Semnopithecus johnii*), and purple-faced langur (*Semnopithecus vetulus*) have a tail posture that curves backward.

The six species of limestone langurs of the genus *Trachypithecus* show a very similar differentiation, with a geographical separation that also lies at around 20°N. Four species belonging to a northern group, the white-headed langur (*Trachypithecus leucocephalus*), Francois' langur (*T. francoisi*), Cat Ba langur (*T. poliocephalus*), and Delacour's langur (*T. delacouri*), display a backward-facing tail posture, in contrast to the species of the genus *Semnopithecus*. Two species of the southern group, the Hatinh langur (*T. hatinhensis*), including the completely black morph *ebenus*, and the Lao langur (*T. laotum*), display an arched, forward-facing tail posture.

The cause of the likely genetically fixed types of tail posture is unclear, as is the roughly similar geographical separation of the types on the Indian peninsula and in Indochina.

# Đặc điểm tư thế đuôi của các loài voọc núi đá vôi chi *Trachypithecus* và sự tương đồng về hình thái với các loài voọc Hanuman chi *Semnopithecus*

**Tóm tắt**

Đuôi dài của các loài thuộc chi *Semnopithecus* trên tiểu lục địa Ấn Độ và các loài voọc núi đá vôi thuộc chi *Trachypithecus* ở miền nam Trung Quốc và Đông Dương có vai trò duy trì thăng bằng và ổn định khi di chuyển. Mặc dù có những yêu cầu sinh thái tương tự và sinh sống trong các sinh cảnh có cấu trúc tương đối đồng nhất, các loài thuộc hai chi này lại thể hiện những khác biệt rõ rệt nhưng mang tính song hành về tư thế đuôi.

Tám loài thuộc chi *Semnopithecus* thể hiện các tư thế đuôi khác nhau và có thể được chia thành hai nhóm, với ranh giới phân bố địa lý nằm gần vĩ tuyến 20°B. Nhóm phía bắc gồm *Semnopithecus schistaceus*, *Semnopithecus ajax*, *Semnopithecus hector* và *Semnopithecus entellus*, có đặc điểm đuôi cong về phía trước và vắt qua lưng. Nhóm phía nam gồm *Semnopithecus hypoleucos*,

*Semnopithecus priam*, *Semnopithecus johnii* và *Semnopithecus vetulus* có đuôi cong về phía sau.

Sáu loài voọc núi đá vôi thuộc chi *Trachypithecus* cũng cho thấy sự phân hóa tương tự với ranh giới địa lý nằm gần vĩ tuyến 20°B. Bốn loài thuộc nhóm phía bắc gồm *Trachypithecus leucocephalus*, *Trachypithecus francoisi*, *Trachypithecus poliocephalus* và *Trachypithecus delacouri* có tư thế đuôi hướng về phía sau, trái ngược với các loài thuộc chi *Semnopithecus*. Hai loài thuộc nhóm phía nam là *Trachypithecus hatinhensis* (bao gồm cả dạng hình thái màu đen hoàn toàn *ebenus*) và *Trachypithecus laotum* có đuôi cong hình vòng cung hướng về phía trước.

Nguyên nhân của các kiểu tư thế đuôi này, vốn có khả năng được cố định về mặt di truyền, hiện vẫn chưa được làm rõ. Tương tự, sự phân chia địa lý gần như tương đồng của các kiểu tư thế đuôi trên tiểu lục địa Ấn Độ và khu vực Đông Dương vẫn là một vấn đề cần được nghiên cứu thêm.

## Introduction

The relatively long tail of the so-called limestone langurs (Groves 2004) of the genus *Trachypithecus* from southern China, Vietnam, and Laos undoubtedly serves to stabilize and balance the animals while climbing and jumping in their specific habitat of rugged and steep rocks. Although the habitat structure and lifestyle of the six species belonging to this group are quite similar: white-headed langur (*Trachypithecus leucocephalus*), Francois langur (*T. francoisi*), Cat Ba langur (*T. poliocephalus*), Delacour's langur (*T. delacouri*), Hatinh langur (*T. hatinhensis*), and Laos langur (*T. laotum*), there are clear differences in the posture of their tails. This was first mentioned by Nadler & Ha Thang Long (2000) and a more detailed study for some species followed by Stevens et al. (2008).

A taxonomic and geographical classification based on tail posture has been described for the genus *Semnopithecus* on the Indian subcontinent. Roonwaal documented intensive and detailed studies (Roonwaal 1970; 1979a; 1979b; 1980; 1981; 1984a; 1984b; Roonwaal & Makwana 1981; Roonwaal & Pirta 1984; Roonwaal et al. 1984). Roonwaal's work focused on the 'Hanuman' langur, which at that time was classified as *Presbytis entellus* with about 15 subspecies (Ellerman & Morrison-Scott 1951; Roonwaal et al. 1984; Roonwaal & Makwana 1981). Pocock (1935) classified Asian langurs into three genera: *Semnopithecus*, *Trachypithecus*, and *Presbytis*. This was followed in the taxonomic revision by Groves (2001), which is currently recognized.

Originally, only 'Hanuman' langurs were classified in the genus *Semnopithecus*, while purple-faced langurs (*S. vetulus*) and Nilgiri langurs (*S. johnii*) were placed in the genus *Trachypithecus* based on phenotypic and morphological similarities (Groves 2001). However, genetic data clearly place these species to the genus *Semnopithecus* (Zhang & Ryder 1998; Karanth et al. 2008; Osterholz et al. 2008).

Primarily on a genetic basis, the Hanuman langurs were split into six species, some with several subspecies, which is now recognized.

Nepal gray langur (*Semnopithecus schistaceus*)
Kashmir gray langur (*Semnopithecus ajax*)
Tarai gray langur (*Semnopithecus hector*)
Northern plains gray langur (*Semnopithecus entellus*)
Black-footed gray langur (*Semnopithecus hypoleucos*)
- *S. hypoleucos hypoleucos*
- *S. hypoleucos achates*
- *S. hypoleucos iulus*

Tufted gray langur (*Semnopithecus priam*)
- *S. priam priam*
- *S. priam anchises*
- *S. priam thersites*

Nilgiri langur (*Semnopithecus johnii*)
Purple-faced langur (*Semnopithecus vetulus*)
*S. vetulus vetulus*
*S. vetulus nestor*
*S. vetulus philbricki*
*S. vetulus monticola*

The systematic splitting of the limestone langurs in the genus *Trachypithecus* was very similar to the development of the systematics of the Hanuman langurs. Until the 1990s, the six species were listed as subspecies of the Francois' langur (Corbet & Hill 1992). It was only with the work of Groves (2001), Nadler (2013), Nadler & Brockman (2014), and Roos (2003; 2004; 2014) that these were elevated to valid species.

A comparison of tail posture between the species in the genus *Semnopithecus* and the limestone langurs of the genus *Trachypithecus* reveals a kind of parallelism that is examined in more detail here.

**Material**

Roonwaal compiled extensive and detailed material on the tail posture of *Semnopithecus* species (Roonwaal 1970; 1979a; 1979b; 1980; 1981; 1984a; 1984b; Roonwaal & Makwana 1981; Roonwaal & Pirta 1984; Roonwaal et al. 1984). The taxonomy of the genus, which was unclear at the time and has not yet been fully clarified, does not call his findings into question, as they are based not on the taxonomy of the species at the time, but on the geographical distribution of the animals.

The distribution of the species now belonging to the genus *Semnopithecus* is essentially allopatric. Hybridization can occur in some contact areas, for example between *S. priam priam* x *S. johnii* and *S. hypoleucos* x *S. johnii* (Brandon-Jones 2004). Some of Roonwaal's findings and descriptions have been confirmed by my own observations, for example for *S. schistaceus* in Nepal and Bhutan, for *S. entellus* in Assam, India, and for *S. priam thersites*, *S. vetulus vetulus*, and *S. vetulus monticola* in Sri Lanka.

The tail posture of limestone langurs of the genus *Trachypithecus* was observed and photographed in their natural habitat of all six species, including the black morph *ebenus* of *T. hatinhensis*. In addition, the tail posture of these species was also documented at the Endangered Primate Rescue Center.

Limestone langurs have an allopatric distribution, except for a contact zone between *T. francoisi* and *T. leucocephalus* in Guangxi Province, China, where hybridization occasionally occurs due to reintroduced *T. francoisi* in the area of *T. leucocephalus*, which is found on the other bank of the dividing river (Que Tengcheng et al. 2007; Wenshi 2021).

Until now, there has been insufficient material available to provide a comprehensive explanation of the genetic relationships within the genus *Semnopithecus*. However, there is already evidence of a clear genetic split into a northern and southern group (Karanth etr al. 2008; Osterholz et al. 2008; Roos & Zinner 2022).

Sufficient material is available for the limestone langurs of the genus *Trachypithecus* (Liu et al. 2025; Roos et al. 2020), and on this basis a clear division into two groups can be identified, which also reflects their geographical distribution. A northern group comprising *T. francoisi*, *T. leucocephalus*, and *T. poliocephalus*. *T. delacouri* also belongs to this group, although it is further away from it genetically, morphologically and phenotypically. A southern group comprising *T. laotum*, *T. hatinhensis*, and *T. ebenus*, which is also considered a morph of *T. hatinhensis* (Fig. 1) (Roos & Zinner 2022).

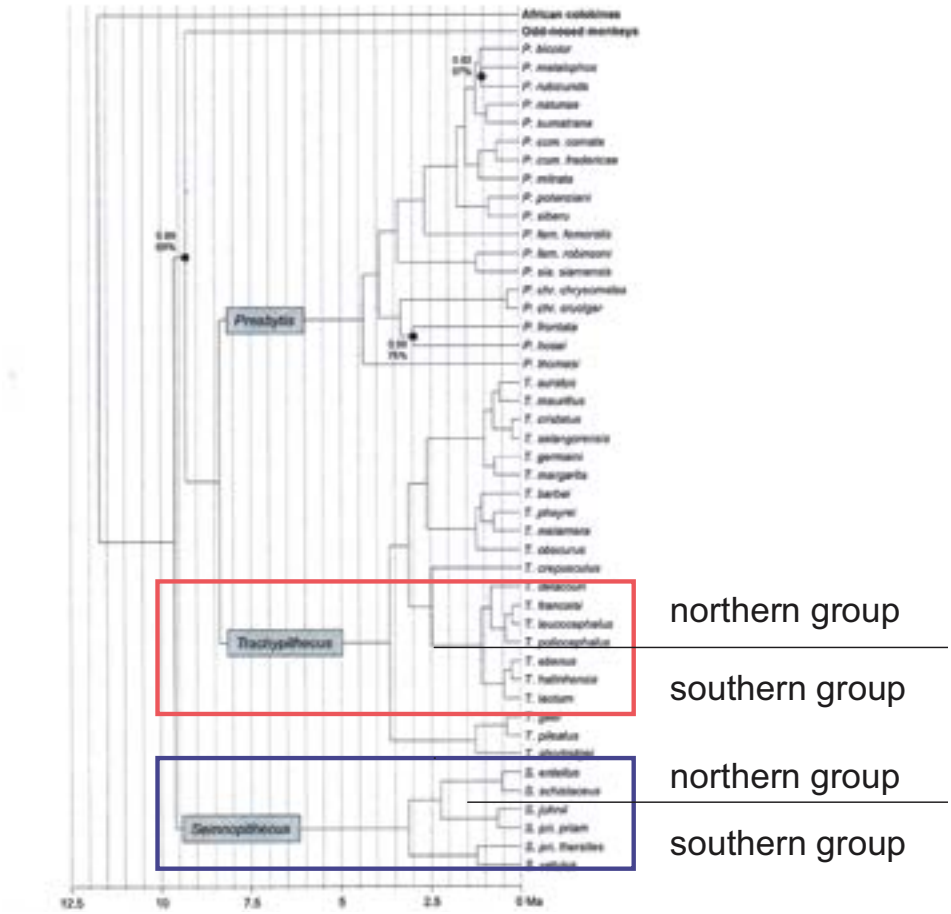



**Fig.1.** The ultrametric tree of the Asian langurs based on complete mitochondrial genomes from Roos & Zinner (2022) showing the splitting of the species in *Semnopithecus* and *Trachypithecus*.

## Comparison of tail posture in *Semnopithecus* with limestone langurs of the genus *Trachypithecus*

Roonwaal (1981; 1984) introduced a new morphological category into taxonomy based on tail posture for the genus *Semnopithecus*. He found that Hanuman langurs could be classified into two types based on tail posture: a northern type and a southern type. The tail posture types refer to individuals standing or walking slowly until this position is interrupted by sitting, running fast, or fighting. After such a temporary interruption, the individuals return to their typical tail posture. The tail posture of the northern type is directed forward, while that of the southern type is directed backward. Within these two types, Roonwaal documented various subtypes (Figs. 2, 3, 4).

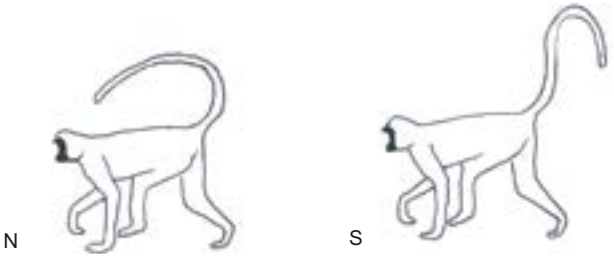



**Fig.2.** The fundamental difference in tail posture of the genus *Semnopithecus* of the northern species (N) and southern species (S).

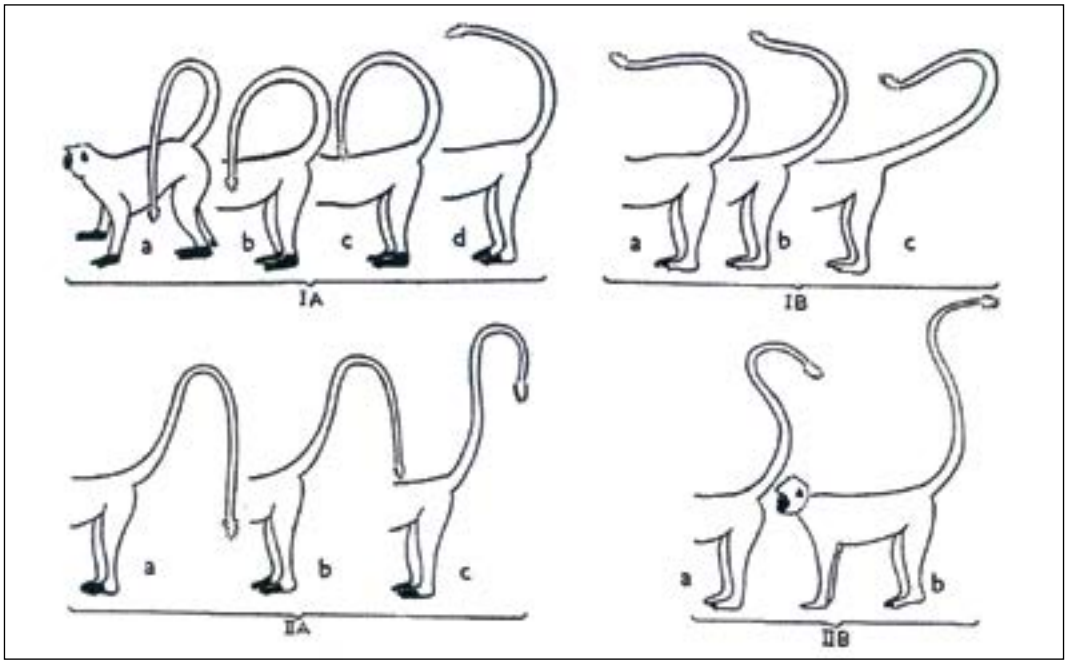



**Fig.3.** Within the two groups, Roonwaal documented further differences in tail posture (Roonwaal 1979; 1981).




**Fig.4.** The typical tail posture of the northern and southern species of Semnopithecus.
Northern species: A: S. schistaceus, Bhutan. Photo: Tilo Nadler; B: S. ajax, Kashmir, India. Photo: from Anandam et al. (2013).
Southern species: Fig. C, D: S. priam thersites, Sri Lanka. Photo: Tilo Nadler.

Roonwaal identified a geographical boundary between the northern and southern types in tail posture as a line through the Indian peninsula at approximately 20° north latitude, roughly following the courses of the Tapti and Godavari rivers. The western end of the line lies at 21°50'N to 21°10'N and slopes southward to the eastern end of the line at 19°50'N to 20°20'N. According to recent genetically based studies, this boundary coincides with the distribution of the now accepted species of *Semnopithecus* (Ashalakshmi et al. 2014; Roos 2022; Roos & Zinner 2022) (Fig. 5). The extent to which and whether the subtypes can now be assigned to the now widely accepted subspecies in terms of tail posture is unclear. Further detailed studies are needed to clarify this.

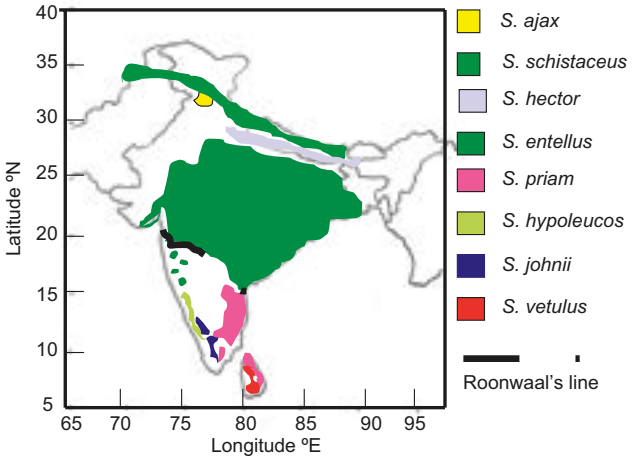



**Fig.5.** Distribution of *Semnopithecus* species and the dividing line, known as Roonwaal's line, between the northern and southern types of tail posture at about 20°N.

The six species of limestone langurs of the genus *Trachypithecus* can be divided into two groups which can be classified both geographically and genetically. The northern group (*T. francoisi, T. leococephalus*, *T. poliocephalus*, and *T. delacouri*) inhabits areas in southern China and northern Vietnam. The southern group (*T. hatinhensis*, its morph *ebenus* and *T. laotum*) inhabits northern central Vietnam and eastern and central Laos (Fig. 6).

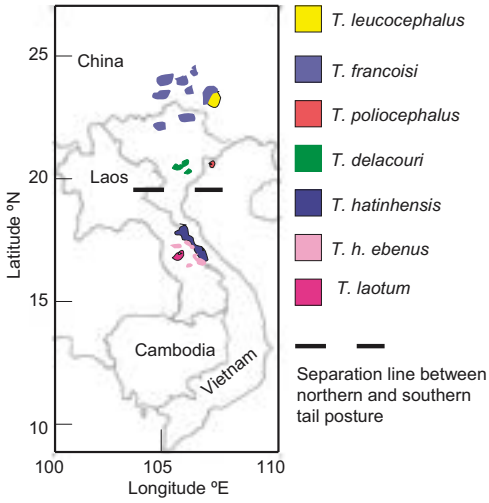



**Fig.6.** Distribution of limestone langurs of the genus *Trachypithecus* in southern China and Indochina. Here, too, there is a dividing line in the tail posture of a northern and a southern type at about 20°N.

There are also two basic types of tail posture among these limestone langur groups. In the northern group, the tail is arched backward, while in the southern group it is arched forward (Fig. 7). However, there are slight differences in tail posture within the northern species (Fig. 8). These are not always clearly visible due to the movement of the animals, and they also vary from individual to individual, but they are present in principle. Even when jumping short distances, these typical tail postures are often maintained (Figs. 9, 10). After well over a thousand hours of observing Delacour's langurs, both in the wild and in closer contact at the Endangered Primate Rescue Center, it appeared that the animals are unable to actively bring their tails over their backs into a forward-facing position. However, few and therefore rare observations refuted this assumption. To avoid dipping their tails in the water, the animals slowly and actively raised them into a forward-facing position without using momentum, and then moved away from the water in this position (Fig. 11).

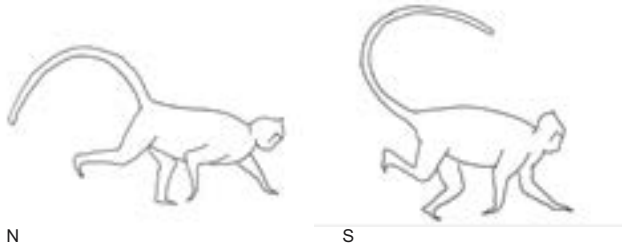



**Fig.7.** The fundamental difference in tail posture of the limestone langurs, genus *Trachypithecus* of the northern species (N) and the southern species (S).

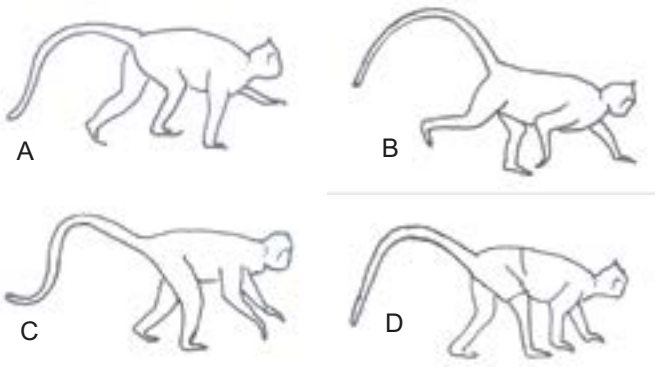



**Fig.8.** The typical tail posture of the northern group of limestone langurs.

A: Francois langurs carry their tails in a slight arc, often with the tip curving slightly upward;

B: White-headed langurs carry their tails in a more pronounced arc, often without the tip curving slightly upward;

C: Cat Ba langurs have a very flexible tail, often with a distinct and strongly upward-curved tip, the curvature of which can occupy about a quarter of the tail;

D: Delacour's langurs most often hold their tails in an arched shape, but with an almost right-angled bend approximately in the middle of the tail and often without a curve at the tip of the tail.

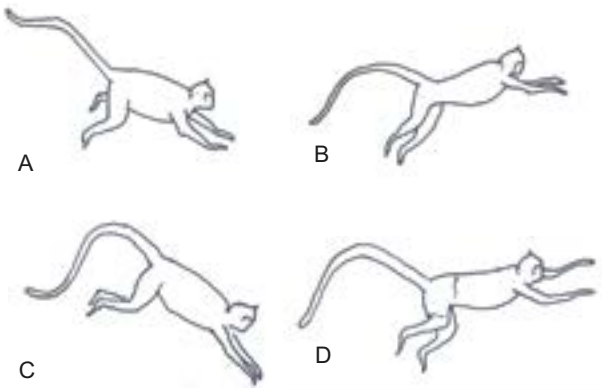



**Fig.9.** The typical tail posture of the northern group of limestone langurs. A: Francois langur; B: White-headed langur; C: Cat Ba langur; D: Delacour's langur.




**Fig.10.** Tail posture of limestone langurs when jumping short distances. A: Francois' langur; B: White-headed langur; C, D: Cat Ba langur; E, F: Delacour's langur. Photos: Tilo Nadler.



**Fig.11.** To prevent its tail from getting wet, a Delacour's langur actively lifts its tail and then moves away from the water's edge in this position. The animal thus displays an extremely rare tail posture for species of the northern group. Photos: Tilo Nadler.

The limestone langurs of the southern group: *T. hatinhensis*, including the *ebenus* morph and *T. laotum* have no clearly visible differences in the type of tail posture. When standing and walking slowly, the tail is carried arched forward over the back, occasionally also standing vertically upright (Figs. 12, 13).

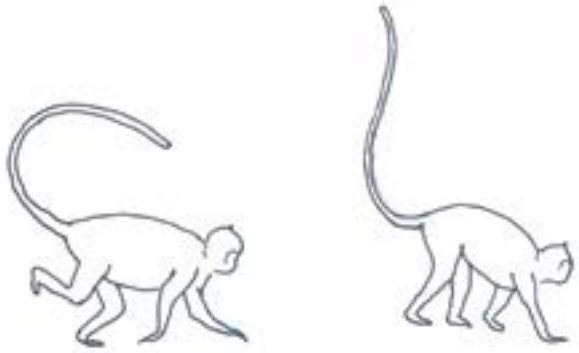


**Fig.12.** The limestone langurs of the southern group: Hatinh langurs, including the morph *ebenus*, and Lao langurs carry their tails arched over their backs and pointing forward when standing and walking slowly, occasionally also pointing vertically upwards.

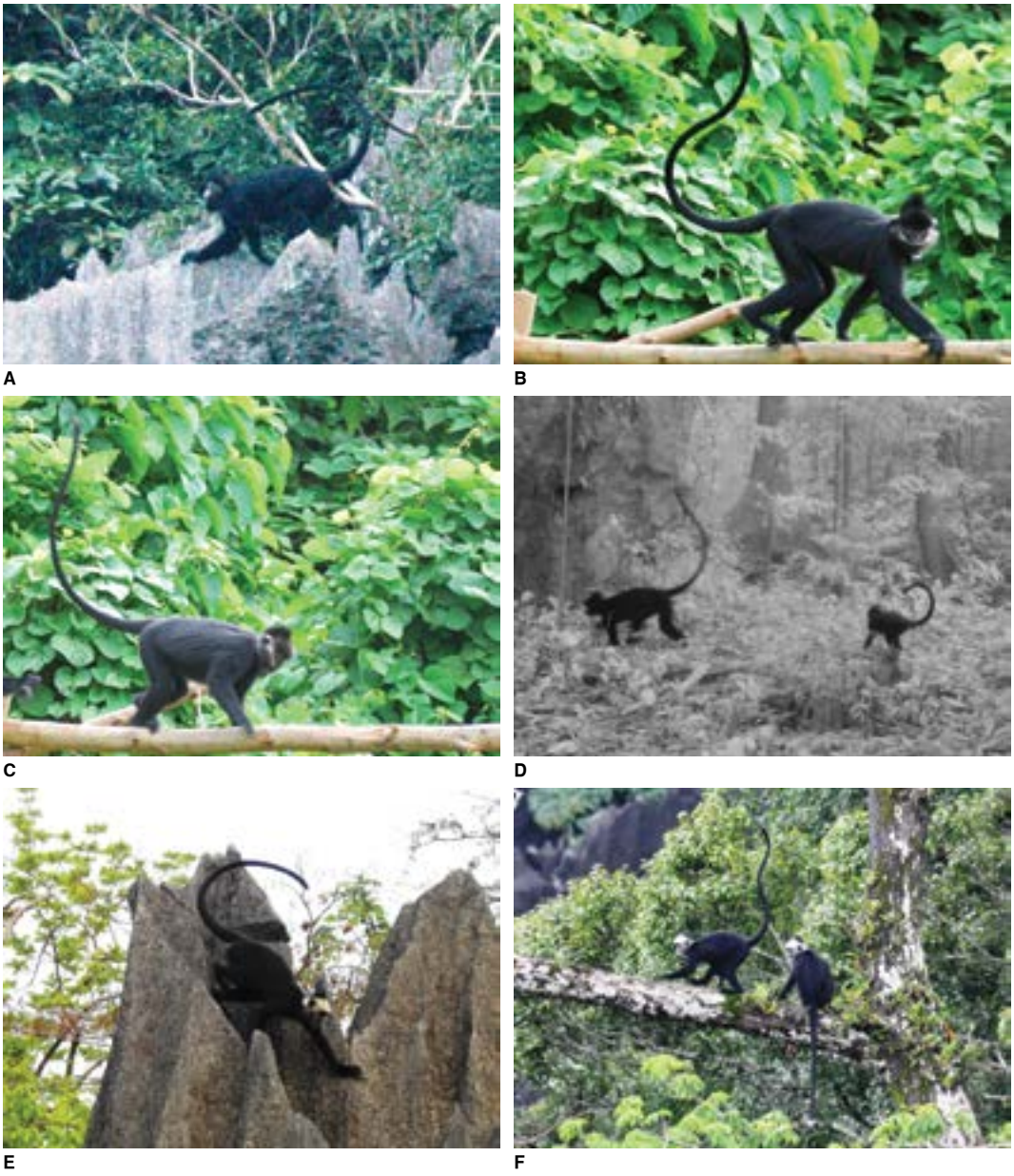


**Fig.13.** Tail posture of the southern group of limestone langurs, genus *Trachypithecus*. A, B, C: Hatinh langur. Photos: Tilo Nadler; D: Hatinh langur morph *ebenus*. Camera trap photo: Nguyen Hai Ha; E, F: Laos langur. Photos: Tilo Nadler.

## Discussion

The tail posture of the *Semnopithecus* species and the limestone langurs of the genus *Trachypithecus* show clear differences in both groups. In each of the two groups, there are two quite similar types of tail posture, with a geographical separation at around 20ºN (Fig. 14). The northern *Semnopithecus* species hold their tails arched forward over their backs when standing, walking slowly, and jumping short distances. In contrast, the southern species carry their tails backward. In limestone langurs, there is a geographical contrast in tail posture. The northern species have a backward-facing tail posture, while the southern species resemble the northern species of *Semnopithecus* in their tail posture.

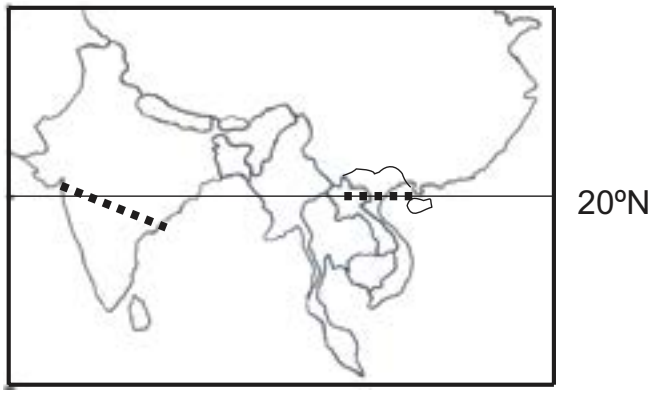



**Fig.14.** The dividing line for tail postures between a northern and a southern groups lies at approximately 20ºN in both India (Roonwaal's line) and Vietnam.

A selective influence on tail posture by environmental factors such as habitat structures, climatic conditions, or social behavior can be ruled out for both the *Semnopithecus* species and the limestone langurs. No differences are apparent, or they are too minor.

No conclusive explanation can be found for the almost identical geographical separation of the types in terms of tail posture in the two groups.

It is surprising that, given the importance of the tail for the locomotion of these species, especially for the limestone langurs that live in an extreme habitat there is such a fundamental difference in posture between the northern and southern species, given that the tail is clearly an important body part for balance and controlling jumps. There is no evidence of any advantage or disadvantage for either group due to the different tail postures in either the *Semnopithecus* species or the limestone langurs. In the limestone langurs, no measurable difference was found between the northern and southern species in the width or angle of their jumps (Nadler, unpubl.).

Tail length cannot be used as a reason for tail posture either (Table 1). Combining the measurements of males and females, the average tail length for the northern type of *Semnopithecus* species is 88.9 cm and for the southern type 80.4 cm. In limestone langurs, the difference is even smaller, with 84.4 cm for the northern type and 84.6 cm for the southern type.

**Table 1.** Compilation of tail lengths of species of the genus *Semnopithecus* and limestone langurs of the genus Trachypithecus from the literature. [1]Brandon-Jones (1995); [2]Francis (2008); [3]Smith & Yan Xie (2008); [4]Pham Nhat (2002); [5]Nadler (unpubl.); [6]Nadler (2013); [7]Brandon-Jones (1996); [8]Nadler & Brockman (2014); [9]Wenshi Pan; [10]Roonwaal (1981); [11]Roonwaal (1984b); [13]Anandam et al. (2013); [14]Nekaris & De Silva (2009); [15]Hill (1936); [16]Prater (1965).

| Species | Tail length (cm) | | |
|---|---|---|---|
| | male | female | sexes combined |
| *Semnopithecus* | | | |
| **Northern types** | | | |
| *S.ajax* | 81-95 [11] | 71-88 [11] | |
| *S. schistaceus* | 75-99 [12] | 87.5 [14] | |
| *S. hector* | 92.5-98 [10] | 70-94 [10] | |
| *S. entellus* | | | 80.3-111.8 [13] |
| **Southern types** | | | |
| *S. hypoleucos* | 72.5-109.2 [13] | | |
| *S. priam* | | | 75-85.5 [14] |
| *S. vetulus* | 57-91.9 [15] | 51.6-82 [15] | |
| *S. johnii* | 75-90 [16] | 75 [16] | |
| *Trachypithecus* | | | |
| **Northern types** | | | |
| *T. francoisi* | 80.5-90 [1]<br>85-93 [5] | 83-90 [1]<br>82-89 [5] | 74-96 [2]<br>70-90 [3]<br>77.5-90 [4]<br>74-90 [6] |
| *T. leucocephalus* | 82-89 [6] | 77-82 [6] | |
| *T. poliocephalus* | 82-87.2 [7]<br>85-96 [9] | 82-88.7 [7]<br>92 [8] | 80-90 [2]<br>82-87 [4] |
| *T. delacouri* | 81-93 [8] | 82-89 [8] | 73-97 [2]<br>72.5-85.5 [4] |
| **Southern types** | | | |
| *T. hatinhensis* | 75-95 [8] | 73-96 [8] | 81-87 [2]<br>74.9-81 [4] |
| *T. hatinhensis* morph *ebenus* | 94 [2] | | |
| *T. laotum* | 85-90 [6] | 81-89.5 [1] | |

However, the thickness of the tail, and thus probably also the mass of the tail, shows a clear difference between the northern and southern species of limestone langurs. The northern species have a much thicker tail, which is about twice the diameter of the southern species over the entire length of the tail. This difference is also clearly visible in the field (Fig. 15). The northern species also include Delacour's langur, but the thickness of its tail is not visible due to the long hair that is characteristic of this species.

The questions remain as to what causes these different tail positions and why their dividing line lies at around 20°N in both India and Vietnam.

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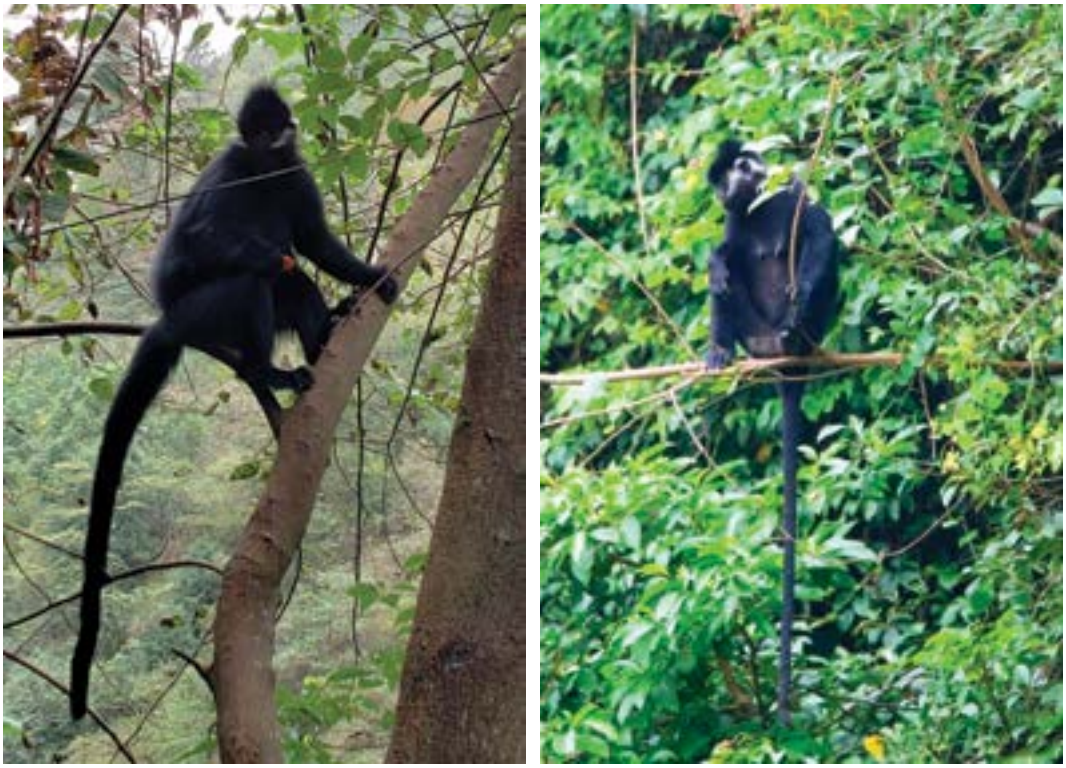


**Fig.15.** Field observations clearly show the difference in tail thickness between the northern and southern limestone langurs. Left: Francois langur. Photo: Yanfumu. Right: Hatinh langur. Photo: Quy Hoang.

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# Field survey for southern pygmy lorises (*Xanthonycticebus pygmaeus*) in the Nui Dinh area, Ho Chi Minh City, Vietnam

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**Keywords:** Pygmy loris, *Xanthonycticebus pygmaeus*, density, field survey, threats.

**Summary**

The southern pygmy loris (*Xanthonycticebus pygmaeus*) is an endangered primate species that plays a crucial role in maintaining forest ecological balance, but is facing significant pressure from habitat loss and hunting. This study assessed the population status, encounter rates, and anthropogenic threats to the southern pygmy loris in the Nui Dinh area, Ho Chi Minh City. The study used a semi-structured interview method with local people combined with field surveys using night vision techniques on ten survey transects with a total length of over 36.2 km. The results showed an average encounter rate of 0.22 individuals/km$^2$ across the entire area, with an estimated average density of 1,062 individuals/km$^2$. The population in the 30 km$^2$ area is estimated to be around 32 individuals, predominantly distributed in natural forest and mixed bamboo-forest habitats. The main pressures identified include hunting for pets and habitat disruption caused by ecotourism and infrastructure development. The study confirms the importance of the Nui Dinh area in conserving the southern pygmy loris population outside of the protected forest system. The research highlights the need for regular monitoring to assess the impacts of human activities and protect the habitat of this endangered primate species.

# Điều tra về loài Cu li nhỏ (*Xanthonycticebus pygmaeus*) tại khu vực rừng Núi Dinh, thành phố Hồ Chí Minh, Việt Nam

**Tóm tắt**

Cu li nhỏ (*Xanthonycticebus pygmaeus*) là loài linh trưởng nguy cấp có vai trò quan trọng trong việc duy trì sự cân bằng sinh thái rừng, nhưng đang đối mặt với áp lực lớn từ việc mất sinh cảnh và săn bắt. Nghiên cứu này đã tiến hành đánh giá hiện trạng quần thể, tỷ lệ bắt gặp và các mối đe dọa nhân sinh đối với loài Cu li nhỏ tại khu vực Núi Dinh, thành phố Hồ Chí Minh. Nghiên cứu đã sử dụng phương pháp phỏng vấn bán cấu trúc với người dân địa phương kết hợp khảo sát thực địa bằng kỹ thuật soi đêm trên mười tuyến khảo sát với tổng chiều dài hơn 36.2 km. Kết quả cho thấy tỷ lệ bắt gặp trung bình của loài trên toàn khu vực đạt 0,22 cá thể/km, mật độ ước tính trung bình 1,062 cá thể/km$^2$. Quần thể Culi nhỏ tại khu vực 30 km$^2$ ước tính có khoảng 32 cá thể với sự phân bố ưu thế tại các sinh cảnh rừng tự nhiên và rừng hỗn giao tre nứa. Các áp lực chính được xác định bao gồm nạn săn bắt làm thú cưng và sự xáo trộn sinh cảnh do hoạt động du lịch dã ngoại và phát triển hạ tầng gây ra. Kết quả nghiên cứu khẳng định tầm quan trọng của khu vực Núi Dinh trong việc bảo tồn quần thể Cu li nhỏ ngoài hệ thống rừng đặc dụng. Nghiên cứu nhấn mạnh nhu cầu giám sát định kỳ để đánh giá các tác động từ hoạt động nhân sinh và bảo vệ sinh cảnh cư trú của loài linh trưởng nguy cấp này.

## Introduction

The southern pygmy loris (*Xanthonycticebus pygmaeus*) is among the world's smallest primates. The species is currently classified as 'Endangered' in both the IUCN Red List of Threatened Species (Nekaris et al. 2025) and the Vietnam Red Data Book (2024).

Its distribution includes areas east of the Mekong in Vietnam, Laos, Cambodia and parts of southern China. (Blair et al. 2023; Brandon-Jones et al. 2004; Fooden 1996; Nisbett & Ciochon 1993; Ratajszczak 1998; Roos et al. 2013). The species has experienced significant population declines across its range due to habitat loss and intensive hunting for traditional medicine and the pet trade (Nadler 2010; Starr et al. 2010; Thach Mai Hoang et al. 2018).

Despite their conservation status, southern pygmy lorises are rarely recorded in standard biodiversity assessments, with existing reports indicating consistently low encounter rates (Nekaris et al. 2008). In some regions where they occur sympatrically with the Bengal slow loris (*Nycticebus bengalensis*), the two species are often collectively reported as "slow loris" due to challenges in field identification (Ashwell & Walston 2008).

While extensive research has focused on the ecology and conservation of pygmy lorises in the major national parks of northern and central Vietnam, populations in the southern part of the country - particularly within fragmented and isolated forest patches - remain poorly understood (Bui Thi Tam Anh & Dinh Thi Thuy Dung 2022). The southern pygmy Loris is widely distributed across the Indochinese Peninsula, including Laos and Cambodia. In Vietnam, its range extends through numerous conservation areas from central to southern regions, such as Son Tra (Da Nang), Song Thanh (Quang Nam), Chu Mom Ray (Kon Tum), Yok Don (Dak Lak), and Cat Tien (Dong Nai), reaching as far south as Binh Chau-Phuoc Buu (Ba Ria-Vung Tau). Notably, recent taxonomic revisions have reclassified populations formerly identified as *X. pygmaeus* from northern Vietnam down to the Hai Van Pass as *Xanthonycticebus intermedius* (Blair et al. 2023). Currently, scientific data regarding the presence and population status of the southern pygmy loris in the coastal regions of southeast Vietnam is extremely limited. To bridge this knowledge gap, this study integrates local ecological knowledge from community members with systematic nocturnal spotlighting surveys to: (1) Confirm the presence of the southern pygmy loris in the Nui Dinh area; (2) Estimate encounter rates and identify preferred habitat characteristics and (3) Identify the primary anthropogenic threats affecting this population.

**Study area**

Nui Dinh is a low-lying coastal mountain within the Toc Tien mountain range, covering approximately 3,000 hectares. Located southeast of Ho Chi Minh City, the site spans Chau Pha Commune, Tan Hai Ward, and Long Huong Ward in Ho Chi Minh City (Fig. 1). Nui Dinh is a representative topographical feature of the southern Vietnam plains, sharing ecological similarities with other regional massifs such as Thi Vai, Chua Chan (Dong Nai), and Ba Den (Tay Ninh). The highest peak, La Ban, reaches an elevation of approximately 504 m asl.

The habitat within the study area consists of a mosaic of regenerating forests and plantations interspersed with patches of natural forest, characterized by a seasonal stream system. The climate is typical of low-altitude tropical zones, with an average annual temperature of 27.25°C. Temperatures fluctuate from a minimum of 23°C in December to a maximum of 31°C in May. Rainfall is highly seasonal, with the highest monthly average reaching 171.4 mm in September and dropping to a minimum of 4 mm in February. The year is divided into two distinct seasons: the wet season from May to October and the dry season from November to April (Nguyen Khanh Van et al. 2000).

Currently, Nui Dinh is not only significant for its biodiversity but is also a prominent destination for spiritual tourism and outdoor recreational activities, including trail running, hiking, cycling, and camping (Nguyen Quang Truong et al. 2014). The intensification of human activities within this isolated forest habitat poses significant conservation challenges for local wildlife, particularly for the southern pygmy slow loris.

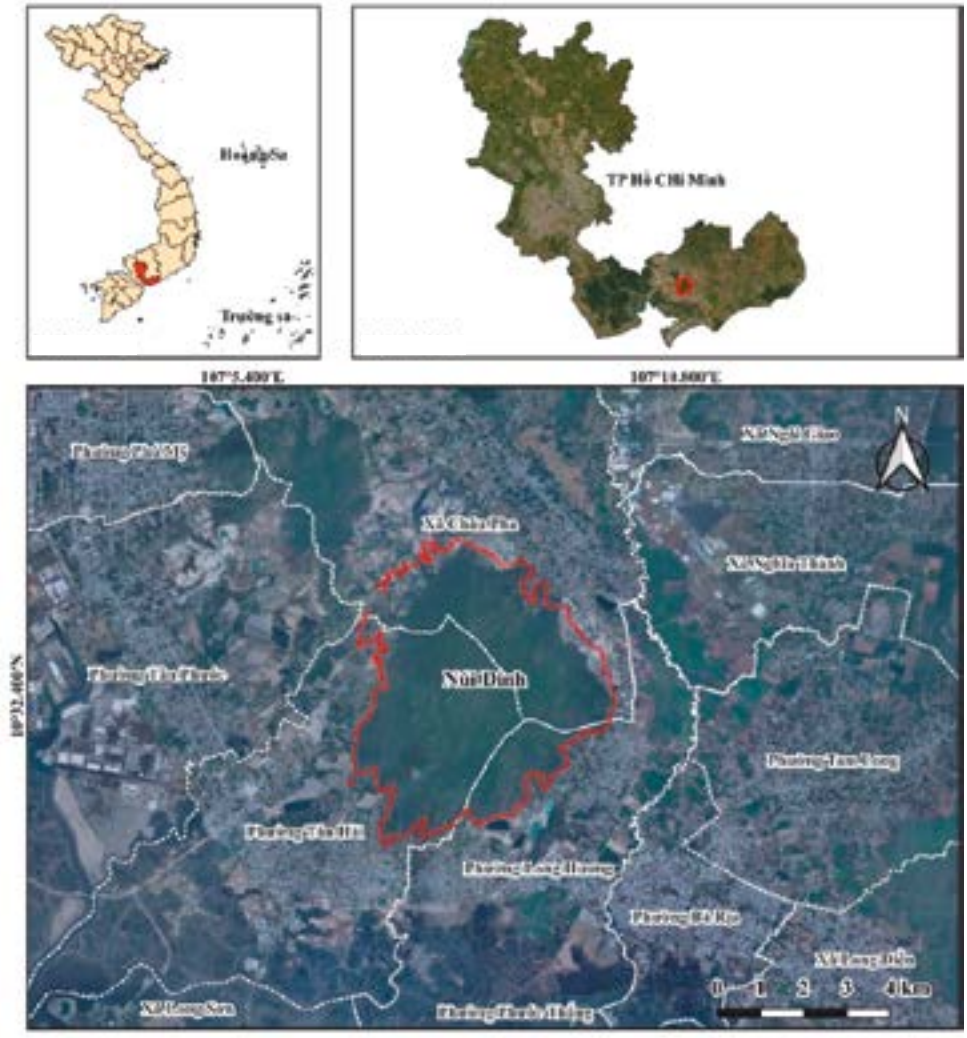



**Fig.1.** Location of the Nui Dinh study area in Ho Chi Minh City, southeast Vietnam.

## Methods

### Interview surveys

Semi-structured interviews were conducted with local communities surrounding Nui Dinh to gather preliminary data on the presence and distribution of slow lorises (Teddlie & Fen Yu 2007). The interview framework focused on morphological identification; respondents were shown high-quality photographs of the two slow loris species found in southern Vietnam to accurately identify the target species in the study area. The interviews covered ecological observations, including food sources, timing of infant sightings, and habitat preferences. Furthermore, questions regarding hunting pressure and illegal trade were discreetly integrated to assess anthropogenic impacts, categorized as low, medium, or high based on reported encounter frequencies from hunters and forest-goers.

### Field Surveys

Field surveys at Nui Dinh were carried out in four trips from August 2024 to June 2025, covering both wet and dry seasons over a total of 20 survey nights. Ten transects were systematically established

along existing trails to facilitate field surveys. Due to the steep and rugged terrain, transects were not randomly selected but followed existing forest trails, prioritizing sections with continuous canopy cover. In priority habitats, new trails were established to ensure representative sampling. Surveys typically commenced after 18:00 and concluded between 1:00 and 4:00 the following morning, conducted regardless of the lunar cycle to maximize detection of nocturnal activity.

To detect individuals at night, we utilized Petzl Zoom 4.5 V headlamps (Petzl, Crolles, France) equipped with red filters to minimize disturbance and light-induced stress to the animals (Nekaris et al. 2008; Streicher 2004). The survey team consisted of a maximum of three members moving at a slow pace (500–1,000 m/h) while maintaining a minimum distance of 10 m between observers. Notably, as pygmy loris vocalizations were not reliably identified by the team until the final stages of the study, acoustic detections were excluded from the formal analysis. Upon detecting eyeshine, high-power Halogen spotlights and 10x40 binoculars were immediately deployed for species confirmation. Morphological traits, such as larger ears, smaller body size, and faster movement compared to the Bengal slow loris, allowed for reliable field identification of the pygmy loris (Bui Thi Tam Anh & Dinh Thi Thuy Dung 2022).

**Data analysis**

Data collected from the survey transects were analyzed to determine fundamental population indices. The Encounter Rate (ER), representing relative abundance, was calculated using the following formula: ER = n/l. Where, n is the total number of individuals observed and l is the total length of the survey transects in km.

To estimate the population density (D) within the habitat, we applied the following equation:

$$D = \frac{n}{2.w.l}$$

In which, w represents the effective strip width, which was adopted from specialized studies on nocturnal primates by Nekaris et al. (2014). An effective strip width of 13 m was adopted based on previous nocturnal loris surveys (Nekaris 2014). By integrating empirical field observations with established ecological parameters, this approach provides an objective assessment of the relative abundance and density of the pygmy slow loris population across different habitat types in Nui Dinh.

**Results**

Interview results

A total of 20 interviews were conducted, involving 16 local residents and four hunters from areas adjacent to Nui Dinh. The results showed that 80% (16/20) of the respondents accurately identified the pygmy loris using the provided photograph sets, confirming the presence of the species in the area based on morphological traits such as small body size and characteristic reddish fur.

Information provided by respondents generally corresponded with patterns observed during field surveys. Informants reported that northern slow lorises are more frequently encountered during the dry season (September to January), particularly in forest areas with high densities of bamboo and wild fruit trees.

Field survey results

A total of 20 survey nights were completed across four seasonal phases from August 2024 to June 2025 in the Nui Dinh area. This sampling period spanned both wet and dry seasons, ensuring a representative dataset for the study period (Fig 2).




**Fig.2.** Map of survey transects and pygmy loris detection points.

## Encounter Rate

Through a survey effort covering 10 transects with a total length of 36.2 km, the research team directly recorded 10 southern pygmy lorises (Table 1). The average encounter rate (ER) for the entire study area was 0.28 individuals/km. However, this rate showed varied across transects: the highest values were concentrated at transect Fn7 (0.59 individuals/km) and Fn10 (0.49 individuals/km). No individuals were recorded at transects Fn2, Fn5, Fn8, and Fn9.

**Table 1.** Summary of survey transects, habitat types, and pygmy loris encounter data in the Nui Dinh study area.

| Transect Code | Survey time | Habitat & Substrate | Length (km) | Individuals (n) | Encounter Rate (ER = n/L) | Density (D - n/km²) |
|---|---|---|---|---|---|---|
| Fn 1 | August 2024, March 2025 | Natural forest | 4.2 | 1 | 0.24 | 9.158 |
| Fn 2 | August 2024, March 2025 | Regenerated forest | 1.8 | 0 | - | - |
| Fn 3 | March 2025 | Mixed forest | 2.6 | 1 | 0.38 | 14.793 |
| Fn 4 | August 2024, March 2025, June 2025 | Mixed forest | 4.8 | 1 | 0.21 | 8.013 |
| Fn 5 | March 2025 | Stream | 1.4 | 0 | - | - |
| Fn 6 | August 2024, March 2025, June 2025 | Mixed forest, Regenerated forest | 5.8 | 2 | 0.34 | 6.631 |
| Fn 7 | August 2024, March 2025 | Mixed forest | 1.7 | 1 | 0.59 | 22.624 |
| Fn 8 | August 2024, March 2025 | Regenerated forest, Concrete road, Religious sites | 3.3 | 0 | - | - |
| Fn 9 | March 2025 | Acacia plantation | 2.4 | 0 | - | - |
| Fn 10 | August 2024, March 2025, June 2025 | Mixed forest, Regenerated forest, Concrete road | 8.2 | 4 | 0.49 | 4.690 |
| | | | **36.2** | **10** | **0.22** | **1.062** |

### Distribution Patterns

The distribution of the pygmy loris in the study area primarily associated with natural habitat types. Results indicate that the population is primarily concentrated in mixed and secondary forests, particularly within forest strips along streams (notably at transects Fn3, Fn4, and Fn6). Interestingly is the recording of 4 individuals near traffic roads (Fn10). Conversely, the absence of the species in *Acacia* plantations (Fn9) and areas under heavy pressure from human activity and infrastructure (Fn8) underscores the critical importance of intact natural forest habitats for the survival of the species.

### Density and Population Estimate

The mean population density in the Nui Dinh area was calculated at 1.062 individuals/km$^2$. This density exhibited non-uniform distribution, peaking in the mixed forest habitat (transect Fn7) at 22.624 individuals/km$^2$, reflecting its status as a vital core habitat. Based on the mean density estimate and the total forest area of approximately 30 km$^2$, the population size in Nui Dinh is roughly estimated at about 32 individuals. It is important to note that this is considered a minimum estimate, as the species' nocturnal biological traits and sophisticated camouflage within dense canopy often result in observation rates lower than their actual abundance in the wild (Fig 3).



**Fig.3.** Two southern pygmy loris (*Xanthonycticebus pygmaeus*) observed during a nocturnal spotlighting survey in the Nui Dinh study area. Photos: Nguyen Van Linh.

## Anthropogenic threats

Interview responses and field data identified three primary pressures on the pygmy loris population in Nui Dinh: tourism, infrastructure development, and historical hunting practices. Hunting appears to be the most direct threat, with 100% of hunters and 43.7% of local residents confirming that the species is targeted for the pet trade and traditional medicine. Increased tourism activities such as camping and recreational visits were observed in several parts of the study area, correlating with zero detection on transects with heavy tourism infrastructure (Fig 4). Furthermore, internal road expansion and facility construction have caused significant canopy fragmentation on the eastern slopes, eliminating essential movement substrates and foraging trees while forcing individuals to travel across the ground, thereby increasing their vulnerability to predation and human detection.



**Fig.4.** Construction activities and road networks in the Nui Dinh area. Photos: Nguyen Van Linh.

## Discussion

This study confirms the persistence of the southern pygmy loris within the Nui Dinh area of Ho Chi Minh City, marking a critical record for the species' distribution in the increasingly fragmented coastal landscapes of southeast Vietnam. Our results indicate that the population is not uniformly distributed across habitat types, with individuals recorded more frequently in regenerating forests and mixed bamboo habitats, with a mean encounter rate (ER) of 0.28 individuals/km. This pattern suggests that despite being isolated within a relatively small massif (approximately 3,000 ha), the pygmy loris maintains ecological resilience by exploiting secondary forest structures and ecotones where natural and anthropogenic factors intersect.

The recorded ER of 0.22 individuals/km at Nui Dinh is higher than those reported in several large-scale protected areas across Vietnam and neighboring regions. For example, Nekaris et al. (2008) documented ERs below 0.1 individuals/km in northern Vietnamese national parks, while Starr et al. (2010) reported rates fluctuating between 0.05 and 0.11 individuals/km in Cambodia. Conversely, our findings align more closely with Bui Thi Tam Anh & Dinh Thi Thuy Dung (2022), who observed higher encounter rates in fragmented secondary forests in central Vietnam. One possible explanation for these differences is from our survey methodology. In this study, surveys were conducted along existing forest trails, which may increase detection probability due to clearer visibility of loris eyeshine, whereas other studies often employ random transects in dense primary forests.

The population density at Nui Dinh, estimated at 1.062 individuals/km$^2$, this relatively high value may reflect a concentration of individuals within the remaining forest patches surrounded by agricultural land and tourism infrastructure. The preference for regenerating forests likely relates to the abundance of exudates and insects, which are characteristic of pioneer floral species in disturbed habitats (Streicher 2004). Seasonal patterns in sightings during surveys conducted from August 2024 to June 2025 may also be influenced by phenological cycles of local gum-producing trees, such as *Acacia* sp., *Albizia* sp., and species within the Anacardiaceae family, which provide critical energy during periods of fruit scarcity. Furthermore, the survey period captured the peak of the rainy season, characterized by a high availability of nocturnal insects - particularly orthopterans and lepidopterans. This surge in protein-rich prey likely increases loris foraging activity, further

influencing the seasonal encounter rates recorded in this study. These findings provide additional information on the southern distribution limits of this endangered primate in Vietnam. Practically, the identification of a resident population (estimated at approximately 32 individuals) in an area characterized by high spiritual tourism underscores the conservation potential of isolated forest fragments outside the formal Special-use Forest system. The results also highlight several areas with relatively high encounter rates, particularly transects Fn6 and Fn10. These locations could be considered priority areas for future monitoring and management within the Nui Dinh landscape.

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# Camera-trap survey in the Yen Mo limestone complex for the establishment of a 'Delacour's Langur Species and Habitat Conservation Area' in Ninh Binh Province, Vietnam

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**Keywords:** Delacour's langur, *Trachypithecus delacouri*, camera-trap survey, Yen Mo limestone complex.

**Summary**

Delacour's langur (*Trachypithecus delacouri*) is one of the world's rarest and most endangered primates. The species is endemic to Vietnam and has a very limited distribution range in the north of the country. In the 1990s, there were populations in 16 isolated areas. By around 2010, 11 of the populations had been wiped out by poaching. The largest of the five remaining populations, with just over 200 individuals, exists in the Van Long Nature Reserve. The second largest population, with approximately 120 individuals, is located in the Kim Bang karst area, for which no protected area status has yet been established.

A survey conducted in 2024 in the Yen Mo limestone complex confirmed the presence of 32 to 37 individuals, making this area home to the third largest population of the species. To provide further information as a basis for granting protected status to the area, a camera trap survey was conducted from July to October 2025. Using 48 cameras, 12 mammal species and 15 bird species were recorded during 3,340 camera trap days.

The results of the survey show that the level of biodiversity in this area is quite high, especially the appearance of 7 threatened wildlife species, including two 'Critically Endangered' species and 14 species protected under the Vietnamese Decree 84/2021/ND-CP.

The human activities detected during the camera trap survey, namely the collection of forest products and the grazing of domestic animals - goats, cows and water buffaloes - are causing disturbance in the area and habitat changes.

Based on the Vietnamese Decree 156/2018/ND-CP, this area fully meets the criteria for a Special-use Forest and the establishment a 'Delacour's Langur Species and Habitat Conservation Area' with the goal of protecting endangered species, conserving nature combined with developing local ecotourism.

# Điều tra bằng bẫy ảnh tại Khu phức hợp núi đá vôi Yên Mô nhằm thiết lập 'Khu bảo tồn loài và sinh cảnh loài Voọc mông trắng' tại tỉnh Ninh Bình, Việt Nam

**Tóm tắt**

Voọc mông trắng (*Trachypithecus delacouri*) là một trong những loài linh trưởng quý hiếm và có nguy cơ tuyệt chủng cao nhất thế giới. Loài này là loài đặc hữu của Việt Nam và có phạm vi phân bố rất hạn hẹp ở phía Bắc. Vào những năm 1990, loài này có 16 tiểu quần thể biệt lập. Đến khoảng năm 2010, 11 tiểu quần thể đã bị xóa sổ do săn bắn trái phép. Quần thể lớn nhất trong năm (05) quần thể còn lại, chỉ với hơn 200 cá thể tồn tại trong Khu bảo tồn thiên nhiên đất ngập nước Vân Long. Quần

thể lớn thứ hai, với khoảng 120 cá thể tồn tại trong Rừng phòng hộ Kim Bảng, nơi chưa được công nhận là khu vực bảo tồn.

Một cuộc tái khảo sát được thực hiện vào năm 2024 tại khu phức hợp núi đá vôi Yên Mô đã xác nhận sự tồn tại của 32 đến 37 cá thể, khiến khu vực này trở thành nơi sinh sống của quần thể lớn thứ ba của loài. Để cung cấp thêm thông tin làm cơ sở cho việc nâng cấp bảo vệ cho khu vực, một cuộc khảo sát bẫy ảnh đã được thực hiện từ tháng 7 đến tháng 10 năm 2025. Sử dụng 48 camera, 12 loài động vật có vú và 15 loài chim đã được ghi lại trong 3.340 lượt bẫy ảnh.

Kết quả khảo sát cho thấy mức độ đa dạng sinh học trong khu vực này khá cao, đặc biệt là sự xuất hiện của 7 loài động vật hoang dã đang bị đe dọa, trong đó có hai (02) loài thuộc diện "Cực kỳ nguy cấp" và 14 loài được bảo vệ theo Nghị định 84/2021/NĐ-CP.

Các hoạt động của con người được phát hiện trong quá trình khảo sát bằng bẫy ảnh, cụ thể là việc thu hái lâm sản và chăn thả gia súc - dê, trâu, bò - đang gây xáo trộn khu vực và làm thay đổi môi trường sống.

Căn cứ Nghị định 156/2018/NĐ-CP, khu vực này đáp ứng đầy đủ các tiêu chí về rừng đặc dụng và thành lập 'Khu bảo tồn loài voọc và môi trường sống Delacour' với mục tiêu bảo vệ các loài nguy cấp, bảo tồn thiên nhiên kết hợp với phát triển du lịch sinh thái của địa phương.

Căn cứ Nghị định 156/2018/NĐ-CP, khu vực này hoàn toàn đáp ứng các tiêu chí của một khu rừng đặc dụng và việc thành lập "Khu bảo tồn loài và sinh cảnh loài voọc mông trắng" với mục tiêu bảo vệ các loài có nguy cấp, bảo tồn thiên nhiên kết hợp với phát triển du lịch sinh thái địa phương.

## Introduction

Delacour's langur (*Trachypithecus delacouri*) is one of the world's rarest and most endangered primates (Nadler et al. 2020). The species is endemic to Vietnam and has a very limited distribution range in the north of the country (Nadler 2004; Nadler & Brockman 2014). In the 1990s, there were populations in 16 isolated areas, and the total population was estimated at 281 to 317 animals (Nadler 1996; 2004; Nadler et al. 2003). By around 2010, 11 of the populations had been wiped out by poaching (Nadler 2010a; 2010b; 2015). Thanks to intensive conservation efforts, stricter laws against poaching and illegal animal trade, and increasing public awareness of wildlife conservation, the populations stabilised in two areas, the Van Long Nature Reserve (Nguyen Van Linh et al. 2019) and the Kim Bang karst area (Fauna & Flora 2024).

Following the discovery of a population in the Van Long area in the early 1990s, the area was granted protected status as a nature reserve in 2001. Thanks to strict conservation measures, the population grew rapidly and now forms the stronghold for the species with more than 200 individuals (Nguyen Van Linh et al. 2019; Nguyen Vinh Thanh et al. 2022; Trinh Dinh Hoang et al. 2024b). The population in the Kim Bang karst area – which does not yet have protection status – comprises around 120 individuals (Fauna & Flora 2024; Nguyen Anh Tuan et al. 2026). A survey conducted in the Yen Mo limestone complex in 2024 identified 32 to 37 individuals, making it the third largest population of the species (Trinh Dinh Hoang et al. 2024b). No exact figures are available for the other two existing populations, the Pu Luong Nature Reserve and the Huong Son limestone area, which also includes the Huong Son Cultural and Historical Site. The population in both areas is estimated at around 20 individuals.

As a long-term conservation initiative, the plan is to establish another population in the UNESCO Trang An World Heritage Landscape Complex, part of the Hoa Lu Nature Reserve, an area where the population was wiped out around 2000. As a first step in this re-wilding programme, three captive-born individuals were transferred from the Endangered Primate Rescue Center to Ngoc Island in the UNESCO Trang An World Heritage Landscape Complex in August 2020, and by 2025, five animals had been born in their natural habitat (Nadler et al. 2020; Nadler pers. observations). Increase the total of the group to 8 individuals.

The third largest remaining population of Delacour's langurs in the Yen Mo limestone complex, Dong Thai commune - covering about 2,800 hectares - requires the area to be secured by granting it as Special-use Forest with the status as 'Species and Habitat Protection Area' in order to prevent future destruction of the habitat and a negative impact on the population. A camera trap survey was conducted to provide sufficient material for the application and granting with the status of a 'Habitat and Species Protection Area'.

## Location

The Yen Mo limestone complex is located in the southeast of Ninh Binh Province, on the border with Thanh Hoan Province (20º03'50''... 20º07'50''/105 º53'20''... 105 º59'40''). The complex includes parts of the former districts of Tam Diep, Yen Mo, now Dong Thai and Trung Son in Ninh Binh Province, and parts of the districts of Bim Son and Nga Trung in Thanh Hoa Province.

## Methods

For the survey, 48 Spartan Lumen Dual Flash Scouting Cameras, Model SR3-CX were installed in the Ninh Binh parts of the limestone complex (Fig. 1, 2). The cameras were provided on loan by WWF-Vietnam. The cameras were installed between 29 July 2025 and 13 August 2025. Due to the difficult access in the limestone area, only two to five cameras (three on average) could be installed each day. After two and a half months of operation, the cameras were dismantled between 8 October 2025 and 21 October 2025.

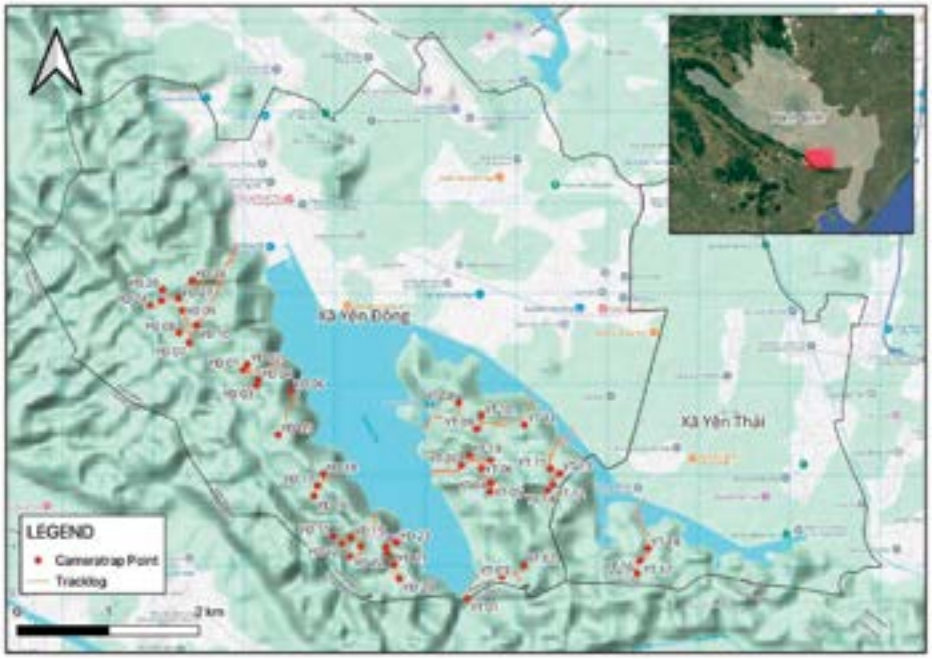



**Fig.1.** Camera trap positions in the Yen Mo limestone complex. YD: Yen Dong forest section; YT: Yen Thai forest section.



**Fig.2.** CThe rugged terrain of the Yen Mo limestone complex is very difficult to access. Photo: Tilo Nadler.

In contrast to the rather gently rolling terrain in the Vietnamese Annamites, the topography of the limestone area does not allow for a sensible arrangement of the cameras in a systematic grid system (Alexiou et al. 2022; Anh Tuan Nguyen et al. 2025) (Fig. 3).

The main objective of the survey was to record ground-dwelling mammals. The cameras were mainly installed in the valleys between the steep limestone peaks, which are preferred by mammals.



**Fig.3.** Installation of a camera in a valley between steep limestone cliffs. Photo: camera trap.

The cameras were installed in two forest sections of the former communes Yen Dong and Yen Thai. The two forest sections of the entire forest differ both topographically and in terms of accessibility. Twenty-eight cameras were installed in the forest section of the former Yen Dong commune and 20 in the forest section of the former Yen Thai commune.

## Results

Of the 48 cameras installed, recordings from 47 cameras could be evaluated. One camera was stolen. All cameras worked reliably and without failure during the installation period. The number of recordings per camera depended on the triggering events at the camera locations. With a few exceptions, where only parts of an animal could be recognised, both the species of mammals and birds could be reliably identified.

For the evaluation of the recordings, we used a threshold value of one day, i.e. an animal was only registered for one day, even if it passed the camera several times a day and recordings were made. This also applies to the recording of domestic animals. In the case of recorded human activities, each recognisable independent activity was registered as an event.

During the 3,340 camera trap days, a total of 417 daily events were recorded, 260 by mammals and 157 by birds, and 35 events with human activities and domestic animals.

### Mammals

Twelve mammal species were recorded (Table 1). Due to the different number of cameras in the two forest sections, the recorded events cannot be directly compared. However, even with a correction, there are significantly more events for most species in the Yen Dong forest section.

**Table 1.** Animal records during the camera trap survey 2025. YD = Yen Dong forest section; YT = Yen Thai forest section.

| **Mammals** | | **YD +YT** | **YD** | **YT** | **IUCN** | **VN RDB** | **Decree 84/2021** | **CITES** |
|---|---|---|---|---|---|---|---|---|
| Brush-tailed porcupine | *Atherurus macrourus* | 86 | 62 | 24 | LC | | | |
| Assameese macaque | *Macaca assamensis* | 40 | 35 | 5 | NT | VU | IIB | |
| Northern treeshrew | *Tupaia belangeri* | 31 | 19 | 12 | LC | | | |
| Burmese ferret-badger | *Melogale personata* | 21 | 16 | 5 | LC | | | |
| Pallas's squirrel | *Callosciurus erythraeus* | 20 | 15 | 5 | LC | | | |
| Leopard cat | *Prionailurus bengalensis* | 19 | 12 | 7 | LC | | IIB | |
| Wild boar | *Sus scrofa* | 17 | 0 | 17 | LC | | | |
| Indomalayan niviventer | *Niviventer fulvescens* | 13 | 13 | 0 | LC | | | |
| Delacour's langur | *Trachypithecus delacouri* | 5 | 5 | 0 | CR | CR | IB | II |
| Masked palm civet | *Paguma larvata* | 3 | 0 | 3 | LC | VU | IIB | |
| Yellow-throated marten | *Martes flavigula* | 3 | 0 | 3 | LC | | | |
| Indochinese serow | *Capricornis maritimus* | 2 | 1 | 1 | VU | EN | IB | I |
| **Birds** | | | | | | | | |
| Red junglefowl | *Gallus gallus* | 42 | 6 | 36 | LC | | | |
| Blue-rumped pitta | *Hydrornis soror* | 27 | 16 | 11 | LC | | IIB | |
| Grey-capped emerald dove | *Chalcophaps indica* | 20 | 16 | 2 | LC | | | |
| Malay night-heron | *Gorsachius melanolophus* | 20 | 10 | 10 | LC | CR | IB | |
| Eared pitta | *Hydrornis phayrei* | 13 | 5 | 8 | LC | LR | IIB | |
| Greater coucal | *Centropus sinensis* | 11 | 3 | 9 | LC | | | |
| Yellow-billed whistling-trush | *Myophonus flavirostris* | 9 | 6 | 3 | LC | | | |
| Crested serpent eagle | *Spilornis cheela* | 5 | 5 | 0 | LC | | | |
| Siberian blue robin | *Larvivora cyane* | 2 | 2 | 0 | LC | | | |
| Mountain scops-owl | *Otus spilocephalus* | 2 | 2 | 0 | LC | | IIB | |
| Slaty-legged crake | *Rallina eurizonoides* | 2 | 0 | 2 | LC | | | |
| Fairy pitta | *Pitta nympha* | 1 | 1 | 0 | VU | VU | IIB | |
| Lesser coucal | *Centropus sinensis* | 1 | 0 | 1 | LC | | | |
| Crested goshawk | *Accipiter trivirgatus* | 1 | 0 | 1 | LC | | IIB | |

Of particular significance are the repeated sightings of Delacour's langurs (Fig. 4) and Indochinese serow (*Capricornis maritimus*) (Fig. 5). Both species were already recorded during the 2024 drone survey (Trinh Dinh Hoang 2024b). The Delacour's langur was detected at three camera stations, the Indochinese serow at two camera stations. Several groups of the Assamese macaque (*Macaca assamensis*), listed as 'Vulnerable' (Vietnam Red Data Book 2024), are found in the area (Fig. 6). The most frequent daily events were recorded by the brush-tailed porcupine (*Atherurus macrourus*) in both forest sections, but with a higher number in the Yen Dong forest section. Only the northern tree shrew (*Tupaia belangeri*) showed a similar frequency ratio. For the other species, where the number

of events allows for a statement to be made, the Yen Dong forest section is predominantly affected. The occurrence of wild boar (*Sus scrofa*), on the other hand, appears to be limited to the Yen Thai forest section.



**Fig.4.** A group of Delacour's langurs. Photo: camera trap.



**Fig.5.** The Indochinese serow has been recorded by camera traps and during the drone survey. Photo: camera trap.



**Fig.6.** A population of Assamese macaques, consisting of several groups, occurs in the area. Photo: camera trap.

## Birds

Fifteen bird species were recorded (Table 1). With the exception of the red jungle fowl (*Gallus gallus*), the number of recorded occurrences does not indicate a preference for either of the two forest sections. The habitat in the Yen Thai forest section, with less rugged rock formations and partially open terrain, is apparently preferred by the red jungle fowl. Of particular importance is an existing population of the 'Critically Endangered' Malay night-heron (*Gorsachius melanolophus*) (Vietnam Red Data Book 2024), which was detected at seven camera stations (Fig. 7). Three species of pitta were also recorded, including the fairy pitta (*Pitta nympha*), which is classified as 'Vulnerable' (IUCN Red List of Threatened Spcecies; Vietnam Red Data Book 2024) (Fig. 8).



**Fig.7.** The Malay night-heron has been recorded several times and is listed as 'Critically Endangered'. Photo: camera trap.



**Fig.8.** The fairy pitta is a rare winter visitor to Vietnam and is listed as 'Vulnerable'. Photo: camera trap.

## Human activities and grazing by domestic animals

The recordings of human activities in the area do not allow any conclusions to be drawn about the actual impact of human activities, but they do show that the area is regularly visited and that forest products are harvested (Fig. 9). The recordings did not provide clear evidence of illegal activities such as hunting or trapping.



**Fig.9.** Harvesting of forest products is ongoing and is causing concern in the area. Photo: camera trap.

A clear difference in the frequency of human activity was recorded between the forest sections in Yen Dong and Yen Thai. In the Yen Dong forest section, 6 events were recorded at 4 camera stations, while in the Yen Thai forest section, 23 events were recorded at 8 camera stations. Taking into account the number of cameras per section (28 in Yen Dong, 19 in Yen Thai), the frequency of human activity in the Yen Thai forest section is approximately five times higher than in the Yen Dong forest section.

The use of the area as grazing land for goats, cows and water buffaloes could only be verified in the Yen Thai forest section, with 6 events at 4 camera stations. This further confirms the more intensive use of this forest section (Fig. 10).



**Fig.10.** Grazing of water buffaloes, cows and goats leads to a deterioration of the habitat. Photo: camera trap.

## Discussion

The events recorded during the two-and-a-half-month camera trap survey enabled the identification of 12 mammal and 15 bird species. Among these species is Delacour's langur, classified as "Critically Endangered" in the IUCN Red List of Threatened Species and the Vietnam Red Data Book (2024). Other endangered species include the Malay night-heron, also classified as 'Critically Endangered' in the Vietnam Red Data Book, the Indochinese serow, classified as 'Endangered', and the Assamese macaque, masked palm civet and fairy pitta, listed as 'Vulnerable' (Vietnam Red Data Book 2024).

The Delacour's langurs and Indochinese serow were also detected in the drone and ground

survey conducted in 2024 (Table 2). Furthermore, rhesus macaques (*Macaca mulatta*) and the keeled box turtle (*Cuora mouhotii*), which is listed as 'Endangered' (IUCN Red List of Threatened Species) (Trinh Dinh Hoang et al. 2024b). The 2024 drone survey detected an Indochinese Serow with a calf, confirming the reproduction of this endangered species in the area. Nguyen Vinh Thanh et al. (2013) also mention a possible occurrence of the Bengal slow loris (*Nycticebus bengalensis*) but confirmed evidence is still pending.

**Table 2.** Animal records during the camera trap survey 2025. YD = Yen Dong forest section; YT = Yen Thai forest section.

| **Mammals** | | **YD +YT** | **YD** | **YT** | **IUCN** | **VN RDB** | **Decree 84/2021** | **CITES** |
|---|---|---|---|---|---|---|---|---|
| Delacour's langur | *Trachypithecus delacouri* | 1 | 1 | 0 | CR | CR | IB | II |
| Rhesus macaque | *Macaca mulatta* | 1 | 1 | 0 | LC | LR | IIB | |
| Assameese macaque | *Macaca assamensis* | 15 | 15 | 0 | NT | VU | IIB | |
| Indochinese serow | *Capricornis maritimus* | 5 | 5 | 0 | VU | EN | IB | I |
| Pallas's squirrel | *Callosciurus erythraeus* | 20 | 15 | 5 | LC | - | | |
| **Birds** | | | | | | | | |
| Oriental pied hornbill | *Anthracoceros albirostris* | 1 | 1 | 0 | LC | - | IIB | II |
| **Reptiles** | | | | | | | | |
| Keeled box turtle | *Cuora mouhotii* | 2 | 2 | 0 | EN | - | IIB | |

The recorded events show differences in both species numbers and species composition in the two forest sections. However, these sections should be regarded as a single entity that is equally important for the protection of endangered species.

## Recommendations

The results of the survey show that the level of biodiversity in this area is quite high, especially the appearance of 7 threatened wildlife species, including two 'Critically Endangered' species (Vietnam Red Data Book 2024) and 14 species protected under the Vietnamese Decree 84/2021/ND-CP. However, the area has the current status of a Protection Forest facing a number of risks that may affect the Delacour's langur as well as the biodiversity.

Based on the Vietnamese Decree 156/2018/ND-CP, this area fully meets the criteria for a Special-use Forest and establishing a 'Delacour's langurs Species and Habitat Conservation Area' with the goal of protecting endangered species, conserving nature combined with developing local ecotourism.

We would like to propose seeking additional resources to support forest protection and management, biodiversity research, and plans to establish a 'Delacour's Langur Species and Habitat Conservation Area'.

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# Primate survey in Pu Huong Nature Reserve, Vietnam - using advanced technologies

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**Keywords:** Primate survey, camera trap, Unmanned Aerial Vehicle (UAV), Pu Huong Nature Reserve.

**Summary**

Pu Huong Nature Reserve, Nghe An Province, Vietnam represents a biodiversity-rich conservation landscape of critical importance for the conservation of primates in north central Vietnam. This study aimed to evaluate the application of camera trapping and unmanned aerial vehicle (UAV) technologies for surveying and monitoring primate populations within the reserve. During 2024–2025, a total of 52 infrared camera traps were deployed along 18 survey transects, generating 2,860 trap-days, while 37 UAV flights were conducted across approximately 12,500 ha. The survey documented five primate species with 96 independent detections, including stump-tailed macaque (*Macaca arctoides*) with 33 detections (34.4%), rhesus macaque (*Macaca mulatta*) with 22 detections (22.9%), Assamese macaque (*Macaca assamensis*) with 21 detections (21.9%), Indochinese grey langur (*Trachypithecus crepusculus*) with 12 detections (12.5%), and southern pygmy loris (*Xanthonycticebus pygmaeus*) with 8 detections (8.3%). Species of the genus *Macaca* were primarily associated with regenerating forests and riparian habitats, whereas the Indochinese grey langur was largely restricted to mature evergreen forests characterized by high canopy cover and minimal anthropogenic disturbance. UAV-derived optical and thermal imagery facilitated the identification of ecological corridors, priority conservation habitats, and anthropogenic disturbance hotspots. The findings demonstrate that integrating camera traps and UAV technologies provides an effective and science-based approach for wildlife monitoring, significantly enhancing biodiversity conservation outcomes and supporting adaptive forest management strategies in Vietnam.

# Khảo sát linh trưởng tại Khu bảo tồn thiên nhiên Pù Hướng, Việt Nam - sử dụng công nghệ tiên tiến

**Tóm tắt**

Khu Bảo tồn thiên nhiên Pù Hướng, tỉnh Nghệ An là khu vực có giá trị đa dạng sinh học cao, giữ vai trò quan trọng trong bảo tồn các loài thú linh trưởng tại vùng Bắc Trung Bộ. Nghiên cứu được thực hiện nhằm ứng dụng công nghệ camera trap và thiết bị bay không người lái (drone/UAV) trong điều tra, giám sát các loài linh trưởng tại khu vực này. Trong giai đoạn 2024–2025, nhóm nghiên cứu đã bố trí 52 camera trap tại 18 tuyến điều tra với tổng số 2.860 ngày bẫy và thực hiện 37 chuyến bay drone trên diện tích khoảng 12.500 ha. Kết quả ghi nhận 5 loài linh trưởng với 96 lần xuất hiện độc lập, gồm: Khỉ mặt đỏ (*Macaca arctoides*) 33 lần (34,4%), Khỉ vàng (*Macaca mulatta*) 22 lần (22,9%), Khỉ mốc (*Macaca assamensis*) 21 lần (21,9%), Voọc xám (*Trachypithecus crepusculus*) 12 lần (12,5%) và Cu li nhỏ (*Xanthonycticebus pygmaeus*) 8 lần (8,3%). Các loài thuộc giống *Macaca* phân bố chủ yếu tại rừng phục hồi và khu vực ven suối, trong khi Voọc xám tập trung ở rừng thường xanh giàu có độ che phủ cao. Dữ liệu ảnh drone hỗ trợ xác định hành lang sinh thái, khu vực sinh cảnh ưu tiên và các điểm tác động nhân sinh. Kết quả nghiên cứu cho thấy việc kết hợp camera trap và drone có hiệu quả cao trong giám sát động vật hoang dã, góp phần nâng cao hiệu quả bảo tồn đa dạng sinh học và quản lý tài nguyên rừng theo hướng hiện đại.

## Introduction

In recent decades, biodiversity loss has emerged as one of the most pressing global environmental challenges. According to the IUCN Red List of Threatehened Species (2026), approximately 60% of the world's primate species are currently threatened with extinction due to habitat loss, illegal hunting, and climate change. Southeast Asia is recognized as one of the global hotspots for primate population decline, driven by rapid deforestation and habitat fragmentation.

Vietnam is internationally recognized as a biodiversity-rich country, harboring 25 primate species. However, the majority of these taxa are currently listed under threat categories in the Vietnam Red Data Book (2024), the IUCN Red List of Threatened Species (2026), and the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Pu Huong Nature Reserve, encompasses more than 40,000 ha within the core zone of the UNESCO-designated Western Nghe An Biosphere Reserve. The reserve supports relatively intact tropical evergreen forest ecosystems, high forest cover, and strong ecological connectivity with Pu Mat National Park and Pu Hoat Nature Reserve. These characteristics provide favorable ecological conditions for the persistence of numerous threatened primate species.

Despite its conservation significance, primate monitoring in Pu Huong Nature Reserve remains limited. Conventional survey methods, including line transects, direct observations, and community interviews, are highly dependent on observer experience, difficult to implement in rugged terrain, and often incapable of generating continuous long-term datasets. Moreover, many primate species are highly sensitive to human presence, arboreal in behavior, or nocturnal, making direct detection particularly challenging.

In this context, the application of advanced technologies such as camera traps and unmanned aerial vehicles (UAV/drone) has become increasingly important in wildlife research and conservation worldwide. Camera traps enable long-term and non-invasive monitoring without disturbing animal behavior, whereas UAV facilitate rapid surveys across large and inaccessible areas while providing high-resolution spatial data. Rovero & Zimmermann (2016) identified camera trapping as a standard methodology for mammal monitoring globally. Similarly, Wich & Koh (2018) and Christie et al. (2016) emphasized the substantial potential of UAV technology for biodiversity monitoring and early detection of forest ecosystem disturbances. In addition, thermal imaging sensors mounted on UAV platforms can substantially improve wildlife detectability under low-light conditions (Chrétien et al., 2016).

Therefore, this study was conducted with the following objectives:

1. to identify primate species composition and occurrence patterns in Pu Huong Nature Reserve;
2. to evaluate the effectiveness of camera traps and UAV technologies for primate monitoring;
3. to assess threats affecting primate populations and habitats; and
4. to propose future directions for applying digital technologies in biodiversity conservation and forest management in Vietnam.

## Material and methods

### Study area

Pu Huong Nature Reserve is located across Que Phong, Quy Chau, Quy Hop, and Tuong Duong Districts in Nghe An Province, Vietnam between 19°10'–19°46' N and 104°37'–105°24' E. The reserve covers approximately 40,000 hectares, of which more than 85% consists of natural forest (Fig. 1).

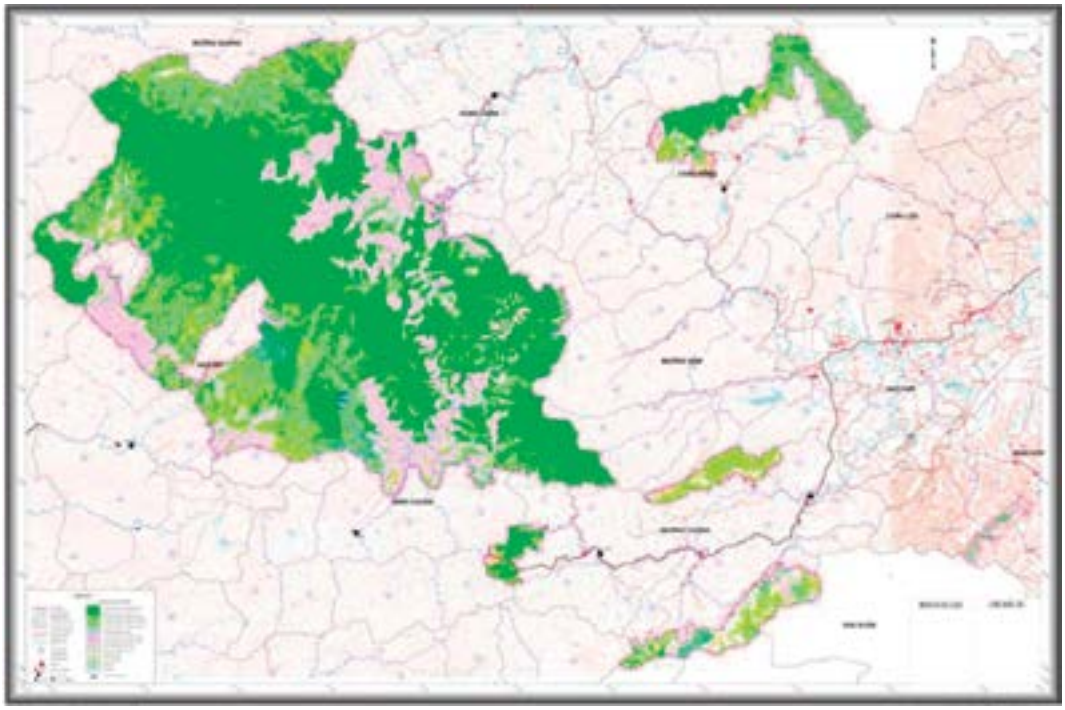


**Fig.1.** Pu Huong Nature Reserve.

The landscape is dominated by rugged mountainous terrain dissected by streams and narrow valleys. Elevation ranges from 700 to 1,500 m asl, with several peaks exceeding 1,800 m. These complex topographic conditions contribute to high habitat heterogenity and microclimatic diversity.

The climate is characterized as tropical monsoonal; with a rainy season extending from May to October and annual precipitation ranging from 1,800 to 2,000 mm; mean annual temperature averages 22 to 24°C. Major vegetation types include evergreen broadleaf forests, mixed bamboo forests, and regenerating secondary forests.

According to the 2024 forest resource assessment report of Pu Huong Nature Reserve, the area supports more than 1,200 plant species and over 400 vertebrate species, including numerous threatened primates protected under Vietnamese Decree No. 84/2021/ND-CP (Government of Vietnam 2021).

## Target species

The study focused on primate species occurring within Pu Huong Nature Reserve, including the Indochinese gray langur, rhesus macaque, Assamese macaque, Pygmy loris, and stump-tailed macaque. All target species possess high conservation value and are listed in the IUCN Red List of Theatened Species and the Vietnam Red Data Book (2024).

## Camera trap survey methods

A total of 52 infrared camera traps (Bushnell Trophy Cam HD and Browning Strike Force Pro XD) were deployed following a 2.5 km x 2.5 km grid system across 18 survey transects representing different habitat types (Fig. 2).

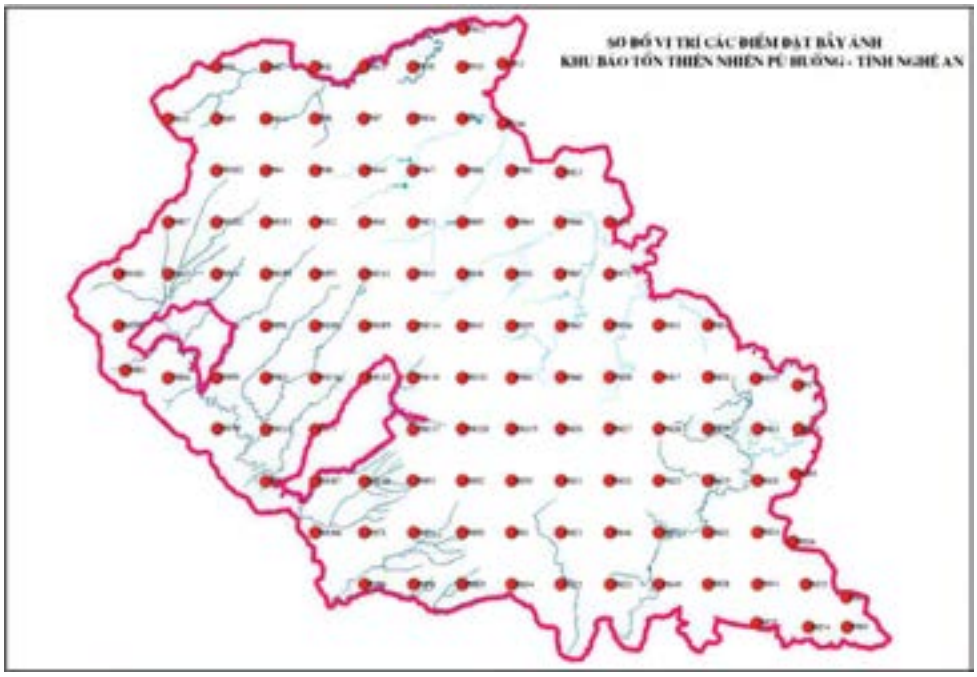



**Fig.2.** Spatial distribution of camera trap locations.

Camera placement was determined based on evidence of primate activity, proximity to water sources and feeding trees, natural movement routes, high canopy cover, and minimal human disturbance. Average spacing between cameras was approximately 2.5 km to minimize data overlap. Cameras were installed at heights of 0.8 to 1.5 m above ground level and operated continuously for 24 hours per day.

Following recommendations of WWF (2020), tropical mammal monitoring studies should exceed 1,000 trap-days to ensure statistical reliability. This study achieved a total sampling effort of 2,860 trap-days.

### Camera trap data collection and analysis

Camera data were checked every three months for battery replacement, memory card retrieval, and equipment maintenance. Each image or video record was classified according to species identity, detection time, geographic coordinates, habitat type, and observed behavior.

Independent detections were defined as consecutive records of the same species separated by at least 30 minutes at the same camera station following O'Brien et al. (2003).

Relative Abundance Index (RAI) values were calculated using the following formula:

$$RAI = \left(\frac{\text{Total independent detections}}{\text{Total trap-days}}\right) \times 100$$

RAI and wildlife insights software platforms were used to compare activity levels among species and habitat types.

### UAV-based Monitoring Methods

The study employed a DJI Mavic 3 Enterprise UAV equipped with a 48 MP optical camera and an integrated thermal infrared sensor. UAV surveys were conducted during early morning (5:30 to 8:00)

and late afternoon (16:00 to 18:00), corresponding to peak primate activity periods. Flight altitude ranged from 80 to 120 m above ground level, with an average flight speed of 5 to 8 m/s.

A total of 37 UAV flights were conducted across approximately 12,500 hectares. Flight paths were designed using a grid-based survey framework to maximize spatial coverage and minimize sampling bias.

### UAV image processing and spatial analysis

Optical and thermal imagery acquired from UAV surveys were processed using ArcGIS Pro, Pix4D Mapper, and DJI Thermal Analysis Tool software. Spatial datasets generated from the analysis included: forest cover maps; priority habitat maps; primate movement corridors; anthropogenic disturbance hotspots; areas experiencing forest degradation. Thermal imaging analysis enabled the detection of wildlife under dense canopy cover and during low-light conditions. UAV-based thermal infrared sensing has been demonstrated to significantly improve wildlife detectability in complex forest ecosystems. According to Chretien et al. (2016), UAV-based thermal imaging can improve wildlife detection rates by approximately 30 to 40% compared with conventional ground-based observation methods.

### Data Analysis

Survey data were compiled and analyzed using Microsoft Excel 365, and IBM SPSS Statistics 22.0. Relative Abundance Index (RAI) calculations and camera trap image processing were supported by Wildlife Insights, an AI-driven platform for automated species identification and ecological data management. This system enabled standardised species recognition, as well as comparative analyses of activity patterns across species and habitat types (Wildlife Insights, 2024).

The analytical framework included key ecological indicators such as species detection frequency, relative abundance index, habitat-based distribution patterns, diel activity patterns, and indices of anthropogenic disturbance. These metrics were used to evaluate spatial–temporal variation in primate occurrence and habitat use.

Habitat fragmentation and loss were further interpreted in the context of broader landscape-scale processes. Estrada et al. (2017) emphasise that habitat loss and fragmentation are among the primary drivers of reduced genetic diversity and increased extinction risk in global primate populations. Consistent with this, UAV-derived spatial analyses in the present study identified multiple anthropogenic disturbance hotspots, including illegal logging, shifting cultivation, and road expansion. These processes were observed to disrupt forest continuity and habitat connectivity, aligning with broader patterns of landscape degradation reported across Southeast Asia (Wich et al. 2015; Wich & Koh 2018).

Finally, a comparative analytical approach was employed by benchmarking findings against previous studies conducted in Pu Mat National Park, Cuc Phuong National Park, and Pu Hoat Nature Reserve. This comparative framework allowed for the assessment of regional trends in primate distribution across the north central ecological landscape of Vietnam.

## Results and discussion

### Primate species composition in Pu Huong Nature Reserve

Camera trap and UAV surveys documented five primate species with a total of 96 independent detections (Table 1). Among these, the stump-tailed macaque exhibited the highest detection frequency (34.4%). This species demonstrates relatively high ecological adaptability across secondary forest habitats and areas with abundant food resources. The relatively high occurrence of stump-tailed macaques indicates that ecological connectivity among natural forest patches in Pu Huong remains comparatively intact. Similar findings from Pu Mat National Park and Pu Hoat Nature Reserve suggest that this species is commonly associated with habitats characterized by moderate-to-high forest cover and proximity to natural water sources.

**Table 1.** Primate species recorded in Pu Huong Nature Reserve.

| Species | IUCN Status | Independent detections | Frequency (%) |
|---|---|---|---|
| Stump-tailed macaque *Macaca arctoides* | VU | 33 | 34.4 |
| Rhesus macaque *Macaca mulatta* | LC | 22 | 22.9 |
| Assamese macaque *Macaca assamensis* | NT | 21 | 21.9 |
| Indochinese grey langur *Trachypithecus crepusculus* | CR | 12 | 12.5 |
| Southern pygmy loris *Xanthonycticebus pygmaeus* | EN | 8 | 8.3 |

Rhesus macaques and Assamese macaques exhibited comparable detection frequencies of 22.9% and 21.9%, respectively. Both species were frequently recorded in regenerating forests, riparian habitats, and moderately disturbed areas, reflecting the high ecological adaptability of the genus *Macaca* under secondary forest conditions.

The Indochinese grey langur exhibited a lower detection frequency (12.5%) compared with macaque species. Nevertheless, this finding remains of high conservation significance because the species is globally threatened, highly sensitive to anthropogenic disturbance, and dependent on well-preserved habitats. Most detections were concentrated in mature evergreen forests characterized by dense canopy cover and limited human activity.

The southern pygmy loris exhibited the lowest detection frequency (8.3%), with most records obtained through nocturnal infrared camera traps. These findings are consistent with Nekaris & Nijman (2007), who described the species as nocturnal, solitary, and difficult to detect using direct observation methods.

Comparisons with previous studies conducted in north central Vietnam indicate that Pu Huong Nature Reserve continues to maintain relatively high primate diversity. These findings reinforce the reserve's critical role in primate conservation and in maintaining ecological connectivity within the Western Nghe An Biosphere Reserve.

### Effectiveness of camera traps for primate monitoring

Camera trapping demonstrated high effectiveness in documenting natural primate activity without causing significant habitat disturbance (Table 2). The total sampling effort reached 2,860 trap-days, with an operational efficiency rate of 91.4%. The results indicate that camera traps were particularly effective for monitoring terrestrial and semi-terrestrial primates such as rhesus macaques and Assamese macaques. Beyond species identification, the camera system also documented several important ecological behaviors, including: group foraging behavior; infant care; vigilance behavior; route-based movement patterns; nocturnal activity.

**Table 2.** Comparison between ground surveys and camera trap surveys.

| Criteria | Ground surveys | Camera trap surveys |
|---|---|---|
| Monitoring duration | Intermittent | Continuously 24/7 |
| Wildlife disturbance | High | Low |
| Labor requirement | High | Low |
| Rare species detection | Limited | High |
| Long-term data storage | Limited | Extensive |

However, camera trapping also exhibited several limitations, including restricted detection range, reduced effectiveness for canopy-dwelling species, and sensitivity to environmental conditions such as heavy rainfall, dense vegetation, and extreme humidity.

According to Rovero & Zimmermann (2016), camera trapping is highly effective for monitoring ground-dwelling mammals; however, its application for arboreal primates remains limited. Therefore, integrating camera traps with complementary technologies is essential to improve detection probability and achieve more comprehensive monitoring of canopy-dwelling primate species.

### Effectiveness of UAV applications for habitat and primate monitoring

UAV technology enabled rapid assessment of large forested areas with high spatial accuracy. Analysis of UAV imagery indicated that approximately 68% of the surveyed area retained relatively intact forest cover.

The study identified several key primate movement corridors along mountainous ridgelines and in relatively undisturbed forest areas. In addition, UAV surveys detected multiple anthropogenic disturbance hotspots, including: illegal logging activities; shifting cultivation; expansion of forest access roads; slash-and-burn practices; livestock grazing within forest habitats.

Thermal imaging obtained from UAVs substantially improved wildlife detection under low-light conditions and beneath dense forest canopies, representing a major advantage over conventional visual observation methods.

Comparisons with studies conducted by Wich et al. (2015) in Indonesia demonstrated that UAV-based wildlife detection efficiency in Pu Huong Nature Reserve was relatively comparable, particularly in rugged mountainous terrain.

However, UAV deployment in tropical forest environments also faces several operational constraints, including limited flight endurance, adverse weather conditions, GPS signal instability, and reduced visibility under dense canopy cover. Consequently, integrating UAV surveys with camera trap systems is considered a more robust and complementary approach for improving wildlife monitoring efficiency and spatial coverage.

### Habitat-specific distribution patterns of primates

The study revealed clear differences in primate distribution among habitat types (Table 3). The Indochinese grey langur was primarily associated with mature evergreen forests characterized by dense canopy cover and minimal disturbance. This distribution pattern is consistent with the species' ecological dependence on continuous forest canopies.

**Table 3.** Habitat-specific distribution of the primate species.

| Habitat type | Indochinese grey langur | Rhesus macaque | Assamese macaque | Pygmy loris |
|---|---|---|---|---|
| Mature evergreen forest | High | Moderate | Moderate | High |
| Regenerating forest | Low | High | High | Moderate |
| Bamboo forest | Low | Moderate | Moderate | Low |
| Riparian habitat | Moderate | High | High | Low |

In contrast, rhesus macaques and Assamese macaques exhibited greater ecological flexibility and were frequently recorded in riparian habitats and regenerating forests affected by moderate human disturbance.

These findings are consistent with previous studies by Nguyen Xuan Dang et al. (2018) who

reported that primate species in Vietnam exhibit clear habitat segregation patterns, ranging from strict canopy-dependent taxa to more generalist species capable of persisting in anthropogenically altered landscapes.

### Threats to primate populations

The study identified multiple threats directly affecting primate populations in Pu Huong Nature Reserve. Major threats included: illegal hunting; wire snaring; illegal logging; shifting cultivation; habitat fragmentation; forest fires; livestock grazing. UAV surveys documented numerous forest encroachment hotspots near local communities. Camera traps additionally captured images of hunters and hunting dogs operating within the protected area's core zone.

Particularly concerning was habitat fragmentation resulting from road construction and forest resource extraction, which may significantly reduce connectivity among primate populations. According to Estrada et al. (2017), habitat fragmentation is a major driver of genetic isolation and increased extinction risk in primate species worldwide.

### Integrated assessment of advanced technologies for biodiversity conservation

The study demonstrates that integrating camera traps and UAV technologies provides substantial advantages for wildlife monitoring and biodiversity conservation. Camera traps were particularly effective for documenting individual activity patterns and behavioral ecology, whereas UAV proved highly efficient for landscape-scale habitat assessment and spatial analysis.

The combined application of these technologies contributed to: improved detection of rare and elusive species; reduced long-term survey costs; enhanced patrol and monitoring efficiency; development of digital biodiversity databases; and support for adaptive conservation management.

This integrated approach is consistent with Vietnam's national digital transformation strategy for the forestry sector for the period 2021–2030, as outlined in Decision No. 523/QD-TTg (Prime Minister 2021).

However, effective implementation requires: investment in advanced monitoring equipment; technical capacity building for conservation staff; development of shared biodiversity databases; standardization of national technical protocols; and strengthened international collaboration.

In the future, integrating artificial intelligence (AI), satellite remote sensing, and automated species-recognition systems may significantly advance biodiversity monitoring and conservation effectiveness in Vietnam.

## Conclusions

This study provides empirical evidence on the effectiveness of integrating camera trapping and unmanned aerial vehicle technologies for primate monitoring in Pu Huong Nature Reserve. The stump-tailed macaque exhibited the highest detection frequency and was primarily associated with regenerating forests and riparian habitats, whereas the Indochinese gray langur was mainly restricted to mature evergreen forests.

Camera trapping proved highly effective for monitoring primate activity and behavioral ecology, particularly for terrestrial and nocturnal species. UAV-based surveys contributed critical complementary information on habitat condition, anthropogenic disturbance patterns, and the spatial configuration of potential movement corridors.

The integration of these two approaches significantly improved survey efficiency and spatial coverage while reducing field effort, thereby enabling a more comprehensive and cost-effective monitoring framework for primate populations. The results also highlight the value of combining fine-scale behavioural data with landscape-scale habitat assessments to overcome the limitations of single-method surveys in complex tropical forest environments.

Overall, the findings support the application of multi-sensor, technology-assisted monitoring systems as a promising approach for biodiversity assessment and conservation planning in Vietnam. Such integrated frameworks are consistent with global trends in wildlife monitoring and provide a scalable foundation for strengthening evidence-based conservation strategies in tropical forest ecosystems

### Recommendations

Based on the findings, several key recommendations are proposed to enhance primate conservation and biodiversity monitoring in Pu Huong Nature Reserve and comparable tropical forest ecosystems.

- expanding camera trap networks across priority conservation areas is essential to improve spatial coverage and increase detection probability of rare and elusive primate species.
- the development and operationalisation of UAV-based monitoring systems should be prioritised to support large-scale habitat assessment, detection of anthropogenic disturbances, and landscape-level connectivity analysis.
- integrating smart patrol systems that combine GIS and UAV technologies is recommended to strengthen forest law enforcement, improve patrol efficiency, and enable near real-time decision support in conservation management.
- continuous capacity building and technical training for conservation practitioners are critical to ensure effective deployment, maintenance, and data interpretation of advanced monitoring tools.
- establishing a national primate biodiversity database would provide a standardized platform for long-term ecological monitoring, data sharing, and evidence-based conservation planning.
- strengthening international collaboration is necessary to enhance methodological development, promote knowledge exchange, and facilitate access to emerging conservation technologies.
- integrating artificial intelligence (AI) into species identification, automated image processing, and ecological data analytics is expected to significantly improve the accuracy, efficiency, and scalability of biodiversity monitoring systems in Vietnam

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# Expanding the known range of northern yellow-checked gibbon (*Nomascus annamensis*) to the Bac Hai Van Landscape Protection Area, central Vietnam

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**Keywords:** Northern yellow-checked gibbon, *Nomascus annamensis*, new area, Hai Van Pass, distribution, conservation.

**Summary**

The northern yellow-cheeked gibbon (*Nomascus annamensis*) is an 'Endangered' species with poorly documented distribution in central Vietnam. This study reports the first confirmed record of the species in Bac Hai Van Landscape Protection Area, southern Hue City. Surveys conducted from March to July 2024 and in April 2026 across 15 compartments recorded 10 groups and approximately 24 individuals through direct observations and vocal detections. Feeding observations and fresh fecal samples also indicated that fruits and leaf matter are important components of the species' diet in this area. This finding extends the confirmed range of *N. annamensis* eastward and identifies Bac Hai Van Landscape Protection Area as the easternmost known site for the species. The results highlight the conservation importance of Bac Hai Van and its potential ecological connection with Bach Ma National Park. Strengthened protection, habitat connectivity, and improved monitoring are recommended to support long-term conservation.

# Mở rộng vùng phân bố của loài vượn Trung Bộ (*Nomascus annamensis*) đến Khu bảo vệ cảnh quan Bắc Hải Vân, miền Trung Việt Nam

**Tóm tắt**

Vượn trung bộ (*Nomascus annamensis*) là loài linh trưởng Nguy cấp, nhưng thông tin về phân bố của loài ở miền Trung Việt Nam vẫn còn hạn chế. Nghiên cứu này ghi nhận lần đầu tiên sự hiện diện của loài tại Khu Bảo vệ Cảnh quan Bắc Hải Vân, phía nam thành phố Huế. Các đợt khảo sát từ tháng 3 đến tháng 7 năm 2024 và tháng 4 năm 2026, trên 15 tiểu khu, đã ghi nhận 10 đàn với khoảng 24 cá thể thông qua quan sát trực tiếp và ghi nhận tiếng hót. Các quan sát về vượn kiếm ăn và mẫu phân tươi cũng cho thấy quả và vật chất từ lá là thành phần quan trọng trong khẩu phần ăn của loài tại khu vực này. Phát hiện này mở rộng vùng phân bố đã được xác nhận của *N. annamensis* về phía đông và xác định Bắc Hải Vân là điểm ghi nhận xa nhất về phía đông hiện nay của loài. Kết quả nhấn mạnh tầm quan trọng bảo tồn của Bắc Hải Vân và khả năng kết nối sinh thái với quần thể gần đó tại Vườn quốc gia Bạch Mã. Cần tăng cường bảo vệ sinh cảnh, duy trì kết nối rừng và áp dụng các phương pháp giám sát hiệu quả hơn để hỗ trợ bảo tồn lâu dài cho loài.

## Introduction

Among the primates recorded in Vietnam, gibbons are particularly vulnerable to human

disturbance. They depend on healthy, connected forest canopies, and even moderate levels of hunting, logging, forest fragmentation, or human activity can affect their survival (Covert et al. 2017; Rawson et al. 2011; Van Ngoc Thinh et al. 2020). Notably, the northern yellow-cheeked gibbon, a species described by Van Ngoc Thinh et al. (2010) that is endemic to the central Annamite region spanning Vietnam and Laos. The species is classified as 'Endangered' on the IUCN Red List of Threatened Species (Van Ngoc Thinh et al. 2020) due to its narrow geographic range, low encounter rates, and ongoing threats from hunting and habitat conversion. In Vietnam, the species has been confirmed for several protected areas (Hoang Van Chuong et al. 2018; Wearn et al. 2023). It primarily inhabits primary and mature secondary evergreen forests at mid-to-high elevations (100-1200 m asl). Despite its conservation importance, distribution data for this species remain limited across many potential habitats (Hoang Van Chuong et al. 2018; Rawson et al. 2011; Wearn et al. 2023).

This study addresses an important gap in the known distribution of the northern-yellow-cheeked gibbon by conducting a focused field assessment in Bac Hai Van Landscape Protection Area. Specifically, by filling this distribution gap, the study provides baseline information to support long-term monitoring, habitat protection, and conservation planning for the northern yellow-cheeked gibbon in this key part of the central Annamites landscape.

## Material and Methods

### Study area

Bac Hai Van Landscape Protection Area (LPA) is approximately 10,000 ha in size (16°11'49"N/108°08'00"E), and is located in southern Hue City within the Truong Son Mountain range and continues to the East Sea. It forms a strategic terrestrial and marine biodiversity corridor connecting Son Tra Nature Reserve, Nam Hai Van Protection Forest, Bach Ma National Park, and the Ba Na Nui-Chua Nature Reserve (Phan Ke Loc et al., 2018; Tordoff 2003). Despite its ecological importance, Bac Hai Van LPA faces increasing threats from illegal logging, agricultural encroachment, snaring, and infrastructure development (Pham Van Thong et al. 2024). The area extends from coastal forest along the East Sea to high montane forest, reaching Rang Cua Peak at 1,413 m asl, and lies near Hai Van Pass, an important climatic transition zone between northern and southern Vietnam (BQL BHV 2023; CEPF Grant 2025). This creates a diverse habitat gradient, from lowland coastal forest to upper-elevation evergreen forest, supporting both ground-dwelling and canopy-dependent wildlife. However, the northern yellow-cheeked gibbon had not previously been confirmed in Bac Hai Van Landscape Protection Area.

### Field research

Field surveys were conducted using line transect methodology to detect the presence of *N. annamensis*. The study area covered 15 forest compartments (234–237, 240–243, 246–248, and 249–252) within Bac Hai Van Landscape Protection Area (Fig. 1). Surveys were carried out across six sessions between March to July 2024 and March to April 2026. Each field team consisted of 6 to 10 members, including researchers, forest rangers, local residents, and forest guards. This multidisciplinary team structure combined scientific rigor with local knowledge to ensure safe and effective navigation in challenging terrain.

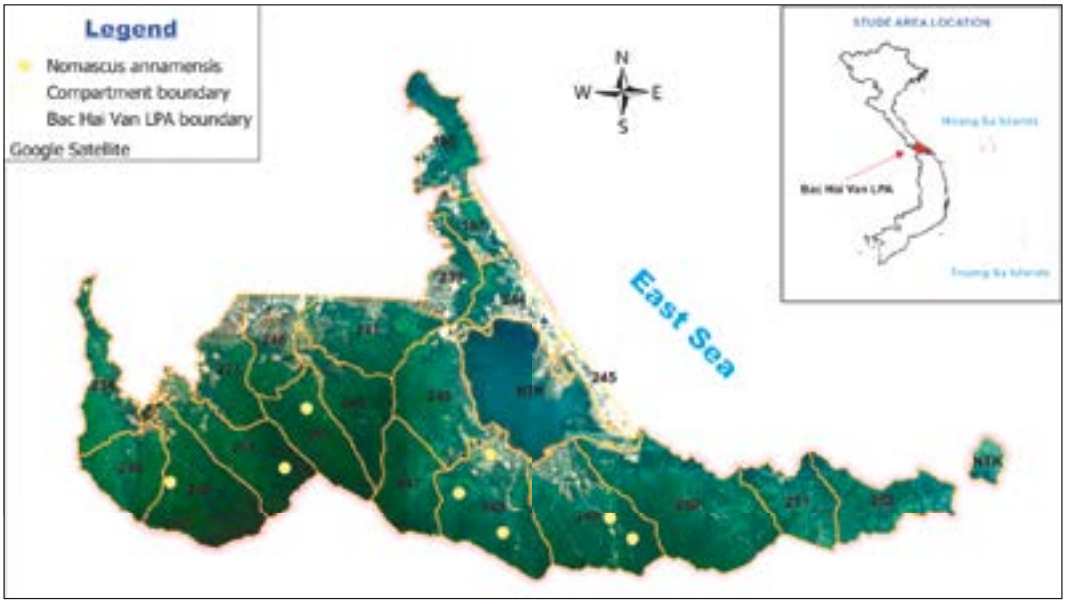



**Fig.1.** Bac Hai Van Landscape Protection Area with compartments and records of northern yellow-cheeked gibbons.

Transect line selection was informed by local knowledge gathered through interviews with residents and hunters. Additionally, the expertise of experienced forest users-including professional hunters, honey collectors, herbalists, and rattan harvesters-was utilized to identify transects and locations where *N. annamensis* had previously been observed.

Survey teams followed these transects and searched for indirect signs of gibbons such as feeding traces (e.g. partially eaten leaves, broken branches, uneaten fruits), feces, and urine marks on leaves or the forest floor. In parallel, listening posts were established at strategic locations along the transects during the early morning (typically between 5:30 and 8:30 am), when gibbon vocal activity peaks. Observers remained silent and stationary at their stations, monitoring gibbon calls and recording the direction and estimated distance of vocalizations to help pinpoint group locations. After 8:30 am, survey teams continued searching within the forest along pre-selected transects until approximately 5:00 pm. During this period, they relied on visual signs, occasional vocalizations, and movement within the canopy to detect and track gibbon groups. Upon detection, teams approached quietly, often splitting into two or three directions to minimize disturbance and enhance visibility. Once a group was located, observers sat silently to count individuals. If the gibbons moved away, they were followed discreetly to confirm or update group counts. All observations were compiled to determine group composition and estimate population size.

For each encounter or call detection, observers recorded time, GPS location (Garmin 64s), number of individuals (if visible), call direction, and habitat description using the SMART Mobile app. Acoustic detections were noted when gibbon calls were heard but not visually confirmed.

## Results

A total of 10 groups of northern yellow-cheeked gibbons were recorded in Bac Hai Van Landscape Protection Area through either direct observation or acoustic detection (Fig. 1). There were three groups that observed directly and two per three observed groups; we were able to get video recorded. The survey estimated 24 individuals across all detections (Table 1). Due to the species' high sensitivity to human presence and tendency to flee quickly, most detection only allowed for the recording of minimum observed group sizes. Therefore, the actual population size of *N. annamensis* in Bac Hai Van LPA is likely underestimated.

**Table 1.** Survey dates in sub-zones of Bac Hai Van Landscape Protection Area.

| Survey date | Sub-zone, survey area |
|---|---|
| 20. to 30. March 2024 | 249, 250,251,252 |
| 12. to 21. April 2024 | 246, 247,248 |
| 21. to 29. May 2024 | 243, 235, 237 |
| 7. to 11. June 2024 | 237,237,234 |
| 26. June to 1. July 2024 | 243,240,233 |
| 27. March to 1. April 2026 | 248, 249, 250, 251, 251 |

This is considered a new record for the region and significantly extends the known distribution range of *N. annamensis* further eastward toward the coastal zone compared to Wearn et al. (2023).

## Discussion

The confirmation of 10 groups of northern yellow-cheeked gibbon in Bac Hai Van Landscape Protection Area is an important addition to the known distribution of the species in central Vietnam. Previous acoustic surveys confirmed *N. annamensis* in several protected areas of the central Annamites (Wearn et al. 2023). This finding highlights the conservation importance of the wider Bach Ma-Hai Van-Ba Na-Nui Chua landscape. Bach Ma National Park has previously been confirmed to support *N. annamensis*, with 13 groups, while Ba Na-Nui Chua Nature Reserve supports a significant population, with 14–16 groups recorded in surveyed expansion areas (Bui Van Tuan et al. 2019; Hoang Van Chuong et al. 2018; Nguyen Van Thien et al. 2017). The discovery of *N. annamensis* in Bac Hai Van suggests that these forest blocks may represent geographically close populations within the same broader landscape, although current habitat fragmentation may limit movement and genetic exchange between them (Bui Van Tuan et al. 2019).

The absence of confirmed gibbon groups from Nam Hai Van so far should be interpreted with caution. This may reflect limited surveys rather than a true absence. Further systematic surveys are needed to assess whether Nam Hai Van still supports gibbons or functions as a potential habitat corridor between Bac Hai Van and Ba Na–Nui Chua. The Bac Hai Van Landscape Protection Area records should therefore be viewed not only as a new site record, but also as evidence that the Hai Van landscape may play a more important role in *N. annamensis* conservation than previously understood.

Future monitoring efforts should consider deploying thermal imaging technologies such as UAV-mounted thermal cameras and handheld infrared binoculars, which are increasingly utilized in primate surveys to detect individuals under dense canopy during low-light conditions (Gazagne et al. 2023; Gang He et al. 2025).

The findings from Bac Hai Van Landscape Protection Area underscore the need to integrate this forest into national gibbon conservation planning frameworks and to prioritize it as a high-value habitat for the northern yellow-cheeked gibbon. The strategic position of Bac Hai Van Landscape Protection Area within the central Annamites landscape, and its potential for ecological corridor development, add further conservation significance.

## Acknowledgements

We sincerely thank the Bac Hai Van Landscape Protection Area Management Board for granting permission to conduct the surveys and for providing logistical support and field staff. We are also grateful to USAID, WWF, SCF, and the Mohamed bin Zayed Species Conservation Fund No 252539149 for their financial and technical support for this survey.

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# Expanding the known distribution of black-shanked douc langur (*Pygathrix nigripes*) and southern yellow-cheeked gibbon (*Nomascus gabriellae*) in central Vietnam

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**Keywords:** Black-shanked douc langur, *Pygathrix nigripes*, southern yellow-cheeked gibbon, *Nomascus gabriellae*, extend known distribution.

**Summary**

The Tay Hoa forest complex in south-central Vietnam comprises a large contiguous forest landscape between the central coast and the Central Highlands, including Deo Ca-Hon Nua Special-use Forest, Tay Hoa Protection Forest, Song Hinh Protection Forest, and Ninh Hoa-Van Ninh Protection Forest. Field surveys of the Center for Technology and Nature Conservation (CTNC) conducted between 2024 and 2026 documented the presence of two threatened primates: black-shanked douc langur (*Pygathrix nigripes*) and southern yellow-cheeked gibbon (*Nomascus gabriellae*). Four groups of black-shanked douc langurs were recorded by direct observation, with an estimated minimum of 55–57 individuals. Nine calling groups of southern yellow-cheeked gibbons were detected by vocalisations across the forest complex. These records expand current knowledge of the distribution of both species and highlight the conservation importance of the Tay Hoa Forest Complex as an overlooked primate landscape. Following these discoveries, the Center for Technology and Nature Conservation has strengthened conservation actions in the area through SMART patrol training, ranger coordination, community awareness activities, school programs, and wildlife education materials. Further systematic surveys and coordinated landscape-level protection are urgently needed to confirm population size, reduce hunting pressure, and support long-term conservation of these primates.

# Mở rộng phạm vi phân bố đã biết của voọc chà đen chân (*Pygathrix nigripes*) và vượn má vàng phía Nam (*Nomascus gabriellae*) ở miền Trung Việt Nam

**Tóm tắt**

Khu phức hợp rừng Tây Hòa ở Nam Trung Bộ Việt Nam là một vùng rừng liên kết rộng lớn giữa duyên hải miền Trung và Tây Nguyên, bao gồm rừng đặc dụng Đèo Cả–Hòn Nưa, rừng phòng hộ Tây Hòa, rừng phòng hộ Sông Hinh và rừng phòng hộ Ninh Hòa–Vạn Ninh. Các đợt khảo sát thực địa từ năm 2024 đến 2026 đã ghi nhận sự hiện diện của hai loài linh trưởng bị đe dọa: chà vá chân đen *Pygathrix nigripes* và vượn má vàng Nam *Nomascus gabriellae*. Bốn đàn chà vá chân đen được ghi nhận bằng quan sát trực tiếp, với tổng số tối thiểu ước tính khoảng 55–57 cá thể. Chín đàn vượn má vàng Nam được ghi nhận qua tiếng hót tại nhiều khu vực trong phức hợp rừng. Những ghi nhận này mở rộng phân bố của cả hai loài và nhấn mạnh giá trị bảo tồn của Khu phức hợp rừng Tây Hòa như một khu vực bảo tồn linh trưởng quan trọng nhưng còn ít được quan tâm nghiên cứu. Sau các phát hiện này, CTNC đã tăng cường các hoạt động bảo tồn tại khu vực, bao gồm tập huấn tuần tra

SMART, điều phối lực lượng kiểm lâm, nâng cao nhận thức cộng đồng, chương trình giáo dục bảo tồn trong trường học và phân phát tài liệu, sách về động vật hoang dã. Cần tiếp tục thực hiện các khảo sát hệ thống và bảo vệ cảnh quan ở cấp liên vùng nhằm xác định quy mô quần thể, giảm áp lực săn bắt và hỗ trợ bảo tồn lâu dài cho các loài linh trưởng này.

## Introduction

Vietnam is one of the most important countries for primate conservation in mainland Southeast Asia, supporting 26 primate taxa, including three endemic and 'Critically Endagered' species (Blair et al. 2011; Covert et al. 2017; Groves 2007; Nadler et al. 2007). Many Vietnamese primates have restricted distributions and small, fragmented populations, and are threatened mainly by hunting, wildlife trade, habitat loss, and forest fragmentation (Covert et al. 2017; Nadler et al. 2007)

Although the distributions of many primate species in Vietnam are now better known due to long-term survey efforts (Thach Mai Hoang 2016), recent findings show that additional populations of rare species remain undocumented. A small population of Hatinh langur (*Trachypithecus hatinhensis*) was recently discovered in Quang Tri Province, extending the known range of the species (Nguyen Van Truong et al. 2023). Recent surveys have also confirmed a population of Delacour's langur (*Trachypithecus delacouri*) in Yen Mo karst area, Ninh Binh Province, and the occurance of northern white-cheeked gibbon (*Nomascus leucogenys*) in Van Ho, Son La Province (Wearn et al. 2023; Trinh Dinh Hoang et al. 2024). A previously unknown population of the 'Critically Endangered' grey-shanked douc langur (*Pygathrix cinerea*) was recorded in Khe Lim Forest, Quang Nam Province (Nguyen Van Linh et al. 2025). These findings suggest that unsurveyed or poorly surveyed forest areas in Vietnam may still support important populations of threatened primates.

The black-shanked douc langur and the southern yellow-cheeked gibbon are found in southern and south-central Vietnam. The black-shanked douc langur is listed as 'Critically Endangered' (Hoang Minh Duc et al. 2021), while the southern yellow-cheeked gibbon is listed as 'Endangered' (Rawson et al. 2020). Both species affected by hunting and habitat degradation (Hoang Minh Duc et al. 2021; Piskovska et al. 2025).

Our surveys document previously unknown occurrences of these two species in the Tay Hoa forest complex. This complex includes the Deo Ca–Hon Nua Special-use Forest, the Tay Hoa Protected Forest, the Song Hinh Protected Forest in Dak Lak Province, and the Ninh Hoa-Van Ninh Protected Forest in Khanh Hoa Province. This forest complex forms a contiguous landscape from the central coast to the Central Highlands and may represent an important but previously overlooked area for primate conservation in south-central Vietnam.

## Material and Methods

### Study area

The survey was conducted in the Tay Hoa forest complex (coordinates: 12.866222/109.267560), south-central Vietnam. The complex includes Deo Ca-Hon Nua Special-use Forest, Tay Hoa Protection Forest, Song Hinh Protection Forest, and Ninh Hoa-Van Ninh Protection Forest, forming an almost continuous forest landscape of approximately 130,000 ha between Dak Lak and Khanh Hoa Provinces. Tay Hoa Protection Forest covers 26,824 ha and directly connects Deo Ca, Song Hinh, and Bac Khanh Hoa forest blocks. Song Hinh Protection Forest covers 26,330 ha; and Bac Khanh Hoa Protection Forest covers 53,476 ha (Fig. 1) (BQL RPH Bac Khanh Hoa 2020; BQL RPH Song Hinh 2020; BQL RPH Tay Hoa 2020).

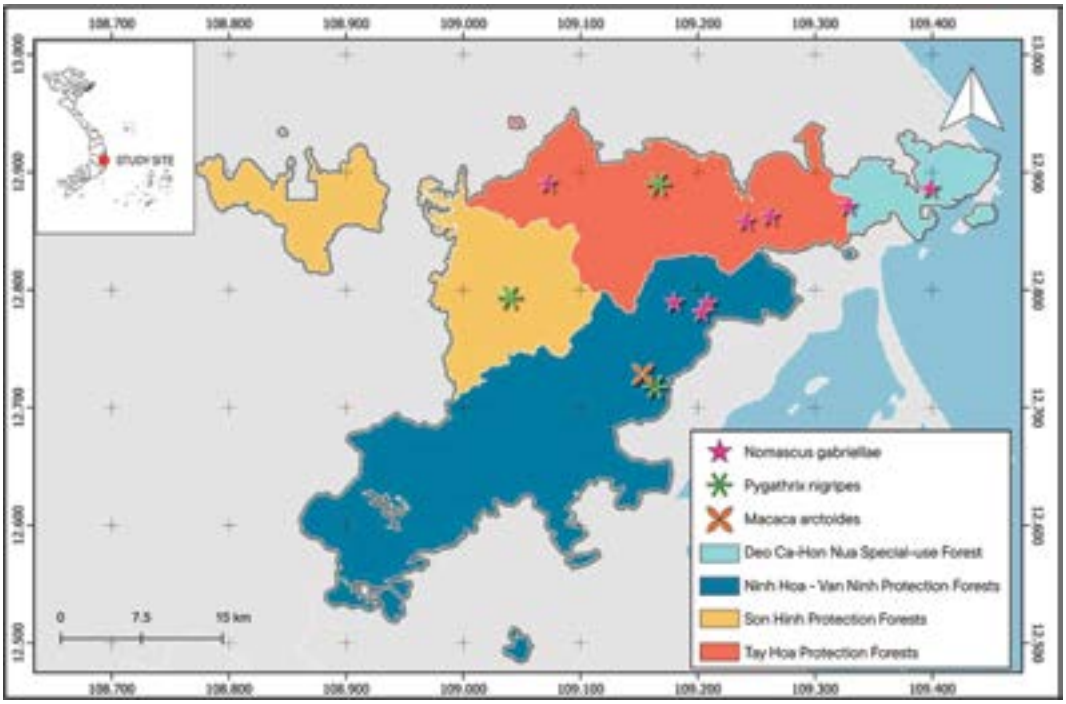



**Fig.1.** The Tay Hoa forest complex with evidence of southern yellow-cheeked gibbon, black-shanked douc langur and stump-tailed macaque.

The landscape contains mountainous terrain from low hills to high mountains, with elevations from about 100 m to over 2,000 m asl. Forest types range from semi-dry coastal forest to tropical evergreen broad-leave forest (BQL RPH Bac Khanh Hoa 2020; BQL RPH Song Hinh 2020; BQL RPH Tay Hoa 2020). Existing biodiversity information is limited; although management plans report important forest habitats and several threatened wildlife species.

## Survey method

Field surveys were conducted in Deo Ca-Hon Nua Special-use Forest and Tay Hoa Protection Forest in April 2024, followed by surveys in Song Hinh and Tay Hoa Protection Forests in August 2025 and March 2026. Additional surveys were conducted in Ninh Hoa-Van Ninh Protection Forest in December 2025, with a second survey in March 2026.

Line-transect surveys were used as the primary survey method. Surveys were carried out by a team of the Center for Technology and Nature Conservation, Hanoi, typically comprising 2–6 field researchers, together with 2-4 local guides and forest rangers. Depending on field conditions, the team was often divided into 2-3 smaller groups to survey areas surrounding each field camp.

Survey teams walked slowly along existing forest trails, ridge lines and suitable transects to detect primates through direct observation, canopy movement, feeding signs and vocalisations. Indirect signs, including faeces, urine marks on leaves, fresh feeding remains, and broken branches, were also recorded to assist in tracking primate groups. Transects and primate localities were documented using SMART Mobile version 7.5. When detected, gibbon calls were recorded using smartphones, and locations were marked for later confirmation. When black-shanked douc langurs were encountered, observers followed the group slowly from a suitable distance to take photographs, confirm species identification, and count individuals where visibility allowed.

## Results

### Primate observations

During the surveys, both black-shanked douc langurs and southern yellow-cheeked gibbon were recorded within the Tay Hoa forest complex.

Four groups of douc langurs were documented through direct observation. One group of at least 10 individuals was recorded in Song Hinh Protection Forest, and one group of approximately 5-7 individuals was recorded in Tay Hoa Protection Forest. In Ninh Hoa-Van Ninh Protection Forest, two groups were recorded, with estimated group sizes of approximately 10 and 30 individuals, respectively (Fig. 2).



**Fig.2.** Black-shanked douc langurs in Ninh Hoa-Van Ninh Protection Forest.

Southern yellow-cheeked gibbons were detected only through vocalisations. One calling group was recorded in the forest behind the headquarters of Deo Ca-Hon Nua Special-use Forest, near an abandoned tourist site containing old buildings and fruiting trees, where local information suggests gibbons frequently move close to the nearby village. A second calling group was recorded in Deo Ca near the border with Tay Hoa Protection Forest. Four additional calling groups were recorded in Tay Hoa Protection Forest, and three calling groups were recorded in Ninh Hoa-Van Ninh Protection Forest.

In total, the surveys documented four groups of black-shanked douc langurs and nine calling groups of southern yellow-cheeked gibbon across the Tay Hoa forest complex. (Table 1, 2).

**Table 1.** Number of southern yellow-cheeked gibbons documented in the Tay Hoa forest complex.

| Forest block / locality | Date | Time | Coordinates | Evidence | No. of groups |
|---|---|---|---|---|---|
| Deo Ca–Hon Nua Special-use Forest, behind headquarters | 1.4. 2024 | 5:00 | 12.8864 109.3978 | Vocalisation | 1 |
| Deo Ca–Hon Nua Special-use Forest, near border with Tay Hoa Protection Forest | 5.4.2024 | 6:00 | 12.8718 109.3279 | Vocalisation | 1 |
| Lac Xanh station, Tay Hoa Protection Forest | 17.8. 2025 | 11:20 | 12.890970 109.07178 | Vocalisation | 1 |
| Hoa Thinh station, Tay Hoa Protection Forest | 9.8.2025 | 5:00 | 12.85862 109.24109 | Vocalisation | 1 |
| Hoa Thinh station, Tay Hoa Protection Forest | 9.8.2025 | 6:37 | 12.86650 109.25068 | Vocalisation | 1 |
| Hoa Thinh station, Tay Hoa Protection Forest | 8.8.2025 | 7:47 | 12.860382 109.26228 | Vocalisation | 1 |
| Doc Mo station, Ninh Hoa–Van Ninh Protection Forest | 17.3.2026 | 5:34 | 12.78961 109.18087 | Vocalisation | 1 |
| Doc Mo station, Ninh Hoa–Van Ninh Protection Forest | 17.3.2026 | 5:46 | 12.79222 109.20904 | Vocalisation | 1 |
| Doc Mo station, Ninh Hoa–Van Ninh Protection Forest | 17.3.2026 | 6:08 | 12.78198 109.20440 | Vocalisation | 1 |
| | | | | **TOTAL** | **9** |

**Table 2.** Number of black-shanked douc langurs documented in the Tay Hoa forest complex.

| Forest block / locality | Date | Time | Coordinates | Evidence | No. of groups | No. of individuals |
|---|---|---|---|---|---|---|
| Song Hinh Protection Forest | 4.8.2025 | 10:25 | 12.795700 109.03835 | Observation photograph | 1 | ~ 10 |
| Tay Hoa Protection Forest | 11.3.2026 | 12:29 | 12.89329 109.167873 | Observation photograph | 1 | 5–7 |
| Ninh Hoa–Van Ninh Protection Forest | 16.4.2026 | 13:15 | 12.72189 109.16146 | Observation photograph | 1 | ~ 30 |
| Ninh Hoa–Van Ninh Protection Forest | 16.4.2026 | 12:55 | 12.72189 109.16146 | Observation photograph | 1 | ~ 10 |
| | | | | **TOTAL** | **4** | **55–57** |

An additional observation included a group of stump-tailed macaques (*Macaca arctoides*) detected near the large group of black-shanked douc langurs, indicating that this area supports a broader primate community. However, one local report of a black-shanked douc langur entering a house in Hoa My Commune, Dak Lak Province (Fig. 3), should be treated cautiously because the village is far from the forest, and several villagers suggested that the animal may have escaped from captivity, possibly having been kept as a pet.



**Fig.3.** Black shanked douc langur in Hoa My commune, a buffer zone of Tay Hoa Protection Forest. The origin and history of the individual is unknown.

### Threats to the primates in the arrea

Threats remain a concern across the landscape. According to local ranger information, gun hunting may still occur in Song Hinh, though hunting pressure appears lower in Tay Hoa, Deo Ca-Hon Nua and Ninh Hoa-Van Ninh. Gibbons were reported to be more heavily targeted than douc langurs because of demand for bones used in traditional medicine, with a reported local price of approximately VND 5 million/kg (about 190 USD/kg). Previous studies have also identified hunting and wildlife trade as major threats to gibbons and douc langurs in Vietnam (Rawson et al. 2011; Wearn et al. 2023; McEwan et al. 2021).

### Protection activities

Following the discovery of these primate populations, Center for Technology and Nature Conservation identified the Tay Hoa forest complex as a priority landscape for long-term conservation action. Since then, the NGO has worked closely with forest management boards and ranger stations to strengthen site-based protection across the complex.

Center for Technology and Nature Conservation has stationed staff at Tay Hoa Protection Forest to coordinate the implementation of SMART (Spatial Monitoring and Reporting Tool), support ranger teams, and improve the effectiveness of regular patrols. Intensive SMART mobile training has also been provided to 88 forest guards and local people involved in forest protection contracts across Tay Hoa, Song Hinh, Deo Ca, Ninh Hoa-Van Ninh. In addition, five smartphones were provided to Tay Hoa Protection Forest as SMART equipment, to improve patrol quality, threat recording, and long-term monitoring of key wildlife populations.

Center for Technology and Nature Conservation has also implemented awareness-raising activities in communities surrounding the forest complex. These activities included the design and distribution of hundreds of posters on wildlife protection regulations, regular radio broadcasts through commune and village loudspeaker systems reaching at least 10,000 people, and school programs involving 1000 students across three schools. Interactive art competitions were also organized to help students learn about wildlife conservation and share conservation messages within their communities.

In addition, CTNC distributed 500 conservation and wildlife books to schools in the region to improve access to conservation education materials and encourage local pride in protecting the region's threatened species. Primates, including black-shanked douc langurs and southern yellow-cheeked gibbons, were treated as priority conservation species in these education and awareness activities.

## Discussion

For southern yellow-cheeked gibbon, the new records confirm that the species occurs further toward the coastal forest belt of south-central Vietnam than previously understood, helping to fill an important distribution gap between inland Central Highlands populations and coastal forest blocks. This is consistent with recent reviews showing that this species has the largest range of any gibbons in Vietnam, but that populations are highly fragmented (Wearn et al. 2023)

Previous records summarized by Wearn et al. (2023) that are cited from Tran Van Bang (pers. comm. 2023), reported one group of *N. gabriellae* in Deo Ca–Hon Nua, two groups in Tay Hoa Protection Forest, and two groups in eastern Song Hinh Protection Forest. Our record from Deo Ca–Hon Nua may represent the same group previously reported, and two of the Tay Hoa groups may overlap with earlier observations by Tran Van Bang (pers.comm.). However, the two groups previously reported from Song Hinh were not detected during these surveys. These more recent records suggest that the Deo Ca–Tay Hoa-Song Hinh landscape may be an important habitat for gibbons and that systematic acoustic surveys should be carried out.

The records of douc langurs are also important. The species is known from southern Vietnam and Cambodia with its Vietnamese distribution mainly associated with Dak Lak, Khanh Hoa, Lam Dong and Dong Nai Provinces (Nguyen Hai Ha et al. 2023; O'Brien 2014; Rawson 2009; Dung et al. 2020; Truong Thanh Trinh et al. 2023). A modelling study also indicates that black-shanked douc langurs occurs within a relatively narrow latitudinal range in southern Vietnam, with several important known or potential sites including Cat Tien, Bu Gia Map, Hon Ba, Nui Chua and other protected areas (Dung V Tran et al. 2020).

Compared with large known populations such as Nui Chua, where approximately 700 individuals have been reported, the groups recorded in Tay Hoa, Song Hinh and Ninh Hoa-Van Ninh are smaller but remain highly significant because they indicate that coastal and transitional forests between Dak Lak and Khanh Hoa continue to support this threatened species (Nguyen Hai Ha et al. 2023; O'Brien 2014; Truong Thanh Trinh et al. 2023). The estimated total of approximately 55-57 individuals recorded across Tay Hoa Forest Complex is particularly important and suggests that this forest block may support a viable local population if hunting and habitat disturbance are effectively controlled. However, these findings should be considered preliminary because CTNC's surveys covered only a small proportion of this extensive forest landscape. According to information from local communities and forest rangers, additional groups of black-shanked douc langurs may occur elsewhere in the Tay Hoa forest complex.

These findings demonstrate that the Tay Hoa forest complex is an overlooked primate landscape supporting both *N. gabriellae* and *P. nigripes*. As some gibbon records were based solely on vocalisations, future work should include repeated listening-post surveys, acoustic analyses and, where possible, genetic confirmation to clarify group identity and avoid double counting. The findings also highlight the importance of coordinated landscape-level protection across Deo Ca–Hon Nua, Tay Hoa, Song Hinh, and Ninh Hoa–Van Ninh, rather than managing each forest block independently.

In the long term, the ecological connectivity and conservation value of this landscape provide a strong basis for its considering the area as one of Vietnam's largest national parks. In the short term, further systematic surveys are needed to clarify species distribution, estimate population size, and identify priority areas for protection. Future work should combine continued research, community awareness-raising and effective SMART-based patrols. The application of emerging technologies,

such as thermal drones, may also improve detection rates, strengthen monitoring capacity, and support more effective conservation action in the region.

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# Grey-shanked douc langurs (*Pygathrix cinerea*) in Song Thanh National Park, Quang Nam Province, Vietnam: A stronghold for the species

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**Keywords:** Grey-shanked douc langur, *Pygathrix cinerea*, Song Thanh National Park.

**Summary**

The grey-shanked douc langur (*Pygathrix cinerea*) is a 'Critically Endangered' primate species. The main populations of the species are found in central Vietnam, with small populations in the southeastern corner of Laos and in the northeastern corner of Cambodia, near the border with Vietnam. We assessed the population status, distribution, habitat characteristics, and threats to the species in Song Thanh National Park, Quang Nam Province. Field surveys were conducted in January and August 2024. A total of 14 groups comprising 95 individuals were directly recorded during the surveys, considerably higher than previous records from the national park. The species was documented in nine of the twelve communes within Song Thanh National Park and was primarily associated with medium and rich evergreen broadleaf forests. Key populations were identified in Dak Pring, Phuoc Nang, and Ta Bhing communes. The encounter rate was estimated at 0.049 groups/km. The main threats identified were snaring, livestock grazing in natural forests, and non-timber forest product collection. Given its large forest area and connectivity with Ngoc Linh Nature Reserve, Song Thanh National Park represents an important conservation stronghold for the long-term survival of the grey-shanked douc langur.

# Chà vá chân xám (*Pygathrix cinerea*) tại Vườn quốc gia Sông Thanh, tỉnh Quảng Nam, Việt Nam: Thành trì quan trọng cho sự tồn tại của loài

**Tóm tắt**

Chà vá chân xám (*Pygathrix cinerea*) là loài Cực kỳ nguy cấp (Critically Endangered). Các quần thể chính của loài này được tìm thấy ở miền Trung Việt Nam, với các quần thể nhỏ hơn ở góc đông nam của Lào và ở góc đông bắc của Campuchia, gần biên giới với Việt Nam. Nghiên cứu này được thực hiện nhằm đánh giá tình trạng quần thể, đặc điểm phân bố, sinh cảnh sống và các mối đe dọa đối với loài tại Vườn quốc gia Sông Thanh, tỉnh Quảng Nam. Các đợt khảo sát thực địa được tiến hành trong năm 2024. Kết quả ghi nhận trực tiếp 14 đàn với tổng số 95 cá thể, cao hơn đáng kể so với các ghi nhận trước đây tại khu vực nghiên cứu. Loài được phát hiện tại 9 trong số 12 xã thuộc Vườn quốc gia Sông Thanh và chủ yếu phân bố trong các trạng thái rừng lá rộng thường xanh giàu và trung bình. Các quần thể quan trọng được xác định tại các xã Đắc Pring, Phước Năng và Tà Bhing. Tỷ lệ bắt gặp ước tính đạt 0,049 đàn/km tuyến khảo sát. Các mối đe dọa chính đối với loài bao gồm bẫy dây, chăn thả gia súc trong rừng tự nhiên và khai thác lâm sản ngoài gỗ. Với diện tích rừng tự nhiên lớn và sự kết nối sinh cảnh với Khu bảo tồn thiên nhiên Ngọc Linh, Vườn quốc gia Sông Thanh được xem là một thành trì bảo tồn quan trọng đối với sự tồn tại lâu dài của loài Chà vá chân xám.

## Introduction

Douc langurs *Pygathrix* are restricted to Vietnam, Laos, and Cambodia, east of the Mekong River (Fooden 1996; Nadler et al. 2003; Nadler & Brockman 2014). The grey-shanked douc langur (*Pygathrix cinerea*) is listed as 'Critically Endangered' (Ha Thang Long et al. 2020). Its distribution is restricted to the central coastal region and Central Highlands of Vietnam, ranging from approximately 14°30'N to 15°38'N and to small parts in Laos and Cambodia. The species' range encompasses

six provinces: Quang Nam, Quang Ngai, Kon Tum, Binh Dinh, Gia Lai, and Phu Yen (former administrative units). The global population is estimated between 2,500~3,000 individuals, with a few remaining stronghold populations (Wearn et al. 2022). Several larger sub-populations have been documented across its distribution range. Kon Ka Kinh National Park and Kon Chu Rang Nature Reserve, Gia Lai Province support some of the largest known populations, with estimated population sizes of approximately 1,500 and 100 to 120 individuals, respectively (Ha Thang Long et al. 2015; 2021). In Kon Tum Province, about 500 individuals were recorded in Kon Plong Forest (Fauna & Flora International 2016). In Quang Ngai Province, fragmented populations have been reported, consisting of 32 groups with 192–220 individuals (Nguyen Thanh Tuan et al. 2010). Grey-shanked douc langurs have also been reported from Song Thanh National Park, Quang Nam Province, since 2005, where four groups totaling about 25 individuals were observed (Hoang Minh Duc et al. 2005).

## Material

### Study Area

Song Thanh National Park is situated in the western part of Quang Nam Province, central Vietnam, encompassing the mountainous districts of Nam Giang and Phuoc Son Provinces. The national park covers a total natural forest area of 76,593 ha and extends across 12 communes: Ta Bhing, Ta Pơ, Ca Dy, Cha Val, Dak Toi, La Dee, Dak Pring, Dak Pre (Nam Giang District), and Phuoc Xuan, Phuoc My, Phuoc Nang, Phuoc Cong (Phuoc Son District), Quang Nam Province (former administraive units).

Formerly designated as Song Thanh Nature Reserve, the area was upgraded to national park status under Decision No. 3689/QD-UBND on 18 December 2020 by the People's Committee of Quang Nam Province. With its extensive natural forest cover, the national park represents a critical biodiversity hotspot within the Truong Son range of Vietnam.

The park harbors a rich assemblage of fauna, including 68 mammal species, 130 bird species, 112 reptile species, 56 amphibian species, and 103 fish species. Its flora is equally diverse, with at least 881 plant species recorded, of which 32 are recognized as having high conservation value.

Of particular significance is the presence of several globally threatened mammals, including the red-shanked douc langur (*Pygathrix nemaeus*), grey-shanked douc langur (*Pygathrix cinerea*), large-antlered muntjac (*Muntiacus vuquangensis*), and Truong Son muntjac (*Muntiacus truongsonensis*). These taxa contribute to the park's high conservation value and reinforce its importance as a priority area for biodiversity protection in the central Annamites.

Despite its biological significance, Song Thanh National Park faces increasing anthropogenic pressures. Habitat disturbance resulting from gold mining, illegal logging, and poaching threatens wildlife populations and undermines recovery efforts. Without effective management and enforcement, these threats may jeopardize the long-term survival of many species within the park.

## Methods

### Interview survey

Prior to the field surveys, interviews were conducted in twelve communes in the buffer zone of the park from the 4$^{th}$ to 8$^{th}$ December 2023.with a total of 120 local people, including hunters, forest product gatherers and residents, to document sightings, distribution and abundance of primates in the nearby forests with a particular focus on the grey-shanked douc langur. Structured questionnaires were employed following the guidelines of Peterson (2000) to obtain data on species occurrence and to assist in estimating population abundance. The questionnaire included both open-ended and closed-ended questions. A survey team of five members carried out the interview survey. Discussions were also conducted with staff from Forest Protection Departments (FPD) and management units of protected areas to gather information on primate occurrence, forest types, hunting pressure, and wildlife trade.

### Field survey

The field survey took place between January and August 2024. Four teams of five members each – a GreenViet field biologist, a forest ranger, and three local guides – participated in the survey. All team members had previously completed training in primate survey methods, including the identification of grey-shanked douc langurs and standardized data collection procedures.

Due to access restrictions associated with border security regulations, field surveys could only be conducted in eight communes: Ta Bhing, Ta Po, Ca Dy, Cha Val, Phuoc My, Phuoc Xuan, Phuoc Nang, and Phuoc Cong. Thirty-one transects, totaling 285.3 km in length, were surveyed through various forest types. The average transect length was 9.2 km. Survey teams moved at a speed of 0.5-1 km/h and used binoculars for wildlife observation. Observations took place between 6:00 and 11:30 a.m. and between 1:30 and 6:30 p.m. For each sighting, the survey teams documented group size, structure, habitat features, GPS position, weather conditions, and signs of human disturbance.

### Data analyzing

The geographic coordinates of all grey-shanked douc langur sightings recorded during field surveys were imported into QGIS Desktop 3.40.5 for spatial analysis. Habitat disturbance data collected in the field were also analyzed using QGIS. Forest classification and park boundary maps were provided by the Song Thanh National Park Management Board. These datasets were integrated to produce a distribution map of the grey-shanked douc langurs and to assess its occurrence in relation to habitat conditions and disturbance levels.

## Results

### Population status

A total of 14 grey-shanked douc langur groups comprising 95 individuals were recorded in Song Thanh National Park. Group size ranged from a single individual to 15 individuals, with an average of approximately 6 individuals per group. The encounter rate was estimated at 0.049 groups/km and 0.33 individuals/km within the surveyed areas.

Detailed assessment of group composition was limited by challenging observation conditions. The langurs were highly vigilant and frequently moved through dense forest canopy, making it difficult to accurately determine sex and age classes for all individuals. Of the 95 individuals observed, 10 were identified as males, 7 as females, and 78 could not be reliably sexed. Age classification identified 53 adults, 9 sub-adults, 5 juveniles, and 5 infants, while the age class of 23 individuals remained undetermined (Table 1).

**Table 1.** Observations of grey-shanked douc langurs in the Song Thanh National Park during survey.

| No | Commune | GPS Coodinates | | Observed individuals | Males | Females | Unclear sex class | Adults | Sub-adults | Juveniles | Infants | Unclear Age class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | X-UTM | Y-UTM | | | | | | | | | |
| 1 | Ta Bhing | 793186 | 1725262 | 10 | | | 10 | 2 | 3 | 3 | 2 | 0 |
| 2 | Ta Bhing | 794761 | 1724206 | 4 | | | 4 | 4 | 0 | 0 | 0 | 0 |
| 3 | Ta Po | 781124 | 1728227 | 5 | 2 | | 3 | 4 | 1 | | | |
| 4 | Ta Po | 784230 | 1727994 | 15 | 2 | | 13 | 10 | 4 | 1 | 0 | 0 |
| 5 | Phuoc Nang | 788742 | 1706225 | 1 | 1 | 0 | | 1 | 0 | 0 | 0 | 0 |
| 6 | Phuoc Nang | 785552 | 1702560 | 3 | 1 | 2 | 0 | 1 | | | | 2 |
| 7 | Phuoc Nang | 787041 | 1704396 | 8 | 1 | 3 | 4 | 4 | 1 | 1 | 2 | 0 |
| 8 | Phuoc Nang | 787254 | 1703439 | 8 | 1 | | 7 | 2 | | | | 6 |
| 9 | Phuoc Nang | 787118 | 1703583 | 15 | 2 | 2 | 11 | 4 | | | | 11 |
| 10 | Phuoc Nang | 787106 | 1701098 | 4 | | | 4 | | | | | 4 |
| 11 | Phuoc My | 791074 | 1701437 | 5 | | | 5 | 5 | 0 | 0 | 0 | 0 |
| 12 | Phuoc Cong | 798912 | 1687182 | 3 | | | 3 | 3 | | | | |
| 13 | Phuoc Cong | 797817 | 1691023 | 9 | | | 9 | 8 | | | 1 | |
| 14 | Phuoc Cong | 797220 | 1689547 | 5 | | | 5 | 5 | | | | |
| | | | **TOTAL** | **95** | | | | | | | | |

The highest concentration of grey-shanked douc langurs was recorded in sub-compartment 682, Phuoc Nang Commune, Phuoc Son District, where six groups totaling 39 individuals were observed. This area accounted for approximately 42% of all groups and 41% of all individuals recorded during the survey, indicating its importance as a key habitat for the species within Song Thanh National Park. All other survey locations recorded only one or two groups each.

### Distribution status

Based on the survey results and records collected by Song Thanh National Park forest guards between 2022 and 2024, grey-shanked douc langurs have been documented in nine of the twelve communes. No records were obtained from Dak Pre, Cha Val, and La Dee communes. Grey-shanked douc langurs were detected in five of these surveyed communes. Most observations were concentrated in the southern part of the national park, particularly within Phuoc Nang, Phuoc My, and Phuoc Cong communes, indicating that these areas support important populations of the species and represent key habitats for its conservation.

Based on 22 observations collected by Song Thanh National Park forest guards, the Dak Pring commune area recorded 14 sightings of grey-shanked douc langurs, the highest number of observations within the park. This suggests that Dak Pring supports one of the most important habitats for the species inside the national park (Fig. 1).

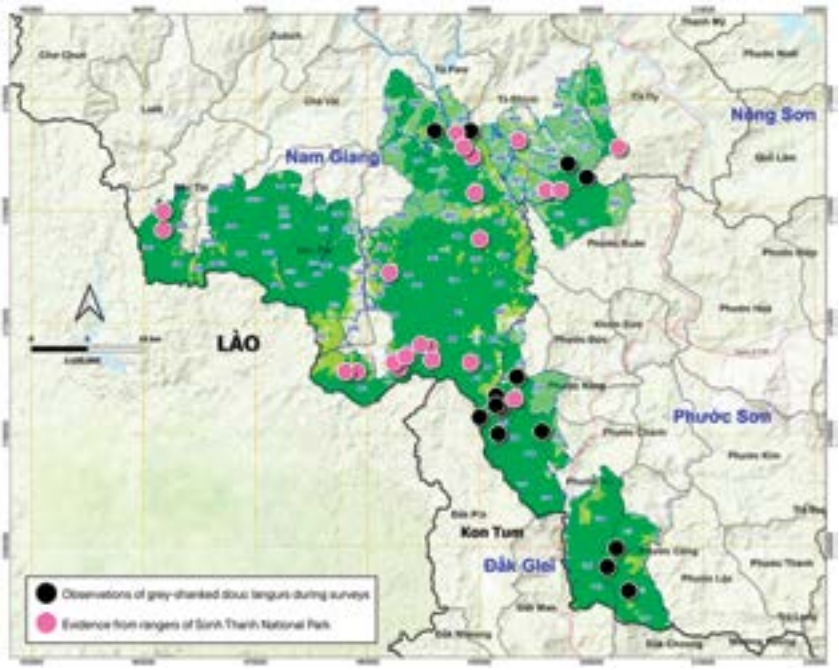



**Fig.1.** Records of grey-shanked douc langurs in Song Thanh National Park.

By combining forest guard records (22 sightings) with the results of the present field survey (14 sightings), three key conservation areas for the grey-shanked douc langurs were identified within the park. These areas are located in Dak Pring, Phuoc Nang, and Ta Bhing communes, where the species was recorded most frequently and in relatively high numbers. These forest blocks likely represent core habitats for the species and should be prioritized for future monitoring, habitat protection, and anti-poaching efforts.

The grey-shanked douc langurs were found mostly in both rich forest and medium forest

conditions, provided that the habitat still maintains sufficient canopy connectivity, food resources, and relatively low disturbance (Table 2).

**Table 2.** Records of the grey-shanked douc langurs, forest condition and human disturbances in Song Thanh National Park.

| | Records in this study | | | | |
|---|---|---|---|---|---|
| Commune | groups | individuals | observations by forest guard 2022 to 2024 | Forest condition according Circular 33/2018/MARD | Human Disturbance this study 2024 |
| Ta Bhing | 2 | 14 | 3 | poor and medium | snaring, cattle and buffalo grazing |
| Ta Po | 2 | 20 | 1 | poor and medium | snaring; cattle and buffalo grazing |
| Ca Dy | | None | 1 | medium | None |
| Cha Val | | None | None | N/A | snaring |
| Phuoc Xuan | | None | None | N/A | cattle and buffalo grazing |
| Phuoc My | 1 | 5 | None | medium | None |
| Phuoc Nang | 6 | 39 | 1 | Medium and rich | snaring, cattle and buffalo grazing |
| Phuoc Cong | 3 | 17 | None | rich | snaring, cattle and buffalo grazing |
| Dak Pring | | Border area, no survey | 14 | medium and rich | N/A |
| Dak Pre | | | None | N/A | N/A |
| La Dee | | | None | N/A | N/A |
| Dak Toi | | | 2 | medium and rich | N/A |

## Threats

During the surveys, several threats to the grey-shanked douc langur and its habitat were identified. These included snaring, cattle and buffalo grazing within natural forests, and the collection of non-timber forest products by local communities,.such as honey, mushrooms, bamboo shoots, and medicinal plants.

No evidence of illegal logging or gold mining was detected within the surveyed areas, suggesting that these activities currently pose a limited threat to the species in the study sites. However, snaring and livestock grazing were found to be widespread and represented the most significant anthropogenic pressures. Both threats were recorded in most survey locations and occurred across a broad range of habitats occupied by grey-shanked douc langurs.

Although grey-shanked douc langurs are not typically targeted by hunters. Extensive snaring poses a serious indirect threat through disturbance to forest ecosystems, and the risk of accidental capture. Livestock grazing within natural forests may also contribute to habitat degradation by altering vegetation structure, suppressing forest regeneration, facilitating human access into remote forest areas, and increasing the frequency of disturbance. The spatial distribution of these threats should identify priority areas for law enforcement, threat mitigation, and future conservation interventions (Fig. 2, 3).

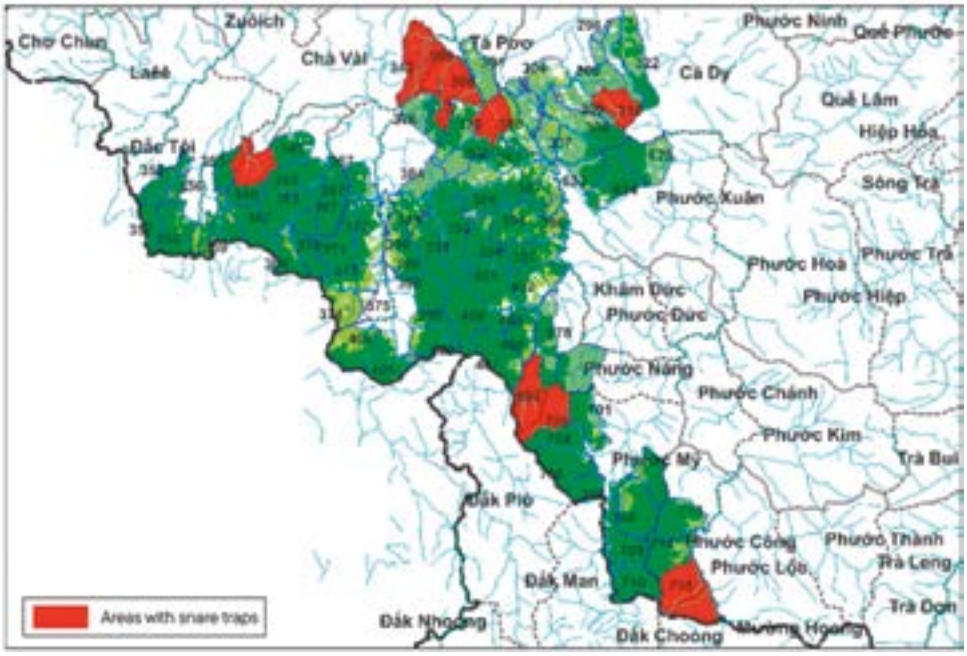



**Fig.2.** Areas within Song Thanh National Park where snaring was found.

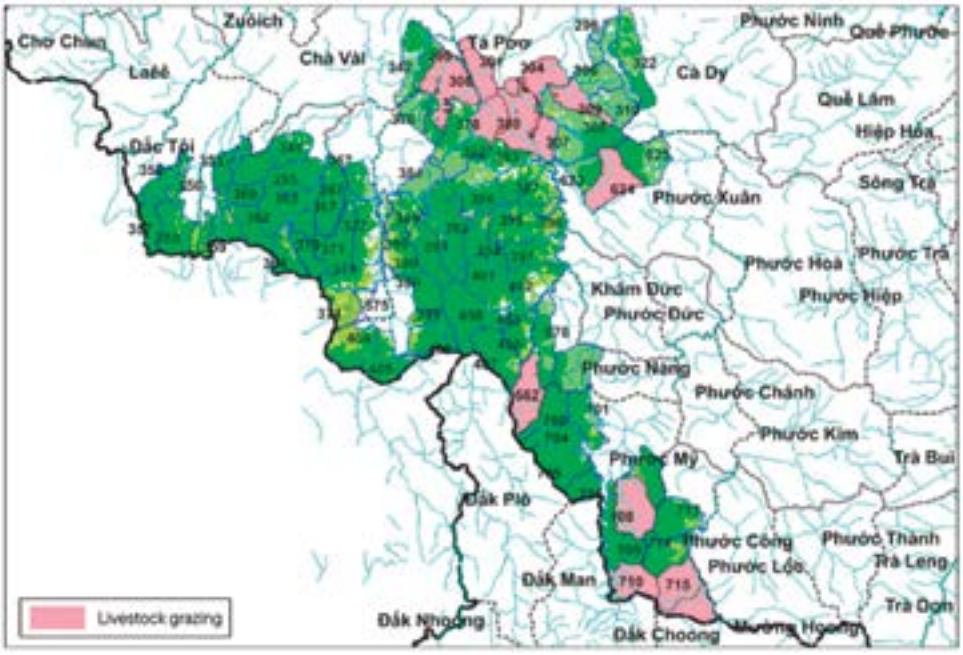



**Fig.3.** Areas within Song Thanh National Park where livestock grazing has been observed.

## Discussion

### Song Thanh National Park as a stronghold of grey-shanked douc langur in Vietnam.

Previous surveys documented only four grey-shanked douc langur groups comprising 25 individuals in Song Thanh National Park (Hoang Minh Duc et al., 2005). The present study recorded

14 groups and 95 individuals. In addition, park forest guards reported 22 sightings of grey-shanked douc langurs between 2022 and 2024. Collectively, these records indicate that the species is more widely distributed within the park than previously recognized and suggest that Song Thanh National Park supports an important population of the species.

The encounter rate recorded during this study was 0.049 groups/km. The comparison with the encounter rate of Kon Ka Kinh National Park with 1.18 groups/km (Ha Thang Long et al. 2021) suggest that substantial variation in population density may occur across the species' range. The relatively low encounter rate in Song Thanh National Park may partly reflect limitations in detectability rather than low population abundance. Grey-shanked douc langurs inhabit rugged mountainous terrain covered by dense evergreen forest, where observation conditions are often challenging. In addition, surveys could not be conducted in four border communes adjacent to Laos because of access restrictions. These communities encompass more than 45,000 hectares of forest and include Dak Pring and Dak Toi, which have been identified by rangers as important habitats for the species. Consequently, the current results are likely to represent a conservative estimate of the population status in Song Thanh National Park. Additional surveys in these un-surveyed areas are required to improve estimates of distribution, encounter rates, and population size, and to provide a more comprehensive assessment of the conservation status of grey-shanked douc langurs within the park.

Song Thanh National Park covers approximately 76,600 ha of natural forest, making it one of the largest protected forest landscapes in Vietnam. The park is part of a larger forest complex in the central Annamite Mountains and is directly connected to the Ngoc Linh Nature Reserve to the south, where the presence of grey-shanked doucs has also been confirmed. Together, these two protected areas form an extensive and largely contiguous block of evergreen forest, providing a suitable habitat for the species across a wide range of altitudes.

The conservation significance of Song Thanh National Park extends beyond the protection of its resident grey-shanked douc langur population. By maintaining forest connectivity with Ngoc Linh Nature Reserve, the park may facilitate dispersal and gene flow between subpopulations, reducing the risk of genetic isolation and inbreeding. Such landscape connectivity is particularly important for long-term population viability, as it allows individuals to move between habitat patches, recolonize areas where local declines have occurred, and maintain genetic diversity. Given the ongoing pressures of habitat fragmentation throughout the species' range, the Song Thanh–Ngoc Linh forest complex likely represents one of the most important strongholds for the grey-shanked douc langur in Vietnam. Ensuring effective protection of Song Thanh National Park will therefore not only contribute to the preservation of local populations, but also to the long-term survival and resilience of species.

**Conclusions**

- Song Thanh National Park supports an important population of the 'Critically Endangered' grey-shanked douc langur, with 14 groups and 95 individuals recorded during this study.
- The species is widely distributed across the park, with key populations concentrated in Dak Pring, Phuoc Nang, and Ta Bhing communes, emphasizing the park's role as a conservation stronghold and landscape connectivity area with Ngoc Linh Nature Reserve.
- Snaring and livestock grazing were identified as the principal threats to the species and its habitat, highlighting the need for strengthened protection, threat mitigation, and long-term population monitoring.

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# Vascular plants (Tracheophyta) composition and habitat characteristics of an area with a newly discovered population of Hatinh langurs (*Trachypithecus hatinhensis*) in Quang Tri Province, Vietnam

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**Keywords:** Hatinh langur, *Trachypithecus hatinhensis.* Conservation, diet, habitat.

**Summary**

Plant species used as food resources play a key role in primate conservation, particularly in degraded or fragmented habitats where food availability may limit population persistence. The study was conducted from February to December 2023 to describe habitat characteristics and identify potential food plant species for the Hatinh langur (*Trachypithecus hatinhensis*) in Quang Tri Province, Vietnam. Line transect surveys combined with direct observations and scan sampling methods were applied throughout the study period. A total of 198 plant species were documented, comprising trees (38 species, 19.2%), shrubs (40 species, 20.2%), herbaceous plants (52 species, 26.3%), lianas (41 species, 20.7%), epiphytes (20 species, 10.1%), and parasitic plants (7 species, 3.5%). Based on a synthesis of dietary studies of *Trachypithecus* species, several plant groups were identified as potential key food resources for the Hatinh langur, with species in the family Moraceae, particularly the genus *Ficus*, being especially prominent. These findings improve our understanding of the diet of this species in a newly surveyed area and underline the urgent need to protect its habitat and implement conservation measures for this endangered species.

# Thành phần thực vật có mạch và đặc điểm sinh cảnh tại khu vực mới ghi nhận quần thể voọc Hà Tĩnh (*Trachypithecus hatinhensis*) tỉnh Quảng Trị, Việt Nam

**Tóm tắt**

Các loài thực vật được sử dụng làm thức ăn đóng vai trò quan trọng trong công tác bảo tồn linh trưởng, đặc biệt tại các sinh cảnh bị suy thoái hoặc phân mảnh, nơi nguồn tài nguyên thức ăn có thể trở thành một yếu tố ảnh hưởng đến sự tồn tại lâu dài của quần thể. Nghiên cứu được thực hiện từ tháng 02 đến tháng 12 năm 2023 nhằm mô tả đặc điểm sinh cảnh và xác định các loài thực vật tiềm năng là nguồn thức ăn của voọc Hàtĩnh (*Trachypithecus hatinhensis*) tại Quảng Trị, Việt Nam. Phương pháp điều tra theo tuyến kết hợp quan sát trực tiếp và phương pháp lấy mẫu quét được áp dụng trong suốt quá trình nghiên cứu. Kết quả bước đầu ghi nhận 198 loài thực vật, bao gồm cây gỗ (38 loài, 19,2%), cây bụi (40 loài, 20,2%), cây thân thảo (52 loài, 26,3%), dây leo (41 loài, 20,7%), thực vật biểu sinh (20 loài, 10,1%) và thực vật ký sinh (7 loài, 3,5%). Trên cơ sở tổng hợp các nghiên cứu về chế độ ăn của các loài thuộc chi *Trachypithecus*, chúng tôi xác định một số nhóm thực vật có khả năng đóng vai trò là nguồn thức ăn quan trọng của voọc Hàtĩnh, trong đó nổi bật là các loài thuộc họ Moraceae, đặc biệt là chi *Ficus*. Kết quả nghiên cứu góp phần bổ sung hiểu biết về sinh thái dinh dưỡng của loài tại khu vực mới được ghi nhận, đồng thời nhấn mạnh tầm quan trọng của

việc bảo vệ sinh cảnh và triển khai các biện pháp bảo tồn phù hợp nhằm đảm bảo sự tồn tại lâu dài của loài linh trưởng nguy cấp này.

## Introduction

Food availability and vegetation structure are widely recognized as key ecological factors shaping primate distribution, habitat use, and population dynamics (Hanya & Chapman 2013). In folivorous primates, plant community composition plays a particularly important role in shaping habitat suitability and the availability of key dietary resources, making detailed vegetation assessments essential for understanding their ecological requirements. Under relatively undisturbed conditions, these resources are largely determined by intact forest structure. However, across many regions worldwide, primate populations are increasingly restricted to human-modified and fragmented landscapes. Habitat fragmentation is widely recognized as a major threat to wildlife survival, particularly for primates (Marsh 2003). It reduces habitat extent and quality while simultaneously altering the structural complexity and ecological functioning of remnant forest patches (Marsh 2003; Wong et al. 2006). These changes often result in shifts in plant community composition and spatial distribution of resources. Such habitat-driven alterations are especially important for folivorous primates, as fragmented forests frequently show increased dominance of secondary vegetation, including lianas and fast-growing pioneer species (Zhu et al. 2004). These shifts can substantially modify both the quantity and quality of available food resources, thereby influencing feeding ecology and ultimately affecting the long-term viability of primate populations (Hu 2011; Chaves et al. 2012).

The Hatinh langur is an 'Endangered' primate and endemic to limestone karst landscapes in central Vietnam and adjacent areas of Laos, including Hatinh and Quang Tri Provinces (Nadler et al. 2003; Roos et al. 2014; Le Khac Quyet et al. 2021). Recently, a small population of Hatinh langurs was discovered along the border between Cam Lo and Da Krong Districts, Quang Tri Province (Nguyen Van Truong et al. 2023), extending the known distribution of the species in the province toward the Southwest. Although the overall distribution and major threats to the species have been documented, detailed information on habitat composition and vegetation structure of recently recorded populations remains limited. In particular, quantitative data on plant community composition and habitat characteristics in Quang Tri Province are still lacking, which constrains our understanding of habitat suitability and local ecological conditions for this species. Such information is critical for evidence-based conservation planning and effective management. Therefore, this study aims to investigate vegetation composition and habitat characteristics associated with this newly recorded population of the Hatinh langur in Quang Tri Province, providing baseline ecological data to support conservation efforts.

## Material and methods

### Study site

This study was conducted in Cam Lo and Da Krong Districts (former administrative units), Quang Tri Province, Vietnam (Fig. 1). The study area represents a fragmented karst landscape where a population of Hatinh langurs was recorded in 2023 (Nguyen Van Truong et al. 2023). The survey covered an area of approximately 250 ha encompassing two limestone blocks: the Rockpile (36 ha) and the so-called Razorback (188 ha) (6°46'–16°48'N, 106°49'–106°51'E). The Rockpile, characterized by several peaks, reaches elevations of approximately 250 m asl, while the Razorback attains elevations of up to 450 m asl (Fig. 2). The two blocks are separated by a distance of about 500 m. Between the two limestone blocks lies a low-elevation area (50–70 m asl) planted by rubber and *Acacia* plantations. Vegetation in the karst formations is characterized as seasonal limestone forest. However, the remaining habitat is highly fragmented due to historical limestone mining, which ceased approximately 10 years ago.




**Fig.1.** Study area in Quang Tri Province.




**Fig2.** Study area with the Area A (Rockpile), Area B (Razorback), and observation post.

## Survey activities

Following the discovery of the Hatinh langur population, field surveys were conducted from February to December 2023 between 06:30 and 18:00 to document plant species composition, habitat characteristics, and food plants associated with areas of confirmed langur presence. Due to the predominantly steep limestone cliffs and rugged terrain, standard plot-based vegetation sampling

was not feasible. Instead, data was collected primarily through transect surveys conducted across the entire study area. Along these transects, direct observations, scan sampling using binoculars, and opportunistic photo and video documentation were used to locate langurs and characterize their habitat. Vegetation records were collected in locations where langurs were directly observed or where their presence was confirmed through field signs.

All vascular plant species encountered were recorded and classified by growth form (trees, shrubs, herbs, lianas, epiphytes, and parasitic plants). Geographic coordinates and elevation were recorded using a GPS device. Plant species were identified in the field using standard floristic guides, and unidentified specimens were collected for subsequent verification through herbarium comparisons and consultation with botanical experts. Scientific nomenclature followed Ho Pham Hoang (1999, 2000a, 2000b), and species were classified according to the Angiosperm Phylogeny Group IV system (Chase et al. 2016).

## Results

### Vegetation composition

A total of 198 plant species belonging to 75 families and 164 genera were recorded within the habitat. We identified the 20 most representative families, each with a relative abundance greater than 2.0%, which together accounted for 58.6% of all recorded species (Fig. 3). Among these, Euphorbiaceae was the most dominant family (7.1%), followed by Fabaceae and Rubiaceae (4.0% each). Annonaceae, Apocynaceae, Araceae, and Rutaceae each contributed 3.5% of the total species richness.

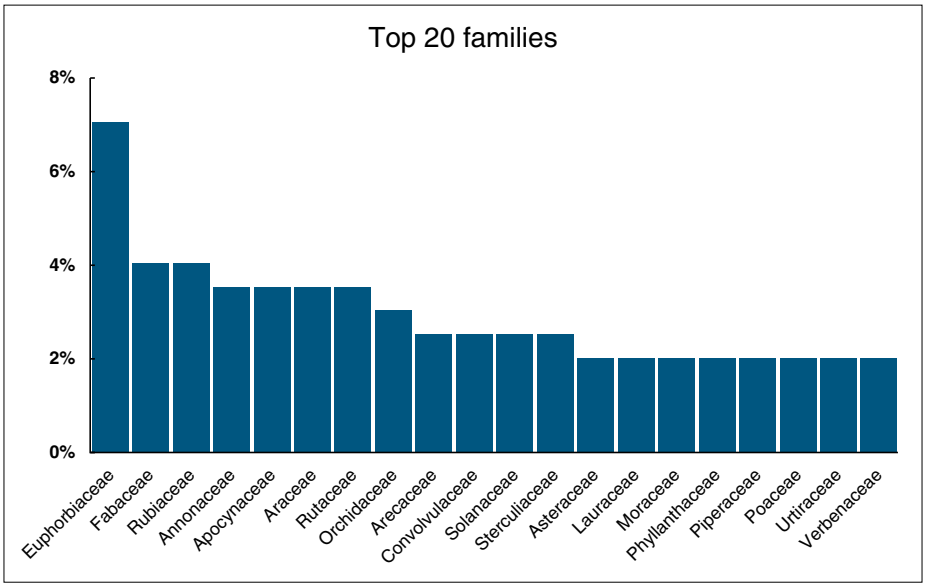



**Fig.3.** Top 20 plant families recorded in the habitat of the Hatinh langurs in the area.

At the genus level, 28 genera with relative abundance greater than 1.0% collectively accounted for 31.3% of all records. Among these, *Solanum* was the most frequent genus (2.0%), followed by *Capparis*, *Ficus*, *Litsea*, and *Piper* (1.5% each) (Table 1).

**Table 1.** Vegetation at the genus level contributing ≥1.0% in the habitat of the Hatinh langur was recorded between February and December 2023.

| No. | Genus | Abundance | No. | Genus | Abundance |
|---|---|---|---|---|---|
| 1 | *Solanum* | 2.0% | 15 | *Glycosmis* | 1.0% |
| 2 | *Capparis* | 1.5% | 16 | *Hedyotis* | 1.0% |
| 3 | *Ficus* | 1.5% | 17 | *Helicteres* | 1.0% |
| 4 | *Litsea* | 1.5% | 18 | *Hoya* | 1.0% |
| 5 | *Piper* | 1.5% | 19 | *Illigera* | 1.0% |
| 6 | *Arenga* | 1.0% | 20 | *Mallotus* | 1.0% |
| 7 | *Bauhinia* | 1.0% | 21 | *Murraya* | 1.0% |
| 8 | *Buxus* | 1.0% | 22 | *Pellionia* | 1.0% |
| 9 | *Callicarpa* | 1.0% | 23 | *Phyllanthus* | 1.0% |
| 10 | *Clerodendrum* | 1.0% | 24 | *Pisonia* | 1.0% |
| 11 | *Cratoxylum* | 1.0% | 25 | *Pyrrosia* | 1.0% |
| 12 | *Croton* | 1.0% | 26 | *Rhaphidophora* | 1.0% |
| 13 | *Deeringia* | 1.0% | 27 | *Trigonostemon* | 1.0% |
| 14 | *Dracaena* | 1.0% | 28 | *Zanthoxylum* | 1.0% |

The family Moraceae, particularly the genus *Ficus*, is widely recognized as an important food resource for many *Trachypithecus* species (Clink et al. 2017; Lim et al. 2021). In the study area, Moraceae accounted for 2% of the total flora and included key species such as *Broussonetia papyrifera*, *Ficus benjamina*, *F. racemosa*, and *F. annulata* (Fig. 4).



**Fig.4.** Langurs resting and feeding on *Ficus* species. Photo: Le Tuan Anh.

## Habitat characteristics

The habitat of the Hatinh langur was characterized by a structurally diverse vegetation community typical of limestone forest ecosystems, with a well-developed canopy and a heterogeneous understory. A total of six major growth forms were recorded, including trees, shrubs, herbaceous plants, lianas, epiphytes, and parasitic plants. The plant community was composed of trees (38 species, 19.2%), shrubs (40 species, 20.2%), herbaceous plants (52 species, 26.3%), lianas (41 species, 20.7%), epiphytes (20 species, 10.1%), and parasitic plants (7 species, 3.5%), indicating a complex vertical and horizontal vegetation structure.

### Threats to the habitat of the Hatinh langurs

We identified main threats to the habitat of the Hatinh langur including both direct and indirect impacts on the species and its habitat. Direct threats primarily comprise human activities such as hunting, trapping, livestock grazing, agricultural expansion, non-timber forest product harvesting, and mining activities (Fig. 5, 6, 7, 8). Another possible pressure on langurs is potential interspecific competition for food resources and space with the Assamese macaques (*Macaca assamensis*), which also occur in the area.



**Fig.5.** Goat grazing is considered a habitat impairment for the Hatinh langurs. Photo: Le Tuan Anh.



**Fig.6.** Quarrying activities and *Acacia* plantations restrict the habitat of the Hatinh langurs. Photo: Le Tuan Anh.



**Fig.7.** Illegal tree felling destroys the habitat and food supply of the Hatinh langurs. Photo: Le Tuan Anh.



**Fig.8.** Unexploded ordnance poses a danger to the population, as well as to the habitat and langurs. Photo: Le Tuan Anh.

## Discussions

This study provides the first comprehensive assessment of plant species composition and associated threats within the habitat of the Hatinh langur in the study area. A diverse vegetation community was recorded, indicating a structurally complex habitat that potentially supports the species' ecological requirements. However, multiple anthropogenic pressures, including hunting, livestock grazing, habitat conversion, and resource extraction, were identified as ongoing threats to habitat integrity.

Based on these findings, further systematic ecological surveys are required to better quantify habitat characteristics in greater detail. In particular, the establishment of standardized vegetation plots will be essential to identify key food plant species and assess their availability and distribution. This will provide a scientific basis for determining habitat preferences and critical food resources of the species. In addition, the study area is also inhabited by Assamese macaques, suggesting potential for interspecific competition for food resources and space between macaques and langurs within the same habitat. Such interactions may represent an additional ecological pressure that warrants further investigation. The results of these analyses will inform the development of targeted conservation measures, including habitat management strategies and the identification of priority

areas for protection. Ultimately, these steps will contribute to the formulation of a comprehensive conservation and management plan aimed at ensuring the long-term survival of the Hatinh langur in this area.

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# Population status of rhesus macaques (*Macaca mulatta*) and capped langurs (*Trachypithecus pileatus*) in a vanishing deciduous forest landscape in Bangladesh

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**Keywords:** Rhesus macaque; *Macaca mulatta*; capped langur; *Trachypithecus pileatus*; Madhupur National Park; habitat loss; density

**Summary**

Wildlife population assessments are essential for long-term monitoring and conservation planning, yet robust baselines remain scarce in many declining forest ecosystems. Madhupur National Park, one of the largest remaining tracts of moist deciduous Sal (*Shorea robusta*) forest in Bangladesh, lacks a systematically established and reproducible baseline of primate populations. We conducted a population survey of diurnal primates in 2022 using complete counts along pre-established forest trails and roads, with density estimates derived from a strip transect approach. Estimated cluster densities were 1.03 clusters/km$^2$ for rhesus macaques (*Macaca mulatta*) and 1.01 clusters/km$^2$ for capped langurs (*Trachypithecus pileatus*), corresponding to individual densities of 40.54 and 7.23 individuals/km$^2$, respectively. Historical data were insufficient to assess population trends. Nearly half of the rhesus macaque population was concentrated near picnic areas where provisioning occurs, whereas capped langurs more frequently used forest-edge settlements, likely reflecting limited food availability within the Sal-dominated forest. Despite potential overestimation associated with linear transects, this study establishes a repeatable monitoring baseline. Overall, extensive forest loss, agricultural expansion and provisioning appear to favor the ecologically flexible rhesus macaque while negatively affecting the forest-dependent capped langurs in the forest, demonstrating how ecological flexibility influences species persistence in changing landscapes.

# Đánh giá tình trạng quần thể khỉ vàng (*Macaca mulatta*) và voọc mũ (*Trachypithecus pileatus*) tại một hệ sinh thái rừng rụng lá đang bị thu hẹp ở Bangladesh

**Tóm tắt**

Đánh giá quần thể động vật hoang dã là nền tảng quan trọng cho công tác giám sát dài hạn và lập kế hoạch bảo tồn. Tuy nhiên, các số liệu cơ sở đáng tin cậy vẫn còn thiếu ở nhiều hệ sinh thái rừng đang bị suy thoái. Vườn Quốc gia Madhupur, một trong những khu rừng Sal (*Shorea robusta*) rụng lá ẩm còn lại lớn nhất tại Bangladesh, hiện chưa có bộ dữ liệu cơ sở được thiết lập một cách hệ thống và có khả năng lặp lại về quần thể linh trưởng. Chúng tôi tiến hành khảo sát quần thể các loài linh trưởng hoạt động ban ngày vào năm 2022 bằng phương pháp đếm toàn bộ dọc theo các tuyến đường và đường mòn rừng được xác định trước, đồng thời ước tính mật độ theo phương pháp tuyến dải (strip transect). Mật độ đàn ước tính đạt 1,03 đàn/km$^2$ đối với khỉ vàng (*Macaca mulatta*) và 1,01 đàn/km$^2$ đối với voọc mũ (*Trachypithecus pileatus*), tương ứng với mật độ cá thể là 40,54 và 7,23 cá thể/km$^2$. Dữ liệu lịch sử không đủ để đánh giá xu hướng biến động quần thể.

Gần một nửa quần thể khỉ vàng được ghi nhận tập trung quanh các khu dã ngoại, nơi thường xuyên có hoạt động cho động vật ăn. Trong khi đó, voọc mũ xuất hiện phổ biến hơn tại các khu dân cư ven rừng, có thể phản ánh sự hạn chế về nguồn thức ăn trong các khu rừng Sal chiếm ưu thế. Mặc dù phương pháp khảo sát theo tuyến có thể dẫn đến hiện tượng đánh giá cao hơn thực tế về mật độ quần thể, nghiên cứu này đã xây dựng được bộ dữ liệu cơ sở có thể lặp lại cho công tác giám sát dài hạn. Nhìn chung, tình trạng mất rừng trên diện rộng, mở rộng đất nông nghiệp và hoạt động cung cấp thức ăn nhân tạo dường như tạo điều kiện thuận lợi cho loài khỉ vàng có khả năng thích nghi sinh thái cao, trong khi gây tác động bất lợi đến loài voọc mũ phụ thuộc nhiều vào sinh cảnh rừng. Kết quả này cho thấy vai trò quan trọng của tính linh hoạt sinh thái trong việc quyết định khả năng tồn tại của các loài linh trưởng trong những cảnh quan đang biến đổi nhanh chóng.

## Introduction

Biodiversity loss is one of the most pressing environmental crises of the 21$^{st}$ century, driven primarily by human-induced habitat fragmentation, alteration, and climate change (Gibson et al. 2011; Haddad et al. 2015). Tropical and subtropical deciduous forests are particularly vulnerable, facing extensive deforestation for agriculture, urban expansion, and commercial plantations (Stan et al. 2024). Such activities not only reduce natural forest cover but also alter habitat structure, microclimate, and ecosystem functioning (Sodhi et al. 2010; Hansen et al. 2013). These disturbances disrupt ecological networks, reduce resource availability, and elevate extinction risks, especially for forest-dependent species with narrow habitat or dietary niches (Devictor et al. 2008; Estrada et al. 2017).

Species responses to habitat alteration are closely linked to their ecological flexibility (Fei et al. 2017). Generalist species with a broad ecological niche, capable of exploiting diverse habitats and food sources, often adapt and persist in human-modified landscapes (Cushman et al. 2025). In contrast, specialists, those with specific habitat or dietary requirements, tend to experience population declines or local extirpation under the changing conditions (Nowak & Lee 2013). Such contrasting responses highlight the importance of investigating how long-term habitat changes affect species populations with differing niches, particularly among tropical mammals (Arroyo-Rodríguez et al. 2017).

Nonhuman primates are one of the most threatened groups of mammals. They occupy a wide range of tropical habitats and play critical ecological roles as seed dispersers and regulators of forest dynamics. Yet, global assessments indicate that about 60% of primate species are threatened with extinction and roughly 75% are in decline, largely due to habitat loss, hunting, illegal trade and climate change (Estrada et al. 2017). As most primates depend heavily on forest integrity, their

population status reflects the broader health of tropical ecosystems and offers insights into their adaptive capacities and persistence in human-dominated landscapes (Nowak & Lee 2013).

In South Asia, the Madhupur deciduous forest tract of Bangladesh is home to three primate species with varying ecological requirements, such as diet, ranging behavior, degree of arboreality, forest dependency, and tolerance to anthropogenic disturbance: rhesus macaque (*Macaca mulatta*), capped langur (*Trachypithecus pileatus*) and the Bengal slow loris (*Nycticebus bengalensis*) (Monirujjaman & Khan 2018; Ahmed & Rupom 2021). In particular, the rhesus macaque is the most widely distributed nonhuman primate globally and occupies a range of habitats in Bangladesh, from deciduous and evergreen forests to urban environments (Hasan et al. 2013; IUCN Bangladesh 2015). Although ecologically flexible, its national population has declined, with fewer than 10,000 mature individuals remaining in Bangladesh (IUCN Bangladesh 2015), and each local population in the country typically numbers fewer than 1,000 (Hasan et al. 2013). It is classified as Least Concern globally but Vulnerable in Bangladesh (IUCN Bangladesh, 2015). On the other hand, the capped langur is an arboreal folivore primate, distributed across Bangladesh, Northeast India, Bhutan, and southern Tibet in China, with the Brahmaputra–Jamuna–Padma–Meghna River system in Bangladesh marking its westernmost range limit (Roos et al. 2014; Ahmed et al. 2025; Gogoi et al. 2025). In Bangladesh, it primarily inhabits the north-central deciduous forests and eastern mixed evergreen and hill forests (IUCN Bangladesh 2015). Globally listed as Vulnerable and Endangered in Bangladesh, the species has suffered over 50% habitat decline, with only small, isolated extant local populations (IUCN Bangladesh 2015; Das et al. 2024). The remaining species, the Bengal slow loris, has only a single sighting from the forest, but no in-depth research has been conducted yet (Ahmed and Rupom 2021).

Over recent decades, the forest has undergone severe degradation due to agricultural encroachment, settlements, and monoculture plantations, leading to substantial loss and fragmentation of natural habitat (Al Faruq et al. 2016; Islam et al. 2023). Such long-term habitat modification may have affected the primate populations in this forest, but have not been investigated yet. Several surveys have attempted to estimate primate populations within the Madhupur deciduous forest, yet the results are difficult to compare. Studies have used different spatial scales for census and effort levels, ranging from opportunistic counts and group tallies to partial line-transect sampling, without standardised detection correction or clear assumptions (e.g., Green 1978; Islam & Hossain 1982; Khan & Ahsan 1986; Akonda et al. 1989; Hasan et al. 2013; Naher et al. 2016; Naher & Khan 2018). Thus, existing estimates provide only incomplete insights and cannot serve as reliable baselines. Robust baselines that are established with reproducible methods are essential for long-term monitoring and adaptive management, particularly in landscapes undergoing rapid transformation (Campbell et al. 2016). To address this knowledge gap, this study aims to establish a baseline of the status of diurnal primates in the vanishing deciduous forest landscape of Bangladesh. By employing systematic data collection and simple analysis, it seeks to provide repeatable estimates that can serve as a foundation for long-term monitoring. Such a baseline is vital for assessing future changes, identifying conservation priorities, and informing the management of one of the last remaining deciduous forest ecosystems in the region.

## Methods

### Study Area

Madhupur National Park is the largest remaining tract of old-growth natural Sal (*Shorea robusta*) forest in Bangladesh (Stanford 1991; Fig. 1). Approximately 500 years ago, this forest served as a hunting ground for the aristocrats of the Mughal Empire and was home to a diverse megafauna, including Indian rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), wild water buffalo (*Bubalus arnee*), nilgai (*Boselaphus tragocamelus*), sambar deer (*Rusa unicolor*), Bengal tiger (*Panthera t. tigris*), leopard (*Panthera pardus*), and sloth bear (*Melursus ursinus*) (Stanford 1991). However, these species have been exterminated most likely due to poaching and sustained anthropogenic pressures on their habitats (Stanford 1991).

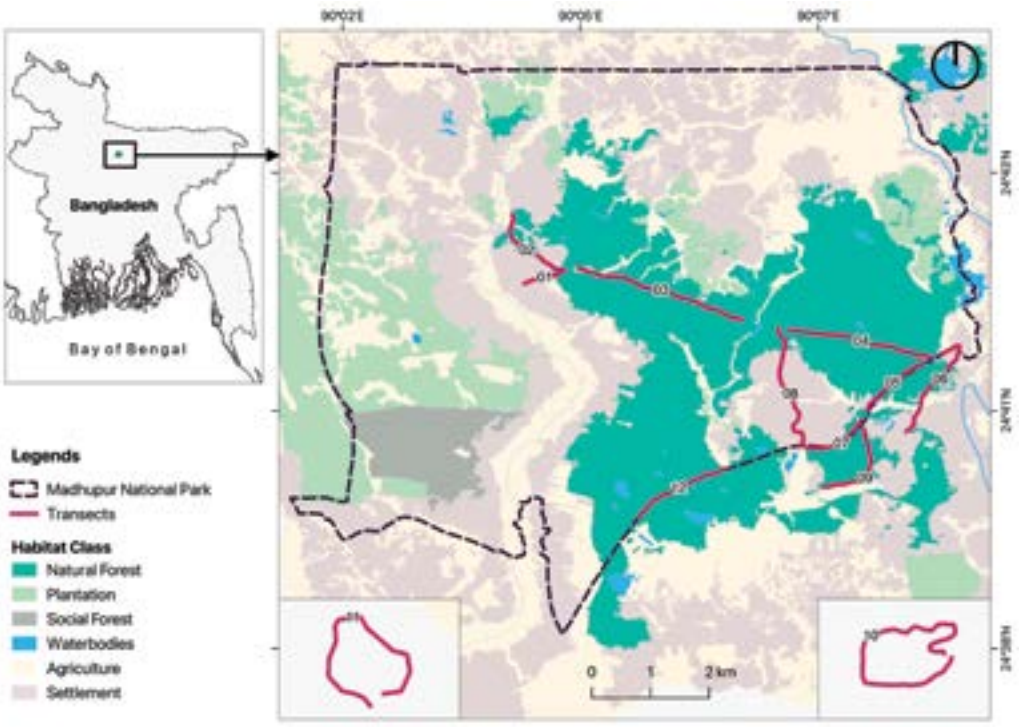



**Fig.1.** Land cover classes of Madhupur National Park in 2015 (Bangladesh Forest Department, 2015) and geographic position of the 12 survey transects (01 – 12). The transects (10 and 11) outside the national park are shown in the corners of the figures. The map insert shows the geographic position of the national park within Bangladesh.

Although legally designated as Madhupur National Park (8436 ha) in 1982, the area now comprises a highly modified agroforestry mosaic, with only about 40% remaining as natural deciduous Sal forest, while the majority is occupied by economically important woody plantations, agricultural land, and human settlements (Bangladesh Forest Department 2025). The floral diversity of the park is substantial, with 102 tree species, with Sal as the dominant tree species (Kibria and Saha 2011). Monirujjaman & Khan (2018) reported at least 111 bird, 15 mammal, 15 reptile, and 10 amphibian species from the park, although no comprehensive faunal survey has been conducted. Besides rhesus macaques and capped langurs, most likely, nocturnal Bengal slow loris occur as a third primate species (Ahmed & Rupom 2021). The Tangail-Mymensingh highway divides the forests, and a firing range of the National Air Force is situated at the forest edge. Several sites within the forest are frequently used as picnic spots (Naher et al. 2017).

## Data Collection

We conducted our census on 26 days between June and December 2022. Preliminary information on primate distribution was obtained through informal interviews with local forest department personnel. Following previous surveys, we did 'Complete Counts' of rhesus macaques and capped langurs along transects (Ross & Reeve 2011; Campbell et al. 2016) that were already used in some of the previous studies in the forest (e.g., Green 1978; Islam & Hossain, 1982; Hasan et al. 2013; Naher et al. 2016; Naher & Khan, 2018). Since both of our focus species are group-living, and since we were not able to identify individuals or individual groups with certainty, we used the more neutral term cluster instead of group. To avoid double-counting of clusters, we regarded two clusters as independent counts if the distance between two clusters was at least 0.5 km for the rhesus macaque and 1.5 km for capped langurs. Distance thresholds were selected based on species-specific spatial ecology, with a shorter threshold for rhesus macaques due to their high ecological flexibility and

varied habitat use, characterized by small and overlapping space use (Sarker et al. 2005; Jaman and Huffman 2013), and a larger threshold for capped langurs, which are forest-dependent primates with comparatively larger home ranges and wider inter-group spacing (Stanford 1991).

We conducted our survey along 12 transects, which included pre-established forest trails, forest roads and a highway (Fig. 1, Table 1). Transect lengths ranged from 0.5 to 3.45 km. Two trained observers, accompanied by a local eco-guide, walked the transects at an approximate speed of 1.5 km/h between 06:00 and 11:00 a.m.. Each transect was walked between 1 and 12 times (mean = 8.8). Observers paused every 100 m for 2–3 minutes to scan for primates. Upon detection, we spent about 10 minutes and recorded species identity, GPS coordinates of the cluster, cluster size, and age-sex composition of the cluster (if possible). We categorised individuals into three age classes: adult, non-adult (sub-adult and juvenile), and infant (Hasan et al. 2013; Naher et al. 2016). Additionally, we visited two nearby rubber and mahogany plantations outside the park boundary to collect data on primate abundances that have been reported by local staff.

**Table 1.** Details of the primate survey transects in the Madhupur deciduous forest during 2022.

| Transects | Name of the area | Length (km) | Number of repetitions | Main habitat |
|---|---|---|---|---|
| 1 | Vutia Village - Dokhola Gate | 0.73 | 12 | Teak plantation and human settlements |
| 2 | Dokhola Gate - Chunia Cottage | 1.57 | 12 | mixed vegetation and agricultural fields |
| 3 | Dokhola Gate - Lohoria Watch Tower | 3.45 | 12 | deciduous forest |
| 4 | Lohoria Center - Rasulpur Gate | 2.9 | 12 | deciduous forest |
| 5 | Rasulpur Gate - Mohua Cottage | 1.52 | 12 | deciduous forest |
| 6 | Rasulpur Gate - Rajbari Village | 2.37 | 6 | Teak plantation and human settlements |
| 7 | Telki Village - Mohua Cottage | 1.24 | 8 | agricultural landscapes |
| 8 | Lohoria Center - Telki Village | 2.51 | 6 | deciduous forest, settlements, agricultural field |
| 9 | Mohua Cottage - Air Force Camp | 1.81 | 12 | deciduous forest |
| 10 | Santoshpur Beat | 0.53 | 6 | rubber plantations |
| 11 | Jagirachala | 1.14 | 1 | settlements and homestead vegetation |
| 12 | Jolchatra-Telki Road | 1.7 | 6 | settlements, homestead vegetation, agricultural field |

## Data analysis

The mean cluster size for each species was calculated as the arithmetic mean of the number of individuals per observed cluster, excluding solitary individuals. We used the maximum perpendicular distance of the cluster's centre from the transect as the effective strip width, where the detection probability is assumed to be 1 (Green 1978; National Research Council 1981). We calculated the total transect length by multiplying the transect length by the number of repetitions and summing the results. Finally, we estimated the primate density following the Kelker-based method, using the equation, $D = n / 2La$, where $D$ = density of individuals or groups per unit area, $n$ = number of individuals or clusters along the transects, $L$ = total length of the transect, and $a$ = half the effective strip width (National Research Council 1981).

## Results

In 2022, we surveyed 197.5 km along the 12 transects and identified 25 clusters, comprising 11 rhesus macaque clusters and 14 capped langur clusters (Fig. 2). The average strip width for rhesus macaques was 54.1 m, resulting in a surveyed area of 533.8 ha (6.3% of the study area), while with an effective strip width of 70.2 m, the surveyed area for capped langurs was 693 ha (8.2% of the study area). Cluster density of rhesus macaque and capped langur was 1.03 and 1.01 clusters/km$^2$, and the individual density was 40.54 and 7.23 individuals/km$^2$, respectively. In addition, we observed one solitary adult male capped langur within the park boundary. The average inter-cluster distance between rhesus macaque clusters was 2.6 km (range: 0.5 to 5.2 km; SD: ± 1.4 km), and the average inter-cluster distance between capped langur clusters was 11.4 km (range: 2.1 to 24.4 km, SD: ± 4.2 km). Because of this distance, double-counting of clusters was unlikely, and these clusters were most likely identical with social groups (Table 2, 3).

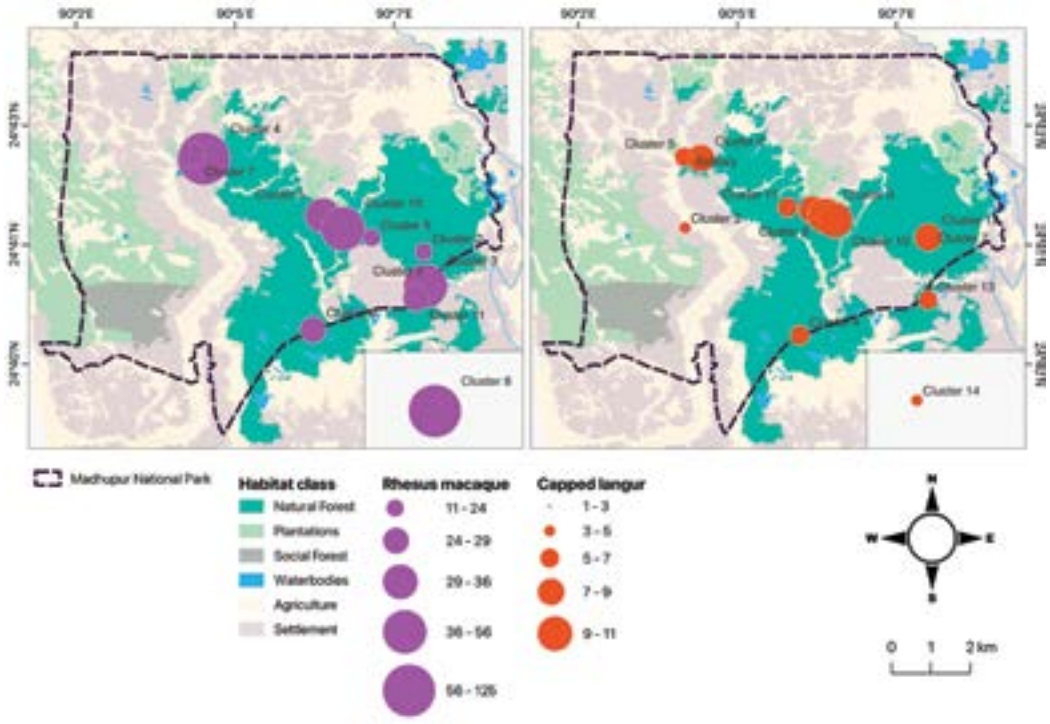



**Fig.2.** Distribution and sizes of rhesus macaques (*Macaca mulatta*) (blue) and capped langurs (*Trachypithecus pileata*) (red) clusters along our survey transects within and near Madhupur National Park. The clusters recorded outside the national park are shown in the right corners of the figures.

**Table 2.** Rhesus macaque populations in and around Madhupur National Park. AM = adult male, AF = adult female; SA+J = subadult and juvenile.

| Group No. | Location | GPS coordinate (Latitude, Longitude) | Transect no | Cluster Size | AM | AF | SA + J | Infant |
|---|---|---|---|---|---|---|---|---|
| 01 | Rasulpur Gate | 24° 39.989' N, 90° 11.594' E | 6 | 24 | 1 | 3 | 8 | 12 |
| 02 | Lohoria - Rasulpur | 24° 40.447' N, 90° 11.485' E | 4 | 11 | 2 | 2 | 3 | 4 |
| 03 | Beribaid Watch Tower | 24° 39.947' N, 90° 11.515' E | 5 | 38 | 8 | 10 | 14 | 6 |
| 04 | Chunia Cottage | 24° 41.798' N, 90° 9.003' E | 2 | 90 | 19 | 25 | 28 | 18 |
| 05 | Dokhola - Lohoria | 24° 40.867' N, 90° 10.398' E | 3 | 36 | 7 | 9 | 7 | 13 |
| 06 | Goyra Village | 24° 40.535' N, 90° 11.000' E | 8 | 13 | 3 | 3 | 5 | 2 |
| 07 | Dokhola Gate | 24° 41.885' N, 90° 8.896' E | 1 | 29 | 4 | 9 | 11 | 5 |
| 08 | Santoshpur Beat | 24° 35.287' N, 90° 12.609' E | 10 | 125 | 22 | 13 | 59 | 31 |
| 09 | Telki – Mohua Cottage | 24° 39.264' N, 90° 10.293' E | 7 | 25 | 5 | 3 | 12 | 5 |
| 10 | Dokhola- Lohoria | 24° 40.689' N, 90° 10.542' E | 3 | 56 | 4 | 7 | 32 | 13 |
| 11 | Dokhola - Lohoria | 24° 39.675' N, 90° 11.397' E | 3 | 29 | 4 | 9 | 11 | 5 |
| | | | **Total** | **476** | **79** | **93** | **190** | **114** |

**Table 3.** Capped langur populations in and around Madhupur National Park. AM = adult male, AF = adult female; SA+J = subadult and juvenile

| Group No. | Location | GPS coordinate (Latitude, Longitude) | Transect no | Cluster Size | AM | AF | SA + J | Infant |
|---|---|---|---|---|---|---|---|---|
| 01 | Dokhola -Lohora | 24° 41.925' N, 90° 5.938' E | 3 | 8 | 2 | 2 | 2 | 2 |
| 02 | Dokhola - Lohoria | 24° 41.842' N, 90° 6.123' E | 3 | 11 | 2 | 1 | 7 | 1 |
| 03 | Vutia Village | 24° 41.658' N, 90° 4.012' E | 1 | 4 | 1 | 1 | 1 | 1 |
| 04 | Beribaid | 25° 8.617' N, 90° 14.325' E | 5 | 7 | 1 | 2 | 2 | 2 |
| 05 | Watch Tower | 24° 42.723' N, 90° 4.005' E | 2 | 7 | 2 | 2 | 1 | 2 |
| 06 | Chunia Cottage | 24° 42.703' N, 90° 4.253' E | 3 | 9 | 1 | 3 | 2 | 3 |
| 07 | Dokhola | 24° 41.497' N, 90° 7.685' E | 4 | 6 | 1 | 2 | 1 | 2 |
| 08 | Watch Tower | 24° 41.857' N, 90° 6.090' E | 3 | 9 | 1 | 3 | 2 | 3 |
| 09 | Rasulpur- Lohoria | 24° 41.833' N, 90° 6.140' E | 3 | 10 | 2 | 2 | 4 | 2 |
| 10 | Dokhola - Lohoria | 24° 41.773' N, 90° 6.273' E | 4 | 11 | 1 | 2 | 6 | 2 |
| 11 | Dokhola - Lohoria | 24° 41.965' N, 90° 5.560' E | 3 | 7 | 1 | 2 | 3 | 1 |
| 12 | Lohoria - Rasulpur | 24° 41.512' N, 90° 7.685' E | 4 | 9 | 2 | 1 | 4 | 2 |
| 13 | Dokhola - Lohoria | 24° 40.565' N, 90° 7.677' E | 9 | 6 | 2 | 2 | 1 | 1 |
| 14 | Jagirachala | 24° 41.075' N, 90° 0.450' E | 11 | 5 | 1 | 1 | 2 | 1 |
| Solitary | Chunia Cottage | 24° 42.738' N, 90° 4.140' E | 2 | 1 | 1 | | | |
| | | | **Total** | **110** | **21** | **26** | **36** | **25** |

We counted 476 rhesus macaques in 11 clusters. Their cluster size ranged from 11 to 125 individuals (mean = 43.3, SD = 33.6). Ten out of 11 clusters (91%) contained more than one adult male. About 36% of the individuals (n = 172) were adults, 40% (n=190) sub-adults and juveniles, and 24% (n = 114) were infants. We found 10 clusters within the national park, and one outside near a rubber plantation (cluster 8, Fig. 2-blue). We found 50% of the macaque population in only three clusters (4, 8, and 10) situated near picnic sites.

We counted 109+1 capped langurs in 14 clusters. The cluster size ranged from 4 to 11 individuals (mean = 7.8, SD = 2.1). The proportion of adults was 43% (n = 47), of sub-adults and juveniles 35% (n = 36), and of infants 23% (n = 25). Among the adult individuals, 44.7 % (n = 21) were males and 55.3% (n = 26) were females.

**Discussion**

During the 2022 survey, we identified 11 clusters of rhesus macaques, comprising 476 individuals, and 14 groups of capped langurs, comprising 109 individuals (+1 solitary individual), in the Madhupur deciduous forest. The cluster density of rhesus macaque and capped langur was 1.03 and 1.01 clusters/km$^2$, and the individual density was 40.54 and 7.23 individuals/km$^2$, respectively. Several studies have been conducted on primate populations in the forest (Green 1978; Islam and Hossain 1982; Khan and Ahsan 1986; Hasan et al. 2013; Naher et al. 2016; Naher and Khan 2018), but primate densities were not reported except for the very first survey from 1976 (Green 1978). The estimated densities were 0.7 clusters/km$^2$ and 6.8 individuals/km$^2$ for rhesus macaques and 4.4 clusters/km$^2$ and 31.1 individuals/km$^2$ for capped langurs (Green 1978). The total survey effort of the 1976 study was 830 ha, including 340 ha of foot walks and 490 ha of vehicle-based surveys. The maximum transect width in the foot-walks and vehicle-based surveys were reported to be approximately 200 m and 100 m, respectively. During 2022, we conducted only foot walks, with an effective transect width of 54.1 m for rhesus macaques, resulting in a total surveyed area of 533.8 ha and an effective strip width of 70.2 m, totalling 693 ha for capped langurs. However, lacking specific information on historically used transects, we cannot confirm whether we used the same transects. The major differences in the rhesus macaque densities can be attributed to the export of 1829 rhesus macaques from Bangladesh to the United States for biomedical research between 1972 and 1976 (Muckenhirn 1977; Green 1978), and one of the several sources of the exported wild macaques was Madhupur forest (Akonda et al. 1989). Thus, direct comparison of rhesus macaque density between the 1976 and 2022 surveys is not appropriate.

Following the cessation of exports and subsequent behavioural adaptation to human-modified environments, the rhesus macaque population appears to have rebounded, facilitated by increased access to agricultural resources in the surrounding landscape and by food provisioning. In other forests and urban landscapes in the country, the rhesus macaque densities ranged from 2.2–19.2 individuals/km$^2$ (Feeroz 1999; Khan 2012; Neha et al. 2021). Furthermore, between 1976 and 2022, the mean cluster size of rhesus macaques in Madhupur has increased from 9.3 to 43.3 ± 33.6, also reflecting recovery following the cessation of export, and an increase toward 2022. Over the years, there was a high variability among cluster sizes in the forest (Table 4). Among others, the mean cluster size for rhesus macaque was 41.3 ± 16.7 in human settlements and 30.2 ±10.9 in forest habitats in Bangladesh (Hasan et al. 2013).

**Table 4.** Demographic data of primate populations in Madhupur National Park between 1976 and 2022.

| Survey period | Species | Total population | Number of clusters | Mean cluster size | Individual density/ km$^2$ | Cluster density/ km$^2$ | Source |
|---|---|---|---|---|---|---|---|
| 1976 | Rhesus macaque | 56 | 6 | 9.3 | 6.8 | 0.7 | Green 1978 |
| 1979-81 | Rhesus macaque | 142 | 7 | 20.3 | | | Khan & Ahsan 1986 |
| 2005-2010 | Rhesus macaque | 347 | 18 | 19.3 | | | Hasan et al. 2013 |
| 2015 | Rhesus macaque | 248 | 11 | 22.5 | | | Naher et al. 2016 |
| 2022 | Rhesus macaque | 476 | 10 | 43.3 ± 33.6 | 40.5 | 1.0 | This study |
| 1976 | Capped langur | 258 | 34 | 7.6 | 31.1 | 4.4 | Green 1978 |
| 1977 | Capped langur | 134 | 17 | 6.4 | | | Islam & Hossain 1982 |
| 1977 | Capped langur | 135 | 25 | 6.4 | | | Islam & Hossain 1982 |
| 1979-81 | Capped langur | 165 | 29 | 5.7 | | | Khan & Ahsan 1986 |
| 1986-88 | Capped langur | 417 | 49 | 8.5 | | | Stanford 1991 |
| 2015 | Capped langur | 99 | 12 | 7.6 | | | Naher et al. 2018 |
| 2015-16 | Capped langur | 155 | 18 | 8.6 | | | Khan et al. 2022 |
| 2022 | Capped langur | 110 | 14 | 7.8 ± 2.1 | 7.2 | 1.0 | This study |

Regarding capped langurs, a survey from 1979-81 reported 1.43 clusters/km$^2$ and 8.12 individuals/km$^2$ in the deciduous forests in Bangladesh, but the survey was not restricted to the Madhupur deciduous forest (Khan & Ahsan 1986). The reported capped langur densities in the semi-evergreen and hill forests in the country ranged from 1.2–3.5 individuals/km$^2$ (Feeroz 1999). Thus, the current density of rhesus macaque and capped langur in Madhupur forest is the highest among all reported densities in Bangladesh (Table 5). However, the mean cluster size of capped langurs between 1976 and 2016 did not change much, ranging between 5.7 and 8.6 individuals in Bangladesh, while our estimate of mean cluster size in Madhupur forest (7.8 ± 2.1) was within the reported range (Table 4).

**Table 5.** Density of rhesus macaques and capped langurs in Bangladesh.

| Species | Survey year | Habitat type | Individuals/km$^2$ | Clusters/km$^2$ | Source |
|---|---|---|---|---|---|
| *M. mulatta* | 1976 | Deciduous | 6.8 | 0.7 | Green 1978 |
| *M. mulatta* | 1979 – 81 | Deciduous | 7.0 | 0.34 | Khan & Ahsan 1986 |
| *M. mulatta* | 1979 – 81 | Evergreen | 7.85 | 0.40 | Khan & Ahsan 1986 |
| *M. mulatta* | 1979 – 81 | Mangrove | 17.05 | 1.58 | Khan & Ahsan 1986 |
| *M. mulatta* | 1996 – 97 | Evergreen | 6.0 – 19.2 | 0.2 – 0.8 | Feeroz 2002 |
| *M. mulatta* | 2015 – 16 | Urban | 15.5 | – | Neha et al. 2021 |
| *M. mulatta* | 2001– 07 | Mangrove | 2.2 – 6.5 | – | Khan 2012 |
| *M. mulatta* | 2022 | Deciduous | 40.54 | 1.03 | This study |
| *T. pileatus* | 1976 | Deciduous | 31.1 | 4.4 | Green 1978 |
| *T. pileatus* | 1976 | Evergreen | 1.5 – 6.0 | 0.3 – 0.9 | Green 1978 |
| *T. pileatus* | 1979 – 81 | Deciduous | 8.12 | 1.43 | Khan & Ahsan 1986 |
| *T. pileatus* | 1979 – 81 | Evergreen | 3.48 | 0.52 | Khan & Ahsan 1986 |
| *T. pileatus* | 1996 – 97 | Evergreen | 1.2 – 3.5 | 0.2 – 0.7 | Feeroz 2002 |
| *T. pileatus* | 2017-2023 | Evergreen | – | 0.01 – 2.46 | Ahmed et al. 2025 |
| *T. pileatus* | 2022 | Deciduous | 7.23 | 1.01 | This study |

In this study, we conducted line transect surveys along multiple pre-established forest trails, forest roads, and a highway to maximize the spatial coverage. From an ecological perspective, roads represent linear openings that may influence animal space use and detectability in non-random ways (Thomas et al., 2010; Campbell et al., 2016). In Madhupur forest, the ecologically flexible rhesus macaques frequently use roads as travel routes or foraging sites and are often provisioned by visitors along roadsides (Monirujjaman & Khan, 2017). While capped langurs are more forest-dependent, they may still be more detectable along roads due to improved visibility associated with reduced canopy and understory cover. Thus, road-based transects may elevate encounter rates and detectability and can lead to an overestimation of population densities relative to the true population. Therefore, density estimates should be interpreted with appropriate caution when making comparisons (Kiffner et al. 2022).

### Implications for management and conservation

In Madhupur forest, forest cover declined substantially from 6166.8 ha to 4001.0 ha, while agricultural land expanded from 677.3 ha to 3350.3 ha between 1990 and 2020 (Karim et al. 2023). These land-use changes may have contrasting implications for primates with differing ecological strategies. The rhesus macaque is a habitat generalist, whereas the capped langur is a predominantly folivorous and forest-dependent species. Rhesus macaques readily exploit human-modified environments, including agricultural landscapes within and around the forest, and are heavily provisioned by visitors and local authorities, contributing to increased human–macaque conflict (Naher et al. 2016, 2017). In contrast, deciduous forests inherently provide limited and seasonally variable food resources (Green 1978), a constraint that disproportionately affects capped langurs. During the dry season, several capped langur clusters frequently move into forest-fringe villages and adjacent agricultural areas in search of food (Khan 2022). Furthermore, disrupted canopy continuity caused by roadside tree removal, illegal logging, vehicle collisions, occasional hunting, and electrocution continues to result in individual losses (Naher et al. 2017). Together, these changes in habitat quality, food availability, and anthropogenic pressures have likely differentially shaped the abundance, ecology, and long-term persistence of these two species over the past four decades, highlighting the need for species-specific management and conservation interventions.

## Conclusion

In this study, we present the population status of rhesus macaques and capped langurs in the Madhupur deciduous forest in Bangladesh, applying reproducible methods to enable monitoring the populations in the future. Based on the results and the ongoing changes in habitat and anthropogenic factors, we highlighted the need for species-specific management and conservation interventions in the forest.

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# Canopy bridges for the 'Endangered' Hatinh langurs (*Trachypithecus hatinhensis*) – built by local community in Tuyen Phu Commune, Quang Tri Province, Vietnam

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**Keywords:** Canopy bridge, Hatinh langur, *Trachypithecus hatinhensis*, wildlife corridors, Community-based conservation, Primate Tourism for Conservation

**Summary**

Hatinh langur (*Trachypithecus hatinhensis*) is an endangered langur that inhabits limestone forests of central Vietnam. One of the subpopulations of this species is located within 500 ha of isolated forest patches close to Thuan Hoan and Thiet Son village, in Tuyen Phu commune, Quang Tri Province. A volunteer Community Conservation Team has protected this population since 2012. Nevertheless, the fragmented habitats due to road expansion and increases in the traffic volume in the area have been threatening both langurs and the people because of human-wildlife conflict, notably when these animals attempt to cross the road. The initiative of canopy bridges as eco-friendly wildlife corridors had been suggested by the volunteer community conservation group and HIVOOC Co. Ltd - a pioneer in primate tourism for conservation. As a result, two bridges with a total cost of 1,930 US dollars were installed and completed by locals within one month. The majority of funding came from HIVOOC's customers and primatologists. The local team has witnessed langurs crossing the roads safely without difficulties, marking a significant achievement in the conservation effort of Hatinh langur population in the area.

# Cầu treo trên tán cây dành cho loài voọc Hà Tinh (*Trachypithecus hatinhensis*) đang có nguy cơ tuyệt chủng – được xây dựng bởi cộng đồng địa phương tại xã Tuyên Phú, tỉnh Quảng Trị, Việt Nam

**Tóm tắt**

Voọc Hà Tĩnh (*Trachypithecus hatinhensis*) là một loài voọc nguy cấp, sinh sống trong các khu rừng núi đá vôi ở miền Trung Việt Nam. Một trong những tiểu quần thể của loài này phân bố trong khoảng 500 ha rừng bị chia cắt gần các thôn Thuận Hoan và Thiết Sơn, xã Tuyên Phú, tỉnh Quảng Trị. Từ năm 2012, quần thể này đã được một nhóm bảo tồn cộng đồng tình nguyện địa phương bảo vệ. Tuy nhiên, tình trạng sinh cảnh bị chia cắt do mở rộng đường giao thông và lưu lượng phương tiện ngày càng tăng trong khu vực đang đe dọa cả voọc và người dân, đặc biệt là nguy cơ xung đột giữa con người và động vật hoang dã khi các cá thể voọc cố gắng băng qua đường. Sáng kiến xây dựng cầu Voọc rừng như những hành lang sinh thái thân thiện với động vật hoang dã đã được đề xuất bởi nhóm bảo tồn cộng đồng tình nguyện và Công ty TNHH HIVOOC – đơn vị tiên phong trong mô hình du lịch linh trưởng gắn với bảo tồn. Kết quả là hai cây cầu, với tổng chi phí 1.930 USD, đã được người dân địa phương lắp đặt và hoàn thành trong vòng một tháng. Phần lớn kinh phí đến từ sự đóng góp của các khách hàng của HIVOOC và các nhà linh trưởng học. Nhóm địa phương đã ghi nhận các cá thể voọc băng qua đường một cách an toàn và thuận lợi thông qua các cây cầu này, đánh dấu một thành tựu quan trọng trong nỗ lực bảo tồn quần thể Voọc Hà Tĩnh tại khu vực.

## Introduction

Hatinh langur (*Trachypithecus hatinhensis*) is one of the members of limestone langurs that inhabit limestone forests in Vietnam (Fig. 1). The species is recognized as 'Endangered' and protected under Vietnamese Decree 84/2021/ND-CP (The Government of Vietnam 2021), listed in Appendix I of CITES and considered also as 'Endangered' by the IUCN Red List of Threatened Species (Le Khac Quyet 2021). The species occurs in Quang Tri Province, central Vietnam, and eastern Laos. Isolated populations have been reported in different areas of Quang Tri Province (the former Quang Binh province was merged with the Quan Tri province) in Bac Huong Hoa Nature Reserve, Phong Nha-Ke Bang National Park, and karst areas in Tuyen Hoa forest and in Tuyen Phu. There were reports of the estimated population size for Phong Nha-Ke Bang National Park, however, with very low reliability from 150 (Nguyen Van Truong 2013) to about 2200 individuals (Haus et al. 2009). In Tuyen Phu a previous field survey documented 22 groups with 156 individuals (Dong Thanh Hai & Thao A Tung 2018). This population has been protected by the Community Conservation Team since 2012. The main threats to the langur's populations are habitat fragmentation by people's land and forest encroachment, and poaching. Currently, locals in the area have reported various incidents of langurs crossing roads, which startle commuters and result in motorbike accidents. In the past, there have been reports of aggressive attacks by langurs on passers-by in the Huong Lap commune (Huong Lai 2021; Nadler 2020) (Fig. 2). Similar aggressive behavior has also been reported in Francois' langurs, a closely related species (Nadler 2023) A bridge for langurs over a busy road would reduce conflicts for both passers-by and langurs.



**Fig.1.** A family of Hatinh langurs in Tuyen Hoa forest. Photo: Bui Van Tuan.



**Fig.2.** A Hatinh langur crossing the road, potentially causing dangers to both the people and the langur. Photo: Bui Van Tuan.

Artificial canopy bridges have been proven to be an effective and practical solution for assisting wildlife like primates, with documented success across several primate species in different countries. In China, mountaineering-grade ropes are used to build a 15.8 m bridge for the Hainan gibbon (*Nomascus hainanus*), with the species adopting the structure after 176 days (Chan et al. 2020). Rubber-wrapped wire and rigid water pipe were applied for the Javan slow loris (*Nycticebus javanicus*) in Indonesia (Birot et al. 2020) or upcycled fire hose for dusky langurs (*Trachypithecus obscurus*) in Malaysia (Yap & Ruppert 2019); In India, Biswas et al. (2025) installed 15 canopy bridges of four designs for golden langurs (*Trachypithecus geei*), reducing ground-level crossings and road collision risk by approximately 74%. In addition, preserved natural tree branches have been documented as effective canopy bridges for 25 mammal species in Peru (Gregory et al. 2017). Similarly, in Vietnam, the use of canopy bridges for red-shanked douc langurs (*Pygathrix nemaeus*) in Son Tra Peninsula, Danang was also recorded (Ulibarri & Streicher 2012) (Table 1). Against this background, plans were drawn up for the construction of bridges for the langurs in the Tuyen Phu Commune.

**Table 1.** Different types of canopy overpass for arboreal primates.

| Bridge type | Materials | Species | Country | Reference |
|---|---|---|---|---|
| Double rope | Mountaineering-grade 13-mm diameter rope | Hainan gibbon (Nomascus hainanus) | China | Chan et al. (2020) |
| Rubber-wrapped wire/water pipe | Rubber on wire, rigid water pipe | Javan slow loris (Nycticebus javanicus) | Indonesia | Birot et al. (2020) |
| Fire hose | Upcycled NBR fire hose | Dusky langur (Trachypithecus obscurus) | Malaysia | Yap & Ruppert (2019) |
| Multi-design | Pipe, ladder, rope, bamboo | Golden langur (Trachypithecus geei) | India | Biswas et al. (2025) |
| Natural | Preserved tree branches | 25 mammal species | Peru | Gregory et al. (2017) |
| Rope | Rope | Red-shanked douc langur (Pygathrix nemaeus) | Vietnam | Ulibarri & Streicher (2012) |

## Methods and Materials

### Locations

The area is located in the township of Tuyen Phu, Quang Tri Province, central Vietnam, about 100 km from Phong Nha-Ke Bang National Park. It borders the villages of Thuan Hoan and Thiet Son. The

langur habitat covers a total of 500 hectares and consists mainly of limestone outcrops separated by agricultural land.

## Navigation of suitable positions to install canopy bridges

The conservation team and primate experts investigated and selected two suitable locations for the installation of the canopy bridges, both of which are Thiet Son (17°51'19.47528"N/106°6'20.476 44"E) and Thuan Hoan (17°51'42.02532"N/106°5'6.2682"E) (Fig. 3). The selected destinations are where langurs frequently cross roads. The initiative was approved by the local authorities. The bridge was installed with the active help of the villagers (Fig. 4).




**Fig.3.** Tuyen Phu Commune of Quang Tri Province, where the bridges were built.



**Fig.4.** Local community members participated in canopy bridge construction. Photo: Nguyen Thanh Tu.

## Materials and proposed design of the canopy bridge

The bridge structure consists of 6 mm thick steel cables, which serve as the main supporting structure. The distance between the two cables is 50 cm. A 60 cm wide B40 wire mesh is installed between them. The structure is anchored on both sides of the crossing to recycled concrete piers. The total height of each pier to the wire mesh is 8.5 m. The bridges have a span of 14 m. The 40 cm

diameter piers are anchored 1.5 m deep in a 1 m x 1 m concrete foundation. Each bridge is equipped with a steel rod and fixing bolts on both sides to secure the bridge ends and minimize vibrations, thus ensuring safe passage for the langurs. The bridge model was designed after prolonged direct observation of the langurs’ movement patterns at the two studied sites (Fig. 5, 6).

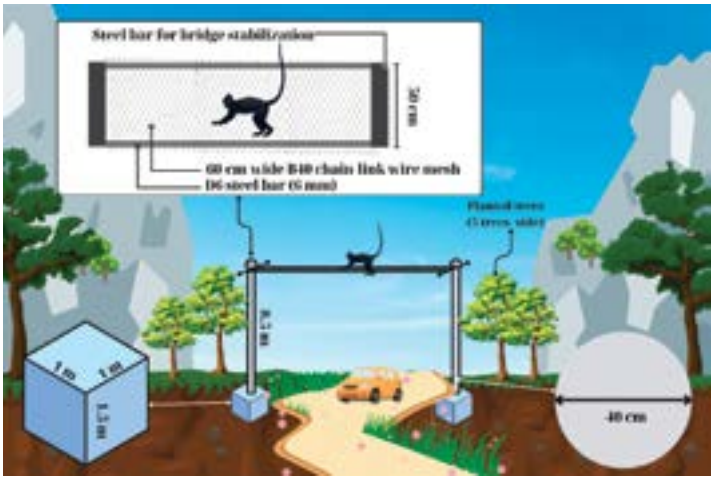



**Fig.5.** Design of the canopy bridge for Hatinh langurs.



**Fig.6.** Canopy bridge in Thuan Hoan village. Photo: Le Quang.

## Results

Two overpasses were constructed by the local conservation community members at two chosen locations in Thiet Son and Thuan Hoan in accordance with the proposed design, with a total budget of VND 50,000,000 (ca. USD 1,930). The budget includes materials, material transportation, and labor. To guide the langurs to the bridges and lead them across, native tree species were planted at each bridge location. These served as natural approach paths and encouraged the animals to use the bridges. Bridge construction was completed at the end of December 2025. The entire construction of the two bridges took approximately one month. Close to each bridge stands a signboard used to introduce the location of the bridges and acknowledge the organizations and individuals for their donation to the construction of the bridges. The inauguration ceremony of the bridges with engagement of the conservation community, local authorities, rangers, and the local citizens took place on May 20th, 2026.

### Records of langur crossing the bridge

Following the installation of the canopy bridges, the local conservation team has observed significant results. In Thuan Hoan, several langur individuals were found to utilize the bridges to cross the road safely one day after the bridge was in use (Fig. 7). After 5 months, community members documented 10 and 2 crossings in Thuan Hoan and Thiet Son, respectively.



**Fig.7.** Hatinhlangur crosses the bridge. Photo: Le Quang.

### Funding for the canopy bridge

The planning and construction of the canopy bridges were made possible through a combination of volunteer work by local people and fundraising activities related to conservation tourism. Visitors to the region came to see the Hatinh langurs and donated to the bridge project. The costs were covered by sponsors Kim Jones, Tilo Nadler and Nguyen Thi Thu Hien, Mohit Gatak, Jorgen Rasmussen, Alhay Aguirre, Donna Swift, and HIVOOC.

## Discussion

The Tuyen Phu bridges represent the first canopy overpass ever documented structure specifically built for the endangered Hatinh langur, filling a notable gap in canopy bridge applications for limestone langurs of central Vietnam. While most documented canopy bridges use flexible organic or semi-flexible materials such as rope (Chan et al. 2020), rubber-wrapped wire and water pipe (Birot et al. 2020), or fire hose (Yap & Ruppert 2019), the Tuyen Phu bridges combine steel tension cables with chain-link wire mesh, providing a continuous, stable walking platform suited to the quadrupedal

locomotion of the langurs. Most of the canopy bridges in other areas are funded and implemented by conservation organizations while those of Tuyen Phu were primarily initiated primarily by enthusiastic locals and tourists.

The evidence of Hatinh langurs using the bridges safely is the sign that they have gotten familiar with the structure and are using them at increasing frequency, which is important for their existence in habitats with human and traffic intervention. The success of this project also highlights the value of community-led conservation. This offers a promising template for similar initiatives in other rural areas of Vietnam in which endangered primates share landscapes with expanding road networks.

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We would like to express our deep appreciation for the endless efforts of the Community Conservation Team members in Tuyen Phu commune, for building the two bridges and providing crucial information about the two bridges. We also extend our sincere thanks to the local authorities for approving our project.

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# SHORT COMMUNICATIONS

## Man in critical condition after being bitten by a loris (*Xanthonycticebus* sp.)

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**Keywords:** Loris, *Xanthonycticebus*, venom, anaphylactic shock.

Lorises are the only primates known to possess venom that they use for intraspecific competition as well as to protect their offspring (Rode-Margono & Nekaris 2015; Fuller et al. 2016; Nekaris et al. 2020). Reactions to venom when biting humans have also been known for a long time (Wilde 1972; Fuller et al. 2013; Madani & Nekaris 2014; Parveen 2019; Utap & Bin Mohd Jamal; Fung & Wong 2016; Inoue et al. 2021; Kumar et al. 2022; Muldani et al. 2024).

The reaction to a bite in humans can range from completely harmless through a gradation of stages to a life-threatening condition. Kenyon & Nguyen Thi Phuong (2024) report from Vietnam in detail on the course of the disease after a bite. Another case of severe health impairment has now been reported from Vietnam.

Ignorance of the dangers of a bite is the reason why lorises are handled very carelessly in Vietnam. This applies both to the illegal animal trade, in which lorises are the most common primate species, and to the keeping of lorises as pets (Dasgupta 2014).

The report of a critical case (Thuy Quynh 2025) in Ha Giang province in northern Vietnam clearly shows that careless handling of lorises is a high health risk.

A 39-year-old man was admitted to Ha Giang Provincial Hospital about 2 hours after being bitten by a loris (*Xanthonycticebus* sp., most likely *intermedius*) (Fig. 1). The patient was in a drowsy state, with a weak pulse, an unmeasurable blood pressure, blue-violet lips, a puffy face, red streaks all over the body and suffered from severe laryngeal spasms (Fig. 2). The patient suffered grade IV anaphylactic shock, the most severe degree of anaphylaxis. He was given artificial respiration and received antihypertensive and antiallergic medication. His state of health only stabilised after three days of treatment in the intensive care unit.



**Fig.1.** Bite wound from a loris.


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**Fig.1.** Swelling in the face after a bite from a loris.

Such a course of events makes it clear that careless and reckless handling of Loris can have serious consequences. The result can be a serious health impairment which can also lead to a high financial burden.

## Một người đàn ông trong tình trạng nguy kịch sau khi bị cắn bởi loài cu li (*Xanthonycticebus* sp.)

Cu li là loài linh trưởng duy nhất được biết đến có nọc độc mà chúng sử dụng để cạnh tranh nội loài cũng như bảo vệ con non của chúng (Rode-Margono & Nekaris 2015; Fuller và cộng sự 2016; Nekaris và cộng sự 2020). Phản ứng với nọc độc khi cắn người cũng đã được biết đến từ lâu (Wilde 1972; Fullet và cộng sự, 2013; Madani & Nekaris 2014; Parveen 2019; Utap & Bin Mohd Jamal; Fung & Wong 2016; Inoue và cộng sự. 2021; Kumat và cộng sự. 2022; Muldani và cộng sự 2024).

Phản ứng với vết cắn ở người có thể hoàn toàn vô hại, qua các giai đoạn khác nhau cho đến tình trạng đe dọa tính mạng. Kenyon & Nguyễn Thị Phương (2024) đã báo cáo chi tiết từ Việt Nam về diễn biến của bệnh sau khi bị cắn. Một trường hợp khác bị suy giảm sức khỏe nghiêm trọng hiện đã được báo cáo từ Việt Nam.

Sự thiếu hiểu biết về nguy hiểm của vết cắn là lý do khiến loài cu li được xử lý rất bất cẩn ở Việt Nam. Điều này áp dụng cho cả việc buôn bán động vật bất hợp pháp, trong đó cu li là loài linh trưởng phổ biến nhất và cho việc nuôi cu li làm thú cưng.

Báo cáo về một trường hợp nghiêm trọng (Thuy Quỳnh 2025) tại tỉnh Hà Giang, miền Bắc Việt Nam, cho thấy rõ ràng rằng việc xử lý loris một cách bất cẩn tiềm ẩn nguy cơ cao đối với sức khỏe con người.

Một người đàn ông 39 tuổi được đưa vào Bệnh viện tỉnh Hà Giang khoảng 2 giờ sau khi bị cắn bởi một con cu li (*Xanthonycticebus* sp., nhiều khả năng là loài trung gian) (Hình 1). Bệnh nhân trong tình trạng lơ mơ, mạch yếu, huyết áp không đo được, môi tím tái, mặt sưng phù, nổi mẩn đỏ khắp người và bị co thắt thanh quản nghiêm trọng (Hình 2). Bệnh nhân bị sốc phản vệ độ IV, mức độ nghiêm trọng nhất của sốc phản vệ. Ông ta được thở máy và dùng thuốc hạ huyết áp và thuốc chống dị ứng. Tình trạng sức khỏe của ông ấy chỉ ổn định sau ba ngày điều trị tại phòng chăm sóc đặc biệt.

Diễn biến sự việc như vậy cho thấy việc xử lý cu li bất cẩn và thiếu thận trọng có thể dẫn đến hậu quả nghiêm trọng. Kết quả có thể là tổn hại sức khỏe nghiêm trọng, đồng thời cũng gây ra gánh nặng tài chính lớn.

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