Observations on the Hatinh langur (*Trachypithecus hatinhensis*) during point and line transect sampling in the Phong Nha – Ke Bang National Park, Central Vietnam

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Key words: Hatinh langur, transect sampling, karst forest

Summary

Hatinh langurs (*Trachypithecus hatinhensis*) are endemic to central Vietnam and southern Laos, and in Vietnam the distribution is restricted to Quang Binh and Quang Tri Provinces. This endangered langur inhabits the dense primary forests in the limestone areas of the Annamite Mountains. The difficult-to-access habitat may have led to only little knowledge of its ecology and behaviour in the past. From April to August 2007 we conducted point (PTS) and line (LTS) transect sampling in the Phong Nha – Ke Bang National Park (PNKB NP) in Quang Binh Province and recorded ecological and behavioural data. We could confirm Hatinh langurs in all survey areas of LTS and at nine of 16 different points. We recorded a more reliable mean group size with PTS and our analyses revealed more than three times higher efficiency of PTS than of LTS. Hatinh langurs use limestone cliffs as sleeping sites. We did not detect preferences in the choice of cliff aspect and size. A Hatinh langur group seems to occupy more than one cliff and to use them alternately. Loud calls (whoops) of male Hatinh langurs were produced mainly early in the morning before sunrise as well as late in the afternoon, and we suggest that these long distance calls of the males mainly serve as territorial markers and spacing mechanisms. The PNKB NP is the most important protected area for the Hatinh langur in Vietnam and we recommend further surveys to improve the knowledge of this rare langur in its natural habitat.

Quan sát Voọc Hà Tĩnh (*Trachypithecus hatinhensis*) bằng phương pháp đường cắt và điểm cố định tại Vườn Quốc gia Phong Nha – Kẻ Bàng, miền Trung Việt Nam

Tóm tắt

Voọc Hà Tĩnh (*Trachypithecus hatinhensis*) là loài đặc hữu cho khu vực miền Trung Việt Nam và Nam Lào. Ở Việt Nam, vùng phân bố của loài giới hạn ở hai tỉnh Quảng Bình và Quảng Trị. Loài voọc đặc hữu này sinh sống trong kiểu rừng kín nguyên sinh phát triển trên núi đá với cửa đáy Trường Sơn. Điều kiện địa hình hiểm trở có thể đã hạn chế những hiểu biết về sinh thái và tập tính của loài trong
Introduction

The Hatinh langur (Trachypithecus hatinhensis) represents one of Vietnam’s eleven colobine species and inhabits the limestone forests of Central Vietnam and Southern Laos. In Vietnam the distribution is restricted to Quang Binh and Quang Tri Provinces (Nadler et al., 2003; Nguyen Manh Ha, 2006). In the IUCN Red List of Threatened Species and in the Red Data Book of Vietnam the Hatinh langur is listed as Endangered (Le Xuan Canh et al., 2008; Ministry of Science and Technology & Vietnamese Academy of Science and Technology, 2007). Similar to other langurs in Vietnam the main threat is hunting for traditional medicine, meat and wildlife trade, and it is also threatened because of habitat loss (Le Xuan Canh et al., 2008; Nadler et al., 2003; Nguyen Manh Ha, 2006). Hatinh langurs are members of the [francoisi] group including the taxa T. hatinhensis, T. francoisi, T. poliocephalus, T. laotum, T. delacouri and T. ebenus (Groves, 2005). The taxonomy is still disputed. Groves (2001; 2005) listed it as full species; however, based on molecular genetics Roos (2003; 2004) included it as subspecies of T. laotum, which was followed by several authors (Nadler et al., 2003; Nadler & Streicher, 2004; Nguyen Manh Ha, 2006; Vogt & Forster, 2008; Vogt et al., 2008).

Since the rediscovery of the Hatinh langur in 1992 in Phong Nha (Le Xuan Canh, 1993), there have been several surveys which contributed to the knowledge of the distribution of Hatinh langurs in Vietnam (Pham Nhat et al., 1996; Le Xuan Canh et al., 1997; Timmins et al., 1999; Nguyen Manh Ha 2004, 2006). Information on the population status were published by Pham Nhat et al. (1996) and Le Xuan Canh et al. (1997), who estimated 520-750 individuals in the Phong Nha – Ke Bang area in central Vietnam. Population density estimates of our recent study in 2007 resulted in 2,143 (±467) individuals in the whole PNKB NP (Haus et al., 2009). Pham Nhat et al. (1996) and Nguyen Manh Ha (2006) published the first ecological and behavioural information on Hatinh langurs, but there is still little known. The natural habitat of Hatinh langurs is characterized by steep limestone areas covered by dense primary forests. It is difficult to approach and to follow Hatinh langur groups at steep limestone slopes to get more detailed data (Nguyen Manh Ha, 2006). Like most other taxa of the [francoisi] group, Hatinh langurs use limestone caves and cliffs for sleeping. At these sites they are not only easy to hunt (Nadler et al., 2003; Ngo Xuan Phong, pers. comm.) but also much easier to detect and to observe than in the dense canopy of the karst forests during foraging and travelling (Nguyen Manh Ha, 2006).
In 2005 the Frankfurt Zoological Society (FZS) in cooperation with Cologne Zoo initiated a primate reintroduction program in the Phong Nha – Ke Bang National Park. This program - as part of the Primate Conservation Programme Vietnam of FZS - aims to release groups of captive-born Hatinh and red shanked douc langurs from the Endangered Primate Rescue Center in Cuc Phuong NP into the PNKB NP (Nadler & Streicher, 2003; Vogt & Forster, 2008; Vogt et al., 2008). Therefore more information about the status, distribution and ecology on these langurs is necessary to find appropriate sites for the final release.

From April to August 2007 we conducted point and line transect sampling to study the distribution and population densities of the primates in the PNKB NP. Here we present our observations on Hatinh langurs and compare the efficiency and the output of both methods in the difficult habitat of this endangered langur.

**Methods**

**Study area**

PNKB NP is located in Quang Binh Province in Central Vietnam at the border to Laos and covers more than 85,000 ha (BirdLife International & Forest Inventory and Planning Institute, 2001; Vogt et al., 2006). As part of the Annamite Mountains it is largely at altitudes between 50 and 1000 m above sea level and is characterized by steep limestone hills and dense primary forests. The karst forests of the PNKB NP with its numerous limestone cliffs and caves constitute a suitable habitat for the Hatinh langur (Nadler & Streicher, 2003; Vogt & Forster, 2008). In the past there was a high activity of loggers and hunters, which disturbed not only the habitat of the primates but also diminished its populations (Nadler et al., 2003; Nguyen Man Ha, 2006). Even though illegal logging and hunting have decreased in recent years, such activities are still present in the PNKB NP affecting primate distribution and densities. Nevertheless, the PNKB NP is the most important protected area within the distribution of the Hatinh langur in Vietnam (Haus et al., 2009).

**Point transect sampling (PTS)**

We conducted PTS from May to August in 2007 in the PNKB NP. We surveyed 16 different points along Ho Chi Minh (HCM) Road and Road 20 that cross the National Park (Fig. 1). We located the points randomly along the roads, but within view of at least one potential sleeping cliff within the survey area. Mostly, distances between points were at least 570 m. Due to large limestone escarpments and a multitude of potential sleeping sites, the first five points in the northern part of the HCM Road were 360-465 m apart. We surveyed adjacent points simultaneously, but survey areas of different points never overlapped.

We measured exposures and distances of the cliffs from the observation points with a compass and a range finder (Bushnell, Yardage Pro Legend), and we took digital photographs of all cliffs. Most points were surveyed at least at three days, but three points could be surveyed only one time due to weather conditions. The data were recorded by four observers, who were trained before the study began. We started the surveys around 4:15 p.m. and continued to dusk so that each survey took around two hours. During this time Hatinh langurs are frequenting their sleeping sites. We observed the survey areas using binoculars and a spotting scope (Bushnell, D = 63 mm, model 787363). For all surveys we recorded date, time, observer, point identity, and weather conditions. At each detection event we measured the radial distance to the first sighted individual using a range finder and a compass (Buckland et al., 2001; Ross & Reeve, 2003). In addition we recorded
time, group size and structure, cue, substrate and activity. We documented all sightings independent of the distance from the observer. If we observed a Hatinh langur group, we recorded ad libitum data of all behavioural patterns.

**Line transect sampling (LTS)**

We conducted LTS in four different areas within the PNKB NP: Hung Lau, Hang E, Cha Noi and Ban Doong (Fig. 1). In each area we designed three different line transects. We intended to survey each transect ten times, but two transects in Ban Doong were surveyed only eight and nine times respectively due to weather conditions (Haus et al., 2009). We recorded the same data as in PTS, but we measured the perpendicular distance or the radial distance and the angle relative to the transect line and, if possible, the sighting height in the tree at each detection event (Buckland et al., 2001; Ross & Reeve, 2003; Haus et al., 2009). We collected the data during two survey phases from April to June and July to August, staying in each area two times for 5-8 days. During these periods we recorded all loud calls of Hatinh langurs heard at any time.

We described basic vegetation structures along transect lines (Haus et al., 2009) resulting in an average canopy cover of 78.90% (45.38-100%) and canopy height of 18.48 m (9.28-25 m). The density of understory was 78.25% (28.59-100%). We estimated the growth of liana on a scale from one (few) to three (plenty) (Haus et al., 2009). Liana growth averaged 2.27 m (1.56-3 m).

**Data analyses**

We recorded all sightings with GPS (Garmin GPS 60 with an external antenna: Gilsson Technologies, High Gain GPS Antenna, MCX, and Garmin GPS 12). We produced a distribution map with MapInfo Professional 7.8 SCP importing the GPS data with the program GarFile 1.5.2. For statistical analyses we conducted Mann-Whitney U and regression tests (linear correlation (r) and Spearman rank correlation (rs)) on a level of significance with $\alpha = 0.05$, using the statistical software PAST (Hammer et al., 2001). We analysed some behavioural data in relation to sunrise and sunset times (Gerding, 2008) by calculating differences between time of data record and respective times of sunrise and sunset for each day.

**Results**

**Point and line transect sampling**

Comparing the efficiency of both sampling methods there are differences in PTS and LTS (Table 1). In relation to the survey effort we recorded more Hatinh langurs during PTS than during LTS resulting in a more than three times higher efficiency for PTS than for LTS.

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Survey effort [h]</th>
<th>Efficiency [n/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTS</td>
<td>23</td>
<td>115.2</td>
<td>0.2</td>
</tr>
<tr>
<td>LTS</td>
<td>27</td>
<td>419.3</td>
<td>0.06</td>
</tr>
</tbody>
</table>

We recorded Hatinh langurs in all survey areas of LTS, most in Hang E and fewest in Hung Lau (Fig. 2). With PTS we confirmed groups at nine of 16 survey points alongside the roads. We recorded a significant higher group size with PTS (mean 5.09, range 1-11) than with LTS (mean 3.54, range 1-10; $N_{LTS} = 27$, $N_{PTS} = 23$, $p = 0.025$; Fig. 3). During LTS we observed a single individual 13 times, ten of which have been confirmed to be single males sitting
Fig. 1. Survey areas of point and line transect sampling in the Phong Nha – Ke Bang National Park in 2007.

Fig. 2. Hatinh langur sightings during point and line transect sampling in the Phong Nha – Ke Bang National Park in 2007.
in the upper canopy of trees. During PTS, we detected only four single individuals, two times a male. Mean group sizes are neither correlated with perpendicular or radial distance of LTS (N = 22, r = -0.22, p = 0.33) nor with radial distance of PTS (N = 23, r = -0.35, p = 0.1).

Radial distances of PTS were significantly higher than sighting distances of LTS (N_{LTS} = 22, N_{PTS} = 23, p ≤ 0.001; Fig. 4). We detected more Hatinh langurs by acoustical cues during LTS and more by visual cues during PTS. Most acoustical cues were caused by movement and feeding in the trees. In LTS 31% of acoustical cues were loud calls. We never detected Hatinh langurs by loud calls in PTS (Fig. 5).

**Ecological and Behavioural Observations**

We detected Hatinh langurs in trees every time during LTS and in 87% of the sightings in PTS. Both during LTS and PTS we observed them in trees growing at steep limestone cliffs in 37% and 52% respectively. We recorded Hatinh langurs directly on cliffs in 13% of all sightings of PTS, but we never detected them on the ground during both PTS and LTS. Combining all data of PTS and LTS, mostly we observed Hatinh langurs in trees (94%), 50% of which grew on limestone cliffs, and in 6% of all sightings we detected them on limestone cliffs between 6:00 a.m. and 6:50 p.m. (Fig. 6).

Analyses of habitat structure revealed no correlations in Hatinh langur abundance and canopy cover (N = 34, r_s = 0.02, p = 0.93), canopy height (N = 34, r_s = -0.19, p = 0.27), density of understory (N = 34, r_s = -0.28, p = 0.12) and growth of liana (N = 34, r_s = 0.03, p = 0.86). We recorded Hatinh langurs along transects in primary forests with an average canopy cover of 79.49% (50-100%) and an average canopy height of 17.92 m (12.65-25 m). The density of understory was 73.83% (33.96-100%) and growth of liana 2.32 m (1.73-3 m) on average. In a valley in Hang E area, we twice detected Hatinh langurs in edges of a regenerated secondary forest, which is surrounded by large limestone escarpments covered by primary forests. On average we saw Hatinh langurs at a height of 10.43 m (5-20 m) in the trees during detection.
With PTS we could confirm seven limestone cliffs as sleeping sites. The limestone cliffs surveyed were faced to almost all directions. Hatinh langur groups occupied cliffs faced to 0-89° (N NE), 135-179° (S SE), 225-269° (W SW) and 315-359° (N NW). We could not detect any preference for cliffs (Fig. 7). Furthermore they occupied small as well as large limestone cliffs for sleeping. We detected a high abundance of Hatinh langur sleeping sites at large limestone escarpments alongside the Chay River (Fig. 2). From May to August the groups returned to the vicinity of their sleeping sites 65 minutes before sunset (4:35 p.m. - 6:16 p.m.) on average, foraging and playing until they entered the sleeping places at the cliff on average 14 minutes after sunset (6:10 p.m. – 6:45 p.m.). We observed a group of Hatinh langurs and eastern Assamese macaques (*Macaca assamensis assamensis*) at the same limestone escarpment at HCM Road. The macaques occupied trees close to the Hatinh langur sleeping places on the cliff for three consecutive days; they always appeared before the Hatinh langurs and we did not recognize any interactions between the groups.

To collect LTS data we spent a total of 59 days in the forest. During this time we could record a total of 51 loud calls (whoops) of Hatinh langurs (Fig. 8). Most whoops (16) were heard between 5:00 a.m. and 6:00 a.m. before sunrise. We observed a second peak of loud calls between 4:00 p.m. and 5:00 p.m. We did not hear whoops before 4:54 a.m. and after 5:43 p.m. as well as between 11:25 a.m. and 1:25 p.m.. If we detected males producing whoop calls, we could observe typical jumping displays in the crowns of trees during the call.

![Graph](image1)

**Fig. 5.** Detection cues in line (LTS) and point (PTS) transect sampling. Loud calls represent percentage of acoustical cues.

![Graph](image2)

**Fig. 6.** Substrates used by Hatinh langurs (*Trachypithecus hatinhensis*) during detection events in line (LTS) and point (PTS) transect sampling.
Discussion

Point and line transect sampling

During PTS we detected Hatinh langurs in longer distances and more often by visual cues, whereas sightings of LTS were closer to the observers and hence more often detected by acoustical cues. Therefore we suggest a higher detection probability of Hatinh langurs applying LTS. However, in dense karst forests the observers are sometimes distracted by uneven ground and climbing in the karst, which can be minimized by frequent stops and walking as slowly as possible.

The mean group size of LTS was relatively low compared to mean group sizes of PTS and previous results of Pham Nhat et al. (1996; mean 7.3) and Nguyen Manh Ha (2006; mean 8.2). We
often recorded single males in the canopy during LTS and we suggest the possibility that some group members were undetected in the dense vegetation beneath (Haus et al., 2009).

In the forest the survey areas of points are limited by dense canopy and understory. Therefore we chose areas along the roads with wide visibility ranges. The points were easy to access by car or motorcycle. To collect LTS data we walked along the transect routes which was very time-consuming and required high physical effort. We could detect more Hatinh langurs with lower effort during PTS by standing at the viewpoints and recording all data from these locations. Due to wide visibility ranges of PTS and the mountainous terrain of karst forests, we were not able to measure applicable survey areas of the points to compare the efficiency of both methods in terms of sightings per hectare. However, according to the long sighting distances recorded during PTS, we suggest that we also could survey a wider area in relation to time expenditure and physical effort.

In respect to survey design and effort we would prefer PTS to LTS for censuses of Hatinh langurs in karst forests, because points are easier to locate randomly and to survey than transect lines (Ross & Reeve, 2001). Furthermore PTS with views to potential sleeping sites allowed us to record more detailed information about ecology and behaviour of Hatinh langurs and to obtain more reliable group sizes at exposed cliff sites. However, it should be noted that there are difficulties in estimating the survey area of points which may lead to an overestimation and underestimation of survey area and primate abundance respectively. In contrast to LTS (Haus et al., 2009) the sample size of PTS was too small to estimate the density of Hatinh langurs in the PNKB NP. To compare density estimates of both methods, further studies are required to increase the sample size of PTS.

Ecology and Behaviour

Nguyen Manh Ha (2006) observed Hatinh langurs more often at cliffs facing west or southwest and he described those cliffs as warmest in the late afternoon. In contrast we did not detect any preference for cliffs, and Hatinh langurs occupied cliffs that faced almost all directions.

The longest time we surveyed one limestone cliff was four consecutive days. Therefore our data do not provide enough information to suggest how many sleeping sites are occupied by one group and for how many consecutive days they are frequented. Nevertheless, on three occasions we observed Hatinh langur groups at the same limestone cliff for four consecutive days. Furthermore during surveys at HCM Road km 33.16 we did not record Hatinh langurs occupying the limestone cliff for two days. Due to weather conditions we surveyed the point two weeks and observed a group occupying the limestone cliff for three consecutive days. Therefore we assume that Hatinh langur groups occupy more than one cliff for sleeping and that these cliffs are used alternately.

Loud calls of Hatinh langurs can be divided into two types: whoops and grunts. Whereas the whoops are produced by exhalation, the grunts are produced by a long inhalation-exhalation interval (Stünkel, 2003). In contrast to other taxa of the genus *Trachypithecus* (Stünkel, 2003), we more often recognized whoops of the Hatinh langur during the time spent in the forest. We heard grunts only few times during detection events and they seemed to be produced as warning calls in direct response to the observers. We did not hear grunts from far distances. We found the greatest peak of the whoops early in the morning before sunrise and a second peak in the afternoon. During these periods, the groups depart from and travel to their sleeping sites, respectively. Most times we were unaware of the stimuli of the whoop calls. Due to the concentration of loud calls early in the morning and late in the afternoon and the observed jumping displays during the call, we assume
that these long distance calls of the males are mainly produced as territorial markers and spacing mechanisms to keep adjacent groups apart (Bates, 1970; Vogt, 2003). However, we twice recognized whoops by several males in response to thunder, indicating that the whoops of Hatinh langurs may also be produced as alarm calls in response to disturbance and threat (Stünkel, 2003; Vogt, 2003).

Conclusions

Our data provide fundamental information on Hatinh langurs in the PNKB NP. Further surveys are necessary to improve the knowledge of status, distribution, behaviour and ecology, and to find appropriate sites for the final release of the Hatinh langur groups of the primate reintroduction program of the Frankfurt Zoological Society and Cologne Zoo.

In terms of future studies in the PNKB NP, PTS along roads provides a low-effort method to observe changes of status, group structure and size, and occupation of sleeping sites.

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