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Estimation of northern yellow-cheeked gibbon (*Nomascus annamensis*) population size in Kon Cha Rang Nature Reserve: a new method–using a weighted correction factor

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Key words: Northern yellow-cheeked gibbon, *Nomascus annamensis*, Kon Cha Rang Nature Reserve, population size, weighted correction factor

Summary

The recently described northern yellow-cheeked gibbon (*Nomascus annamensis*) is endemic to Indochina but the status of the species in Vietnam is still poorly understood. The methods currently used to survey and monitor gibbons do not allow flexible survey designs and often underestimate the numbers of gibbon groups because gibbon groups do not call every day. To determine the status of the species in Kon Cha Rang Nature Reserve in central Vietnam and to contribute to improve methods for field surveys for gibbons and data analysis, we surveyed from 17 listening posts at this site in three weeks from June to July, 2010. During the survey we detected 13 gibbon groups. Daily calling probability was estimated to be 0.3 and the weighted correction factor was estimated to be 0.63. Maximum hearing distance for the gibbon calls was estimated to be about 2 km at this site. The total number of gibbon groups at Kon Cha Rang Nature Reserve was consequently estimated to be 27. These gibbon groups are mainly distributed in the northern part of the reserve.

Ước lượng kích thước quần thể loài Vượn má vàng phía Bắc (*Nomascus annamensis*) tại Khu bảo tồn Kon Cha Răng: Một phương pháp mới sử dụng hệ số hiệu chỉnh có trọng số

Tóm tắt

Vượn má vàng phía Bắc (*Nomascus annamensis*) gần đây được ghi nhận là một loài linh trưởng mới của Việt Nam. Thông tin về tình trạng của loài ở Việt Nam nói chung và Khu bảo tồn thiên nhiên Kon Cha Rang nói riêng còn chưa đầy đủ. Trong điều tra và giám sát vượn, các phương pháp ước lượng hiện đang được sử dụng thường không cho phép việc tổ chức thực hiện điều tra một cách linh hoạt và số đàn vượn ước lượng được thường nhỏ hơn so với thực tế bởi một đàn vượn không phải ngày nào cũng hót. Để xác định tình trạng của loài tại Khu bảo tồn thiên nhiên Kon Cha Rang và góp phần hoàn thiện phương pháp điều tra thực địa và xử lý số liệu trong điều tra giám sát các loài vượn. Chúng tôi tiến hành điều tra tại 17 điểm nghe vượn hót trong thời gian 3 tuần, từ tháng 6 đến tháng 7 năm 2010. Qua đợt điều tra 13 đàn Vượn đã được ghi nhận. Xác suất hót trong một ngày được ước lượng là 0.3 và hệ số hiệu chỉnh có trọng số được ước lượng là 0.63. Khoảng cách lớn nhất mà người điều tra có thể phát hiện ra tiếng hót của vượn được ước lượng vào khoảng 2km và tổng số đàn vượn ở Khu bảo tồn thiên nhiên Kon Cha Rang được ước lượng là 27 đàn. Các đàn Vượn này chủ yếu phân bố ở khu vực phía Bắc của Khu bảo tồn.

Introduction

The northern yellow-cheeked gibbon (*Nomascus annamensis*) is endemic to Indochina and is distributed in southern and central Vietnam, north-eastern Cambodia, and southern Laos. The distribution in Vietnam reaches from the Thach Han River in the North (about 16°40' - 16°50' N) to the Ba River in the South (about 13°00' - 13°10' N) (Van Ngoc Thinh et al., 2010).The species is currently

not listed on the IUCN-Red List of Threatened Species as it has only recently been described (Van Ngoc Thinh et al., 2010). It is likely the species, once listed, will fall within the category 'Endangered' based on the reduction of the population size in recent years due to habitat loss and poaching. However to really clarify the status of the species, efforts must be made to estimate its populations.

Some authors reported that the crested gibbons including northern yellow-cheeked gibbon are fairly common in the Central Highland of Vietnam (Brickle et al., 1998; Geissmann et al., 2000). Located in the Central Highlands region in Gia Lai Province lies Kon Cha Rang Nature Reserve which is believed to support a large population of northern yellow-cheeked gibbons. The presence of gibbons in the nature reserve has been mentioned (BirdLife International & Forest Inventory and Planning Institute, 2001; Geissmann & Orgeldinger, 2000), but adequate efforts have not yet been made to understand the status of gibbons in the reserve. Kon Cha Rang is one of the least disturbed nature reserves in Vietnam, covering an area of 15,472 ha. The forest remains intact or is only slightly disturbed by human activities and creates a very suitable habitat for gibbons. Given its habitat quality and large size Kon Cha Rang Nature Reserve, can support a viable population of northern yellow-cheeked gibbons and serve as an important conservation area for the species.Our survey for this species in the nature reserve will provide a background for conservation of this primate species.

Methods

Study site

Kon Cha Rang Nature Reserve (14°26'-14°35' N/108°30'-108°39' E) is located in K'Bang District, Gia Lai Province. Established in 2000 the total area comprises 15,472 ha. The establishment of a buffer zone of 56.000 ha in Son Lang and Dak Rong Communes in Ang District has been proposed. Kon Cha Rang Nature Reserve borders An Lao Nature Reserve (Binh Dinh Province) to the east and several Forestry Enterprises to the South and West. Soil hills characterize the topography of the reserve, and the elevation ranges between 800 m and 1,152 m asl, with the highest peak Kon Cha Rang at 1,159 m (BirdLife International & Forest Inventory and Planning Institute, 2001). In the northern part of the reserve many peaks reach elevations of more than 1000 m asl.

62 mammal species, 169 bird species and 161 butterfly species have been recorded in the reserve. Notably, the presence of several globally endangered mammals such as *Nomascus annamensis*, *Pygathrix cinerea*, and *Megamuntiacus vuquangensis* have been recorded within the reserve (Anon., 1999; BirdLife International & Forest Inventory and Planning Institute, 2001; Nadler et al., 2003)

Of its 15,472 ha, 13,844.2ha (89.5%) are rich and medium forest and 1627.8 ha (10.5%) are degraded forest or bare land. Of 15,472 ha of rich and medium forest, 70-80 % is tropical evergreen broadleaf forest. The main plant families are Fagaceae, Lauraceae, Magnoliaceae. Mixed forest with broad-leaved and coniferous species such as *Podocarpus imbricatus* and *Dacrydium elatum* also occurs.

Selection of survey areas

According to interview information, gibbons used to be abundant in the northern and central parts of the reserve. These areas, especially the northern part, are also least disturbed by previous logging. The southern part of the reserve has been logged since 1970 by Tram Lap Forestry Enterprise and doesn't provide a good habitat for gibbons. Local people reported that gibbons have not been seen in this area recently. Therefore, we decided to focus our surveys on the northern and central parts of the reserve (Fig. 1).

Survey method

Gibbons live in the upper forest canopy and are mostly sensitive to human presence. Therefore, visual detection of gibbons is very difficult in the field, especially in short surveys. However, gibbons can be detected by their loud and long songs (Geissmann, 1993; Geissmann & Orgeldinger, 2000). Therefore, an audio point counting method was used to assess gibbon population size and density during the survey (Brockelman & Ali, 1987).

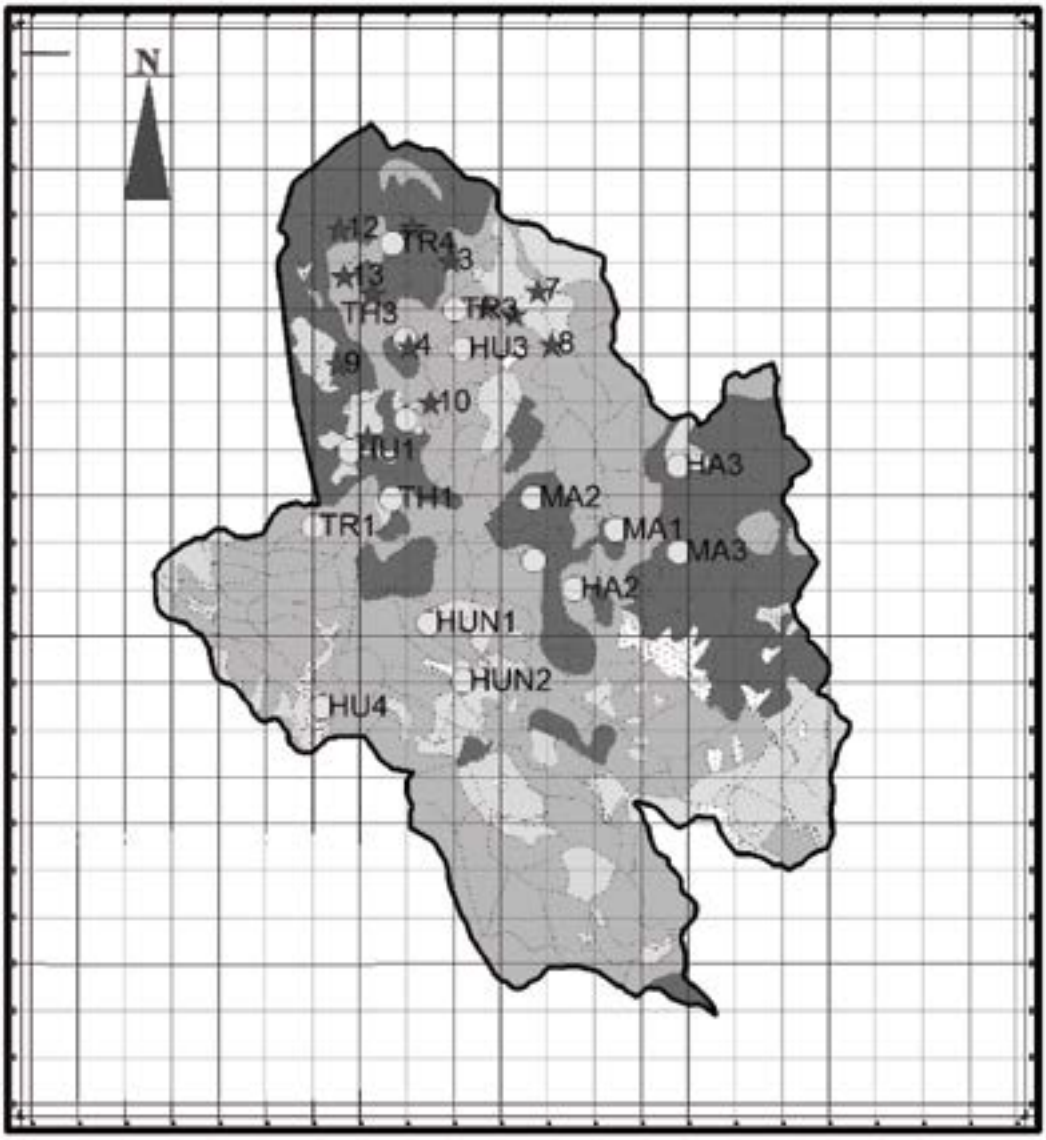

Fig.1. Map of Kon Cha Rang Nature Reserve with listening posts (o) and detected gibbon groups (★).

A total of six camp sites were used during the survey, all of which were located inside the nature reserve. A total of 17 listening posts were selected (Fig. 1), covering an area of 10,250 ha (radius per post 2 km), of which 9,372 ha were included in the nature reserve. Transects were not conducted in this survey due to difficult terrain and inefficiency of this method for gibbon surveys. This method also tends to underestimate gibbon density (Brockelman & Ali, 1987).

Of 17 posts used, 13 posts were surveyed for two days, two posts were surveyed for three days, and two posts were survey for one day. Surveys were conducted in the morning (5:00 to 9:00am), from 17th June to 15th July 2010. During the surveys, the surveyors took a compass bearing of the direction of the group, estimated the distance to the group, and recorded the start and end time of all song bouts, and the type of song.

Data analysis

Locations of gibbon groups could be determined by triangulation using the angle and distance from different surveyors as the areas covered from different listening posts overlapped (Fig. 2). The distance was measured using MapInfo 10.0 (Pitney Bowes Business Insight, New York, US). Maximum hearing distance was estimated using the recorded distance between surveyors and gibbon locations with known coordinates. When gibbon groups were heard by at least two surveyors in the same day, the distance between the surveyors and these gibbon groups could be estimated rather accurately. If the third surveyor could not hear the songs of the identified groups on that day, the minimum distance at which song cannot be detected was also identified. Based on these two distances measured for several groups, the maximum hearing distance for this site was determined. Maximum hearing distance was then used to calculate the area surveyed.

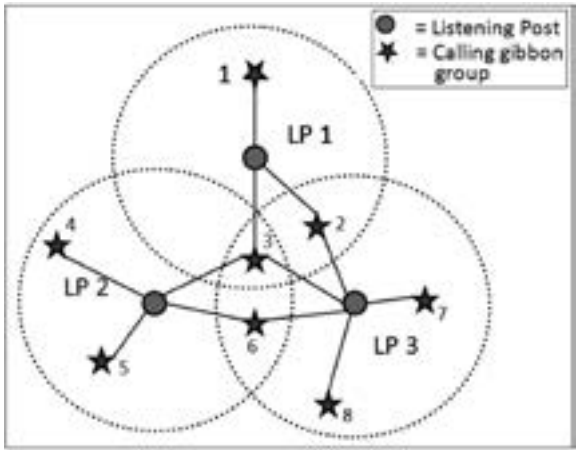

Fig.2. Survey design for the arrangement of listening posts.

Groups were differentiated by their locations; they were considered separate groups if they were detected more than 500 m apart, and group density was then estimated (Brockelman & Ali, 1987).

Using a "common" correction factor as widely accepted might be problematic. In gibbon surveys it is difficult to avoid overlapping survey area across posts. If two adjacent posts are surveyed in different days, then the overlapping areas are surveyed in more days than non-overlapping areas. Therefore, estimation using a common correction factor might be positively biased. The estimate of gibbon group might be higher than the truth. This issue is of critical importance if the overlapping area is large compared to non-overlapping areas. Therefore, we propose using a "weighted correction factor". Additionally, the weighted correction factor also allowed for flexibility in survey design. Different effort might be applied to different listening posts (Fig. 3).

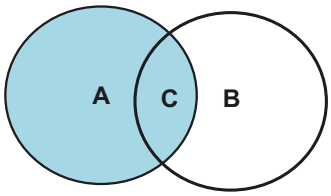

Fig.3. Explaination to the weighet correction factor.
Area A is surveyed for only one day: Correction factor: 1- (1-0.3) = 0.3
Area B is surveyed for 2 days: Correction factor: 1- $(1-0.3)^2$ = 0.49
Area C is surveyed for 3 days: Correction factor: 1- $(1-0.3)^3$ = 0.657
The correction factor is always <1.

The "weighted correction factor" is calculated as follows:

$$WC = \frac{\sum_{i=1}^{m} a_i.C_i}{A}$$

WC: weighted correction factor
C: correction factor
a_i: area surveyed in i days
C_i: correction factor applied for area surveyed i days,
A: total area surveyed
m: maximum number of days surveying an area during the study

C_i is calculated as: $C_i = 1-(1-p_1)^i$

The number of gibbon groups in the surveyed areas was estimated by dividing the number of detected groups by the weighted correction factor. The number of groups in Kon Cha Rang Nature Reserve was then extrapolated based on density and habitat size.

Results

Number of northern yellow-cheeked gibbons

Based on interview information, gibbons were in the past abundant in the northern and possibly the central parts of the reserve. Local people also reported that no gibbons have been recently recorded in the southern part of the reserve. The southern part of the reserve was heavily disturbed by previous logging activities and might no longer be a suitable habitat for gibbon.

During the survey gibbon songs were heard from 20 locations near Kon River, Nuoc Reo, Suoi Reu and Suoi Bom Streams. Most of the locations from which songs were detected were located in the very northern part of the reserve, covering an area of about 4,000 ha. Of that, 3100 ha lies in the sampled area around the listening posts. These areas include 31, 32, 33, 34, 35, and 36 forest compartments.

From the 20 locations at least 13 different groups of gibbons were identified (Fig. 1). Some groups,recorded from different locations on different days were probably the same groups because the distances between the listening locations were relatively short.

Maximum hearing distance

Five gibbon groups were heard from at least two posts on the same day. Therefore, their exact locations could be determined by triangulation. Recorded hearing distances ranged from 300 m to 1800 m (Table 1). In three cases, the surveyors recorded the songs of gibbons at a distance of around 1800 m with a volume level ranging from two to three. We concluded that the maximum hearing distance in this survey may be more than 1800 m. In three other cases, surveyors failed to detect the gibbon songs at distances of more than 2100 - 2200 m. Consequently the maximum hearing distance in this survey lay between 1800 and 2100 m. We arbitrarily selected 2000 m as the maximum hearing distance for our calculations.

Table 1. Distance from observers to gibbon locations with known coordinates.

Gibbon group ID	**Post ID**	**Date**	**Distance** (m)	**Volume level**	**Estimated distance in the field** (m)	**Note**
1	HU1	18/6	300m	1	<500	Heard
	TH1		1400	2	800	Heard
	TR1		2100			Not heard
2	HU3	21/6	1300	2	<2000	Heard
	TR3		1400	2	1000	Heard
	TH3		2400			Not heard
3	HU3	21/6	1800	2	<2000	Heard
	TH3		1800	2.5	2000	Heard
	TR3		900	2	1000	Heard
4	HU3	23/6	1200	1	1500	Heard
	TR3		1300	2	500-1000	Heard
	TR4		2200			Not heard
5	TR3	23/6	1800	3	1500	Heard
	TR4		1200	1	1500	Heard
						Not heard

Volume level: 1 = Loud; 2 = Medium; 3= Slight

Estimated population size of northern yellow-cheeked gibbons

Based on data from 11 groups that were detected on at least 3 days we estimated the probability of singing in one day (p_1) following Jiang et al. (2006).

This data amounted for our area to an estimation of singing probability in one day of p_1= 0.30. This estimate was then used to calculate the correction factor.

As the probability of a gibbon group singing on a single day is smaller than one, the actual number of gibbon groups is higher than the number of groups heard during the survey. The actual number of groups within surveyed areas was estimated by dividing the number of groups heard by a correction factor.

Survey efforts vary among areas of the reserves (Table 2). A total of 9,372 ha of habitat in the reserve was surveyed. The area surveyed in more than one day was 8,728 ha. The weighted correction factor is 0.63 (Table 2). Therefore, the estimated actual number of groups within the surveyed area is 13/0.63=20.66 (≈ 21 groups).

Of the 4,000 ha of probable gibbon distribution range in the reserve, the survey covered about 3,100 ha, and about 900 ha were not surveyed. Therefore, the total number of gibbon groups in the reserve is estimated to be 26.66, about 27 groups. The density of northern yellow-cheeked gibbons in its distribution range of 4,000 ha in Kon Cha Rang Nature Reserve is 0.0066 groups/ha (0.66 groups/km^2). The density of northern yellow-cheeked gibbons in the entire surveyed area of 9,372 ha is 0.0022 groups/ha (0.22 groups/km^2).

Discussion

Distribution of northern yellow-cheeked gibbons in Kon Cha Rang

Information about the distribution of northern yellow-cheeked gibbons collected from interview and field survey was similar. This meant that local informants had been selected well and obtained interview information that was useful for further design of the survey.

Within Kon Cha Rang northern yellow-cheeked gibbons are now confined to a small area of about 4,000 ha in the North of the reserve. This is probably because this area is remote and there is less poaching than in other parts of the reserve and the forest quality in this area is better than in the central and southern parts of the reserve, which have been selectively logged in the past.

Density and population size

The density of gibbons in Kon Cha Rang Nature Reserve was found to be much higher than in the North Central coastal region of Vietnam (Nguyen Manh Ha et al., 2005). In Dak Rong Nature Reserve the density of gibbons was estimated to be only 0.06 groups/km^2, though this area is considered to have the highest gibbon density in the North Central coastal region of Vietnam (Nguyen Manh Ha et al., 2005). This implies that efforts to conserve northern yellow-cheeked gibbons in Vietnam should focus on southern parts of the species' distribution range, including the Central Highland as this region is still supporting viable populations.

The population of northern yellow-cheeked gibbons in Kon Cha Rang Nature Reserve and other protected areas in Vietnam is much smaller than in other countries within the distribution range of this species. In Cambodia, the population in Virachey National Park (332,500 ha), Cambodia, was estimated to comprise about 5,750 groups and the population in Pheapimex Concession (315,028 ha) about 1,100 groups (Traeholt et al., 2005).

Although Kon Cha Rang Nature Reserve is smaller than these protected areas, it is obvious that the population densities in these areas are much higher. Low hunting pressure and less habitat disturbances due to smaller human population density may be the major reason for the greater population sizes of northern yellow-cheeked gibbons found in Lao PDR and Cambodia.

Determination of maximum hearing distance

To estimate the maximum hearing distance is essential in order to extrapolate the number of gibbon groups in the whole nature reserve based on the estimated number of gibbon groups in

surveyed areas. The maximum hearing distance was used to calculate the "weighted correction" factor, which has not been used in previous publications.

The maximum hearing distance allows for calculating overlapping survey areas.

To estimate a common maximum hearing distance, the following conditions must be met:

- All teams have the same hearing capacity.
- Sound transmission is uniform among different areas of the reserve.
- Weather does not influence hearing ability.

In our survey, all conditions were met. All teams have two surveyors, of that at least one will have experience in detecting gibbon songs.

In Table 1, the minimum distance from which the surveyors cannot detect the gibbon groups is rather similar. In a study where the survey teams have different degrees of experience, the maximum hearing might differ between survey teams and must be estimated separately for each group. However, this would require much more survey efforts. Other solutions would be to keep the number of survey teams small and survey over a longer survey period or stratify surveyors by their experience.

The terrain in Kon Cha Rang Nature Reserve is uniform; therefore, we believe that the maximum hearing distance does not vary much among the areas surveyed. The survey was conducted in a short period and the weather in the mornings of all survey days was similar. In other surveys conducted in longer period, days with bad weather should be excluded from maximum hearing distance analysis.

Estimation of the correction factor

The estimation of calling probability in one day was 0.30. Therefore, correction factor for a two day survey and a three day survey was 0.50 and 0.65, respectively. This estimate was small compared to other studies (Jiang et al., 2006; Phanchana & Gray, 2009). These authors reported the correction factor of around 0.90 for a three day survey. The lower correction factor in this study is probably due to the small sample size and the small estimate might result from chance alone. Furthermore the density of gibbons in Kon Cha Rang Nature Reserve is lower than in other studies, therefore, the singing probability may be low due to lack of stimulation from other groups (Raemaekers & Raemaekers, 1985). In addition, using 500 m distance as the threshold to differentiate two groups (Brockelman & Ali, 1987) may be incorrect as northern yellow-cheeked gibbons might have large home ranges in Kon Cha Rang Nature Reserve. Larger home ranges may be possible because of low density and conspecific competition. If one group is considered two separate groups, estimates of singing probability will be lower. Rawson (2004) suggested vocalizations of southern yellow-cheeked gibbons in Cambodia would be less frequent in the raining season (May to October in the Central Highland of Vietnam). This survey was conducted in June and July, therefore the singing probability might be lower than average. Finally, higher hunting pressure in Kon Cha Rang Nature Reserve compared to other areas may lead gibbons to call less frequently than usual.

Using a common correction factor as widely accepted might be problematic, even when survey efforts do not vary between posts. In gibbon surveys, it is difficult to avoid the overlap of areas covered from various listening posts. If two adjacent posts were surveyed in different days, then the overlapping areas are surveyed for more days than non-overlapping areas. Therefore, estimation using a common correction factor might be positively biased resulting in estimates of gibbon group numbers which might be higher than the truth. This is of critical importance if the overlapping area is large compared to areas covered only from one listening post. In this study we used singing probability of 0.30 (in one day). Theoretically, the detection probability in a period of two days is 0.50, in three days is 0.65, and in four days is 0.75 (Table 2). In our study most of the area (82%) was investigated for two to four days. Specifically, 35%, 19%, and 28% of the area was investigated for two days, three days, and four days, respectively. With the weighted correction factor of 0.63, we believed that the correction factor is reasonable. More importantly, the "weighted correction factor" allows for flexibility in survey design.

Table 2. Survey effort allocation and calculation of weighted correction factor.

Number of days	1	2	3	4	5	6	7	8	Total
Area (ha)	644.2	3313.9	1746.9	2581.4	105.4	899.4	0	80.7	9372
Correction factor	0.30	0.50	0.65	0.75	0.83	0.88	0.91	0.94	0.00
Weighted correction factor calculation	0.02	0.18	0.12	0.21	0.01	0.08	0.00	0.01	**0.63**

Conclusions

During the survey 13 gibbon groups were detected. Gibbons are now confined to a small area in the northern part of Kon Cha Rang Nature Reserve.Daily calling probability was estimated to be 0.3 and a "weighted correction factor" was estimated to be 0.63.

The total number of gibbons groups within Kon Cha Rang Nature Reserveis estimated to be 27.

References

Anon (1999): Investment plan for Kon Cha Rang Nature Reserve, Gia Lai Province. Forest Science Institute of Vietnam, Hanoi. (In Vietnamese).

BirdLife International & **Forest Inventory and Planning Institute** (2001): Sourcebook of existing and proposed protected areas in Vietnam, Hanoi.

Brickle N, **Nguyen Cu**, **Ha Quy Quynh**, **Nguyen Tai Tu Cuong** & **Hoang Van San** (1998): The status and distribution of Green Peafowl, *Pavo muticus*, in Dak Lak Province, Vietnam. Birdlife International - Vietnam Programme & Institute of Ecology and Biological Resources, Hanoi.

Brockelman WY & **Ali R** (1987): Methods of surveying and sampling forest primate populations; pp 23-62. In: Marsh CW & Mittermeier RA (eds): Primate Conservation in the Tropical Rainforest. Alan R. Liss Inc., New York.

Brockelman WY & **Srikosamatara S** (1993): Estimating density of gibbon groups by use of the loud songs. Am. J.Primatol. 29, 93–108.

Geissmann T (1993): Evolution of communication in gibbons (Hylobatidae). PhD thesis, Anthropological Institute, Zürich University, Switzerland.

Geissmann T & **Orgeldinger M** (2000): The relationship between duet songs and pair bonds in siamangs, *Hylobates syndactylus*. Animal Behavior 60, 805–809.

Geissmann T, **Nguyen Xuan Dang**, **Lormee N** & **Momberg F** (2000): Vietnam Primate Status ConservationStatus Review 2000. Part 1: Gibbons. Fauna & Flora International, Hanoi.

Geissmann T, **La Quang Trung**, **Trinh Dinh Hoang**, **Vu Dinh Thong**, **Dang Ngoc Ca**n & **Pham Duc Tien** (2003): Rarest apes species rediscovered in Vietnam, with special reference to gibbons. Asian Primates 8(3/4), 8-9.

Geissmann T, **Nguyen Manh Ha**, **Rawson B**, **Timmins R**, **Traeholt C** & **Walston**, **J** (2008): *Nomascus gabriellae*. In: IUCN Red List of Threatened Species. Version 2009.1. http://www.iucnredlist.org (accessed 12 August 2010).

Jiang XL, **Luo ZH** & **Zhao SY** (2006): Status and distribution patterns of black crested gibbon (*Nomascus concolor jingdongensis*) in Wulian Mountains, Yunnan, China: implications for conservation. Primates 47, 264-271.

Margoluis R, & **Salafsky N** (2001): Is our project succeeding? A guide to threat reduction assessment for conservation. Biodiversity Support Program, Washington D.C.

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

Nguyen Manh Ha (2004): The result of first survey for white cheeked gibbon at Dakrong Nature Reserve, Quang Tri Province. J. of Agriculture and Rural Development - Science and Technology 6,764-765.

Phan Channa & **Gray T** (2009): The status and habitat of Yellow-cheeked Crested Gibbon in Phnom Prich Wildlife Sanctuary, Mondulkiri. WWF Greater Mekong – Cambodia Country Program (unpubl. report).

Raemaekers JJ & **Raemaekers PM** (1985): Field playback of loud calls to gibbons (*Hylobateslar*): Territorial, sex-specific and species-specific responses. Animal Behaviour 33, 481-493.

Rawson BM (2004): Vocalisation patterns in the Yellow-cheeked crested gibbon (*Nomascus gabriellae*); pp. 130-136. In: Nadler T, Streicher U & Ha Thanh Long (eds): Conservation of primates in Vietnam. Frankfurt Zoological Society, Hanoi.

Traeholt C, **Bonthoeun R**, **Rawson B**, **Samuth M**, **Virak C** & **Sok Vuthin** (2005): Status review of pileated gibbon *Hylobates pileatus* and yellow-cheeked crested gibbon *Nomascus gabriellae* in Cambodia, FFI Cambodia Programme Office, Phnom Penh.

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