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Population density of the grey-shanked douc langur (*Pygathrix cinerea*) in Kon Ka Kinh National Park and implications for conservation

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Key words: grey-shanked douc langur, *Pygathrix cinerea*, population density, conservation

Summary

The population of the grey-shanked douc langur (*Pygathrix cinerea*) in Kon Ka Kinh National Park was measured using the distance sampling method. Field research was carried out from May to June 2020. Twenty-four line-transects (average 3.8 km in length) were set up across different types of forests at elevations from 950 m to 1400 m. Each transect was surveyed repeatedly three times on three consecutive days. Distance software version 7.3 was used to analyse the population density of the grey-shanked douc langurs. The result showed that the population density is 1.18 group/km^2. It is estimated that there are 248 (± 107) groups with 1,557 (± 696) individuals in the national park. With this updated result, Kon Ka Kinh National Park is home to the largest population of the grey-shanked douc langur in Vietnam. The main threat to the langurs is hunting by homemade guns. It is essential to improve law enforcement and ranger patrolling to stop illegal activities.

Ước lượng mật độ quần thể của loài chà vá chân xám (*Pygathrix cinerea*) bằng phương pháp lấy mẫu khoảng cách (distance sampling) và gợi ý cho hoạt động bảo tồn tại vườn quốc gia Kon Ka Kinh, Việt Nam

Tóm tắt

Quần thể voọc chà vá chân xám (*Pygathrix cinerea*) được ước lượng bằng phương pháp lấy mẫu khoảng cách (Distance sampling). Nghiên cứu thực địa được thực hiện từ tháng 5 đến tháng 6 năm 2020. 24 tuyến điều tra với độ dài trung bình 3,8 km được thiết lập trên các sinh cảnh rừng khác nhau từ 950 m đến 1400m. Mỗi tuyến điều tra được khảo sát lặp lại ba lần trong ba ngày liên tiếp. Phần mềm khoảng cách phiên bản 7.3 được sử dụng để phân tích mật độ quần thể của voọc chà vá chân xám. Kết quả cho thấy mật độ là 1,18 đàn trên 1 km^2. Ước tính có khoảng 248,3 (± 107,3) đàn với khoảng 1557 (± 696,2) cá thể trong vườn quốc gia Kon Ka Kinh. Với số liệu cập nhật này, Vườn quốc gia Kon Ka Kinh là nơi sinh sống của quần thể voọc chà vá chân xám lớn nhất Việt Nam. Mối đe dọa chính đối với GSD là săn bắn bằng súng tự chế. Điều cần thiết là phải tăng cường hiệu quả việc thực thi pháp luật và tuần tra rừng để ngăn chặn các hoạt động săn bắn bất hợp pháp.

Introduction

Kon Ka Kinh National Park is located in northern Gia Lai Province on the Kon Tum Plateau and covers an area of 41.780 ha. The park is known as a global priority area for biodiversity conservationat (WWF 2010) and harbours six primate species: pygmy loris *Nycticebus pygmaeus*, stump-tailed macaque *Macaca arctoides*, rhesus macaque *Macaca mulatta*, pig-tailed macaque *Macaca leonina*, northern yellow-cheeked gibbon *Nomascus annamensis* and grey-shanked douc langur *Pygathrix cinerea*.

The grey-shanked douc langur is listed as 'Critically Endangered' on the IUCN Red List of Threatened Species (Ha Thang Long et al. 2020). The species is restricted to the central coastal area and the Central Highlands of Vietnam (from 14^0 30'N to 15^0 38'N). The distribution range includes

six provinces in Vietnam: Quang Nam, Quang Ngai, Kon Tum, Binh Dinh, Gia Lai and Phu Yen. The population of the species globally is estimated of about 2.000 individuals. (Ha Thang Long et al. 2020).

Larger populations exist in:

Quang Nam Province

Hon Mo Forest, Nong Son District with 173 observed individuals
(Tu Van Khanh et al. 2009)
Tam My Tay Forest, Nui Thanh District with about 65 individuals
(Bui Van Tuan et al. 2019)

Gia Lai Province

Kon Ka Kinh National Park a population of 860-2250 individuals
Kon Chu Rang Nature Reserve a population of 100-120 individuals
(Ha Thang Long 2015)

Kon Tum Province

Kon Plong Forest a population of about 500 individuals (Wearn et al. 2021)

Quang Ngai Province

Fragmented populations with a total of 32 groups with 192-220 individuals
(Nguyen Thanh Tuan et al. 2010).

However, most of the data on population in the surveyed areas is based on direct count on the groups and individuals. And therefore, the real population abundant is probably under estimated.

Since 2010, a long-term project funded by Frankfurt Zoological Society to conserve the forest and biodiversity of the Kon Ka Kinh National Park has been in place. One of the objectives is the conservation of the grey-shanked douc langurs. Necessary activities to protect the species were conducted such as applying the SMART program on forest patrolling and monitoring of endangered species including the grey-shanked douc langurs and raising awareness of local people on protection the species and the habitat (Ha Thang Long 2020). A part of the project was also to obtain a clearer picture about the population of the grey-shanked douc langurs in Kon Ka Kinh National Park. The population density of the grey-shanked douc langurs should be evaluated by the distance sampling method to provide a background for conservation and protection activities. This method has been used for the closely related red-shanked douc langur (*Pygathrix nemaeus*) (Coudrat et al. 2013).

Methods

Location and description of study site

Kon Ka Kinh National Park ($14^0$09' to $14^0$30' N; $108^0$16' to $108^0$28' E) comprises 33,500 ha of intact natural forest, accounting for 80% of the total area. The park has a large range of mountain evergreen forest across 700 m asl to the highest point the Kon Ka Kinh Mountain at 1,784 m asl. The Southwest area with evergreen forest is below 700 m asl. The park's terrain is characterized by high, steep mountains in the Northeast and flatter area in the Southwest. The average rainfall of the park is between 2,000 and 2,500 mm per year. The monthly average temperature ranges between 210 and 250 (Kon Ka Kinh National Park 2021).

Data collection

Twenty-four line transects were set up in forests across different habitat types ranging from 950 m to 1400 m (Fig. 1). The distance between line transects is 2 km. Surveys were carried out in the dry season (May to June 2020). We conducted field surveys from 6:00 am to 11:30 am, and continued from 1:30 pm to 6:30 pm. These are the most active time period of the langurs and thus they are more likely to be detected (Nguyen Thi Tinh et al. 2012). Surveys were repeated 3 times for 3 consecutive days on each transect.

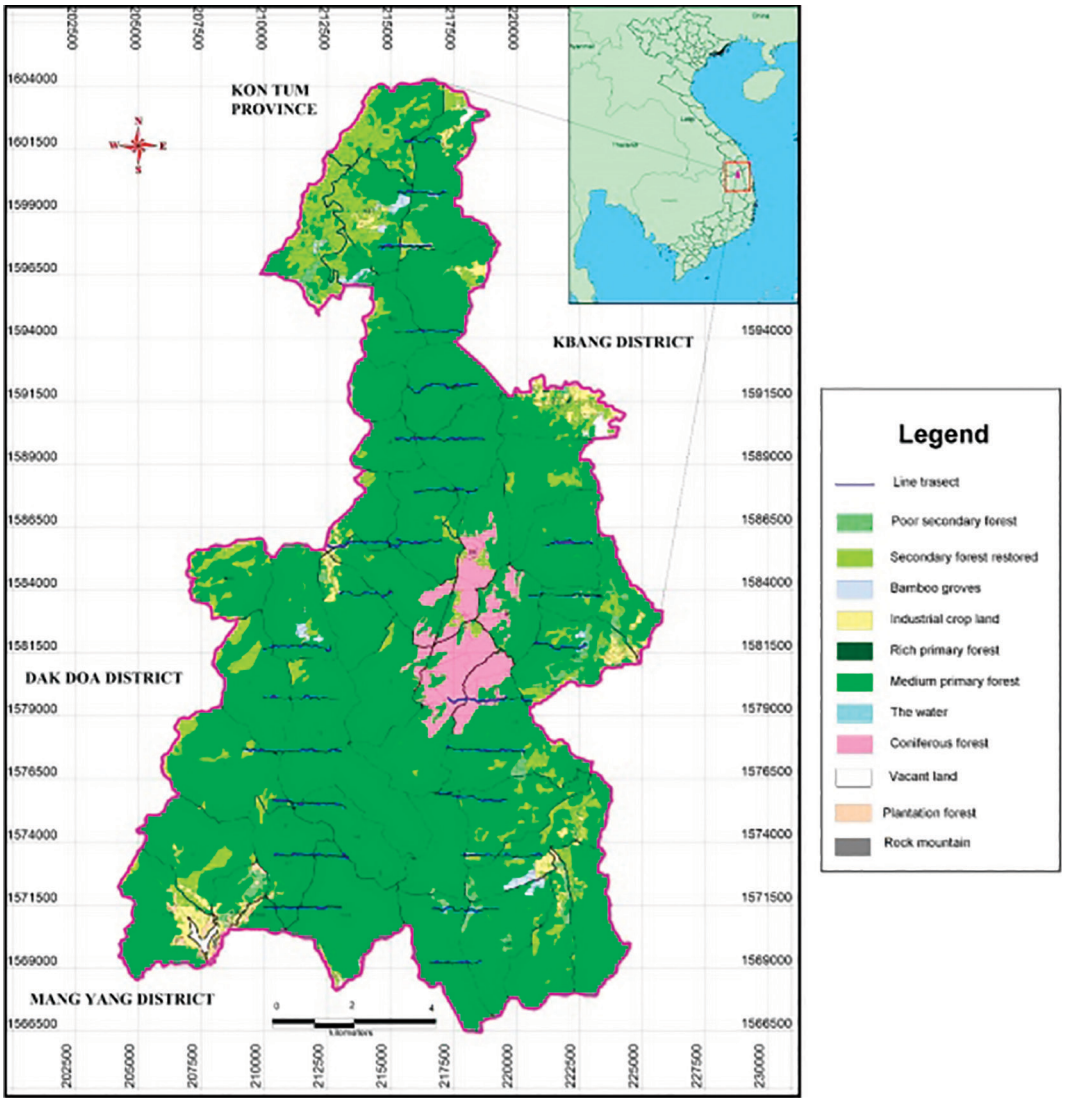

Fig.1. Locations of the twenty-four line-transects used to conduct surveys on the grey-shanked douc langurs in Kon Ka Kinh National Park.

On each transect, a survey team consisted of three people (one expert, one ranger, and one local guide). All members were trained on field data collection methods. In the field, the survey group walked 0.5 to 1 km per hour. We observed and recorded direct and indirect occurrences of the grey-shanked douc langurs. The surveyors used binoculars to search for the langurs. The field researcher recorded date, start and ending time, transect identity, weather conditions, and human activities of each line transect. If langurs were detected, the surveyors determined and recorded group size, group structure, vegetation features, and GPS coordinates. To analyze the population density we measured the radial distance and the angle relative to the transect line to each first sighted individual via a range finder and compass (Buckland et al. 2010).

Data analysis

To run the data analysis we used DISTANCE 7.3 (Buckland et al. 2015). In order to remove the groups that may have been double counts, we compared the group size and the group structure to distinguish the observed groups. In total, we recorded 21 distinctive groups in 24 transects. The

mean group size was calculated. Each transect was replicated 3 times, therefore the total of transect length multiplied by the number of replications (Buckland et al. 2010). We plotted the perpendicular distances data in a frequency histogram of 10 m intervals. There are 6 data groups which range between 0-15.8 m, and the longest perpendicular distance is 94.9 m. The cut-off intervals are 15.8 m, 31.6 m, 47.4 m, 63.2 m, 79.1 m and 94.9 m.

We ran six models with different combinations of key function and adjustment terms: (1) half-normal + cosine, (2) half-normal + polynomial, (3) uniform + cosine, (4) uniform + polynomial, (5) half-normal + Hermite, and (6) uniform + Hermite. We selected the best model according to the Akaike information criterion (AIC), and the coefficient of variation of the group density estimates (Buckland et al. 2001) (Table 1). The suitable habitat area of the grey-shanked douc langurs we measured using the minimum convex polygon method (MCP) (IUCN 1994, Burgman & Fox 2003). To determine the suitable habitat area of the grey-shanked douc langurs we used records of occurrence in this study and our yearly monitoring data of the langurs. The data of occurrence of the langurs was entered in the software ArcGis 10.2 to measure the suitable habitat area for the species.

Table 1. Distance analysis results for different models, calculated with 21 observations (n=21) with group density estimate, probability of detection, coefficient of variation, and AIC value (Akaike Information Criterion).

Model (key function + adjustment term)	Group density estimate (per km^2)	Probability of detection	Coefficient of Variation	AIC
Half-normal + cosine	1.18	0.33	0.447	177.78
Half-normal + polynomial	0.91	0.43	0.423	178.19
Uniform + cosine	0.98	0.40	0.450	177.18
Uniform + polynomial	0.96	0.41	0.451	179.32
Half-normal + Hermite	0.91	0.43	0.428	178.19
Uniform + Hermite	0.76	0.52	0.483	180.21

Results

Using the minimum convex polygon (MCP) method to estimate suitable habitat of the grey-shanked douc langur in Kon Ka Kinh National Park shows that there are 210.44 km^2 of suitable habitat, equivalent to 51% of the whole park. (Fig. 2).

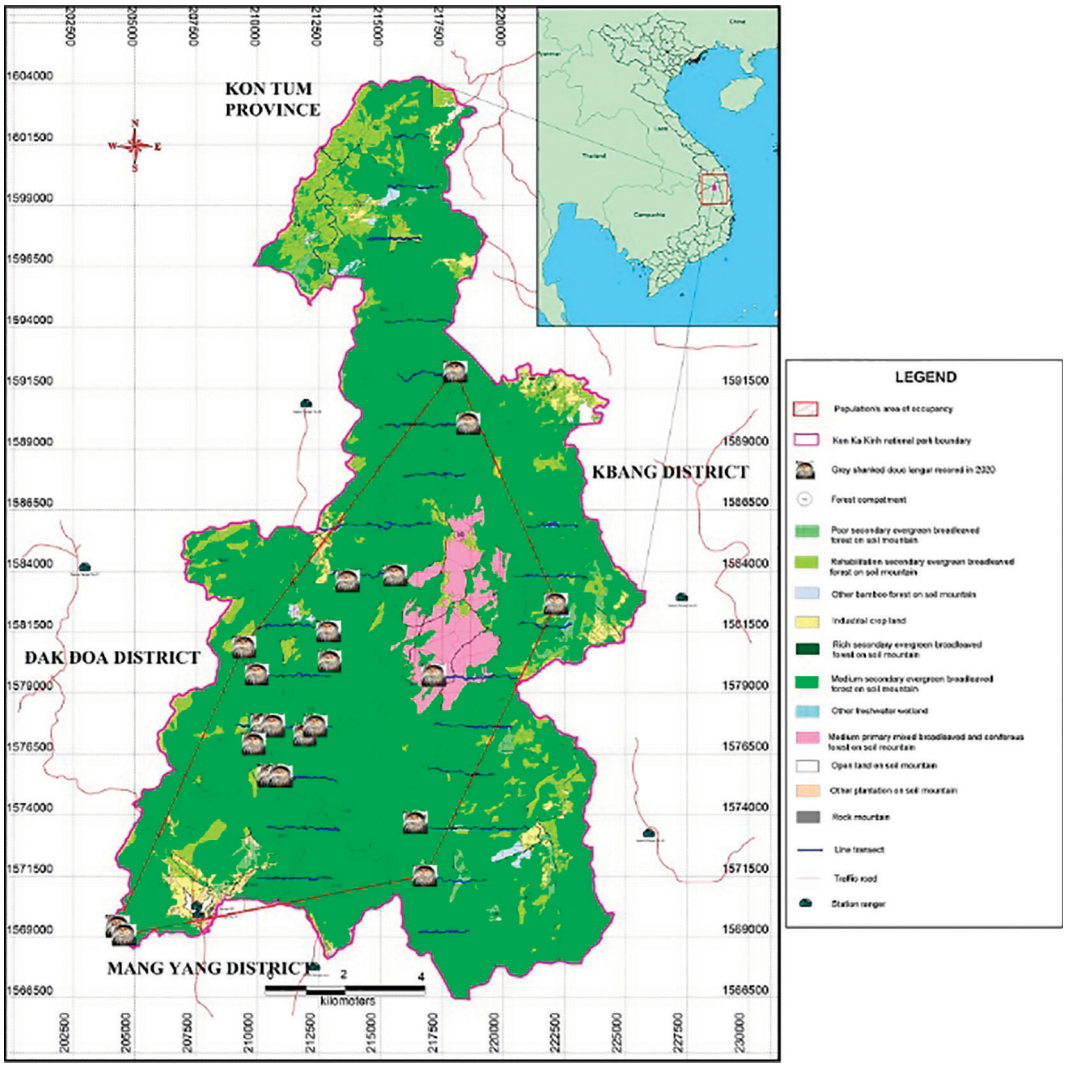

Fig.2. The Minimum Convex Polygon (MCP) of suitable habitat of the grey-shanked douc langurs in the Kon Ka Kinh National Park.

According to DISTANCE 7.3 the model that best fits the field data is half normal key function and cosine adjustment. This model suggests that there are 1.18 (± 0.51) groups per km^2. The group size mean is 6.23 (± 0.74) individuals. The estimated number of groups in the park is 248.3 (± 107.3) with 1,557 (± 696.2) individuals (Table 2).

Table 2. Distance analysis result with estimated group density and individual density of the grey-shanked douc langurs with standard error (SE) n=21. Ds: Density of groups; E(s): Estimated of group size; D: Density of individuals; N: Estimate of individuals in the suitable habitat (210.44 km^2).

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% percent Confidence Interval	
Ds	**1.1863**	0.5112	43.10	0.5120	2.7485
E(s)	**6.2381**	0.7429	11.91	4.8701	7.9903
D	**7.4004**	3.3089	44.71	3.1168	17.571
N	**1557.0**	696.18	44.71	656.00	3698.0

Discussion

Distribution and habitat disturbance

Human disturbance is an important factor influencing primate habitat use and distribution patterns. During this study 90% of observations (19/21) of the grey-shanked douc langurs were made in the restricted zone of the park. This indicates that the main distribution area of the langurs is in the areas with less human disturbances. 71% of observations (15/21) were made in the western part of the park while only 29% (6/21) were in the eastern part. This difference might reflect different levels of human disturbance. During the survey time, we recorded six types of human disturbances that include: gun fire, logging camps, logged trees, traps, forest encroachment, and people in the forest. There is more human disturbance in the eastern part of the park than in the western part in all six types. This is consistent with what has been reported for Francois' langurs (*Trachypithecus francoisi*) in Fusui, China avoids human disturbance in the bottom of valleys, they prefer to feed in the middle zone of forest where less disturbances (Huang et al. 2008) are. Similarly, the black-crested gibbon (*Nomascus concolor*) in Dazhaizi central Yunnan, China also rarely ranged to the forest below 2,100 m where human disturbance mostly occurred (Fan & Jian 2010).

Population of the grey-shanked douc langur in Vietnam

The total and global population of the grey-shanked douc langur has been estimated at about 2,000 individuals (Ha Thang Long et al. 2020). This species is best known from sub-populations in Vietnam, but there is also information of a probably small population in the Southeast corner of Laos and the Northeast corner of Cambodia (Rawson & Roos 2008). In recent years, more sub-populations of the species have been discovered in Vietnam including 65 individuals in Tam My Tay Forest, Quang Nam Province (Bui Van Tuan et al. 2019), about 500 individuals in Kon Plong Forest (Wearn et al. 2021), and probably a population in Phu Yen Province (Tran Van Bang, pers. comm.). Many sub-populations of the species have not been monitored nor have there been systematically size estimates. Therefore, the real number of the remaining grey-shanked douc langurs is still unknown. This study is the first effort to measure population size of the species using the distance sampling method. The outcome of this survey suggests that the remaining population in the Kon Ka Kinh National Park is much higher that it was previous estimated. In the past the population in both Kon Ka Kinh National Park and Kon Chu Rang Nature Reserve together was estimated of 10 groups and 139-150 individuals, based on direct count (Ha Thang Long, 2007).

Given the differences between direct observation and the distance sampling methods the population of the grey-shanked douc langurs in Vietnam is likely to be around 3,000 individuals.

The Long-term conservation project in the Kon Ka Kinh National Park and its effects

Since 2010 the Frankfurt Zoological Society has implemented a project to preserve the forest and wildlife in the park. The grey-shanked douc langur protection is among the objectives of the project. Since 2016 the park rangers have employed the SMART program in their forest patrol activity. Information on wildlife is recorded during the monthly forest patrol trips. In 2020, 272 traps and 35 logging camps were found and destroyed, and 17 homemade guns and firearms were confiscated (Ha Thang Long 2020). It is obvious that the forest patrol program has reduced the threats to the grey-shanked douc langurs. Pusey et al. (2007) stated that a long-term research projects can provide important conservation benefits, not only through research specifically focused on conservation problems, but also from various incidental benefits.

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