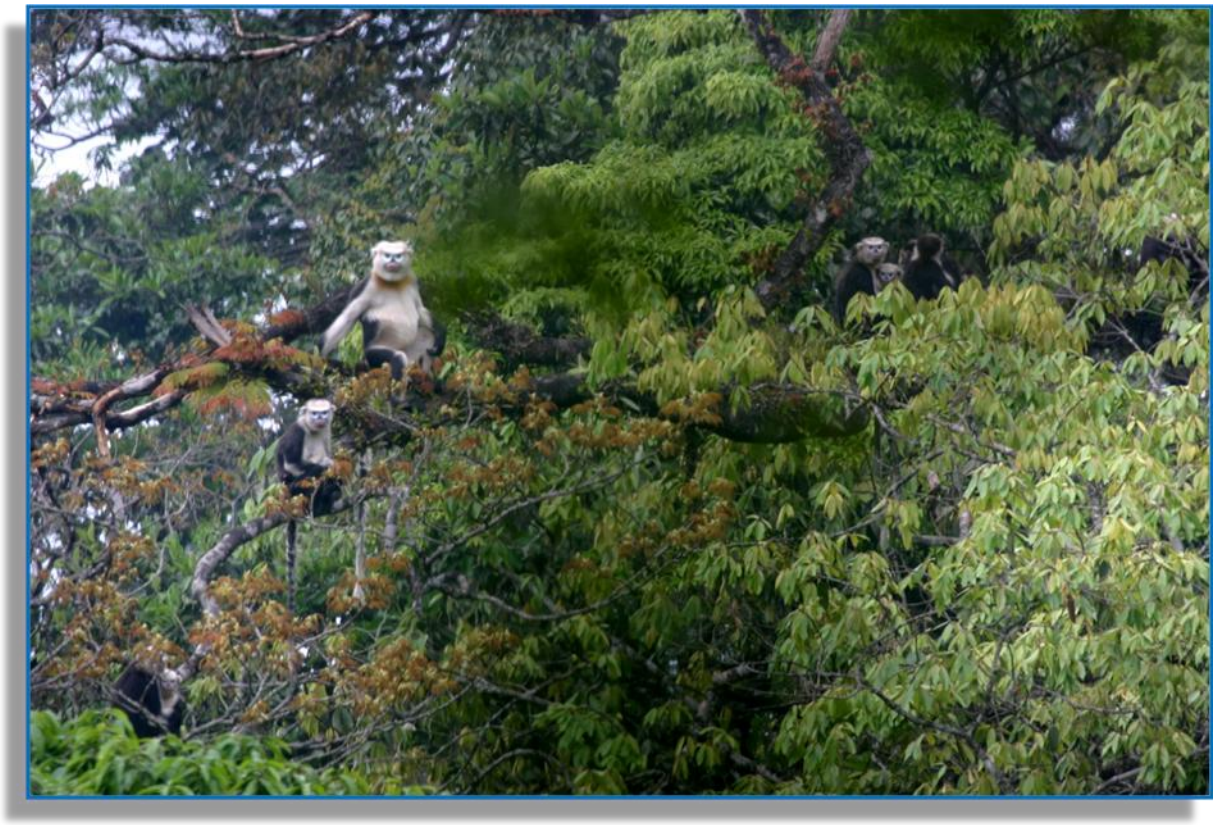
BEHAVIOURAL ECOLOGY AND CONSERVATION OF *Rhinopithecus avunculus* IN VIETNAM



DONG THANH HAI

Hanoi, December 2008

Project title: Behavioural Ecology and Conservation of *Rhinopithecus avunculus* in Vietnam

Principal investigator(S): **Hai Dong Thanh**
Address: **School of Archaeology & Anthropology**
Faculty of Arts
A.D Hope Building (Bldg.14)
The Australian National University
Canberra, ACT 0200
Australia

Telephone/Fax/Email: **Tel: (+61) 2 6125 5198**
Fax: (+61) 2 6125 2711
Email: thanh.dong@anu.edu.au

Field address: **Department of Wildlife Management**
Faculty of Forest Resources and Environmental Management
Vietnam Forestry University
Xuan Mai, Chuong My, Hanoi
Vietnam

Telephone/Fax/Email: **Tel:(+84) 34 840031/(+84) 0915452657**
Email: donghaifuv@yahoo.com

@Photos: All pictures used in this report captured by the author

EXECUTIVE SUMMARY

This report summarizes the results of a study of ecology and behavior of a little known, endemic and critically endangered primate, the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Vietnam. The aim of the study itself is to provide better understanding of social organization and behaviour, and feeding ecology of *R. avunculus* that result in conservation and management recommendations for the species and its habitats.

Study of *Rhinopithecus avunculus* was carried out at two of the four known areas of occurrence of *R. avunculus:* Tat Ke Sector, Na Hang Nature Reserve, Tuyen Quang Province (from September 2004 to July 2005) and Khau Ca Forest, Ha Giang Province (between August 2005 and Oct 2006). Systematic observations were used to collect data on ecology and behavior of *R. avunculus* at two selected sites. Total contact hours at Tat Ke Sector and Khau Ca Forest were 9 and 241 respectively, accounting for 2397 observations.

The results of ecology and behavior of *R. avunculus* in both Tat Ke and Khau Ca are presented in five main sections: group size and composition (section 4.1); social organization of *R. avunculus* (section 4.2); Social behavior (section 4.3); botany and phenology (section 4.5); feeding ecology (section 4.6); conservation (4.7).

This report also provides appropriate recommendations for long-term management and conservation of *R. avunculus* in both sites (see section 4.10)**.** These recommendations can be used as guidelines for developing a Conservation Action Plan for populations of *R. avunculus* at Tat Ke and Khau Ca.

ACKNOWLEAGEMENT

I would like to thank the Provincial Forest Protection Department of Tuyen Quang, Na Hang Forest Protection Department, Na Hang Nature Reserve Management Board, Forest Protection Department of Ha Giang, Du Gia Nature Reserve Management Board, People's Committee of Minh Son communes, Vietnam Forestry University and Institution of Ecological and Biological Resources for their permission and support to undertake this study. In particular I would like to thank the Na Hang Nature Reserve Management Board Director, Mr. Le Hong Binh and Head of Conservation Department, Ha Giang Forest Protection Department, Mr. Hoang Van Tue.

For local assistance and support, I would like to thank Le Xuan Hiep, Quan Van Tinh, Dong Khac Thanh, Ma Van Tu, Ma Van Huong, Quan Van Thiet, Vu Duc Kham. Special thanks go to Ms. Susan Hua, from Cornel University, for her dedication, support, and assistance during the conduction of this study. I am grateful to all the reserve, forest rangers, and patrollers for their assistance.

I would like to thank all the guides and porters who helped in the study, and to households from Tat Ke, Minh Son, Fia Deng, Binh Ba, and Khoi Loa villagers who provided information and supported with accommodation to the research team.

Special thanks go to Prof. Colin Groves, Dr. Ramesh Boonratana, Dr. Craig Kirpatrick, Dr. Le Xuan Canh, Mr. Do Quang Huy, and Mr. Nguyen Van Huy for their great support in all respects of my study.

I thank the following organizations for their financial support to cover my fieldtrip at Tat Ke Sector and Khau Ca Forest: BP Conservation Programme, Primate Conservation Inc (PCI), Wildlife Conservation Society (WCS), Rufford Small Grant (RSG), Zoological Society of San Diego Zoo (ZSSD), The Australian National University (ANU), Conservation International (CI), and Margot Marsh Foundation.

TABLE OF CONTENT

1. INTRODUCTION

1.1. Background information

1.1.1. Animal description

Figure 1.1. Adult male and female of *R. avunculus* at Khau Ca

The Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) is a slender-bodied, sexually dimorphic, arboreal, critically endangered primate, endemic to northern Vietnam. It belongs to the subfamily Colobinae and remains relatively unstudied in comparison with the other members of the "snub-nosed" group. For example, since 1993 data on ecology and behaviour of *R. avunculus* has been known only from Boonratana and Le' s six-month preliminary study at Na Hang Nature Reserve.

The Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) has the least sexual dimorphism among the members of snub-nosed group (Jablonski & Pan, 1995:260). Average body mass of adult male is 14kg, with a head and body 65 cm and tail 83 cm in length, whereas adult females weigh an average of 8.5 kg, with a head and body length of 54 cm and tail 68 cm (Ratajszczack et al., 1992:).

The nose is upturned and tip reaches nearly the forehead (Boonratana and Le, 1994:1; 1998a:208; Le & Boonratana, 2006:10; Nadler, et al., 2003:149; Napier & Napier, 1967:295; Pocock, 1924:330). The digits of hands and feet are similar to those of *P. nemaeus*, *Nasalis* and *Presbytis* (Groves, 1970:570), but longer and more slender than those of other *Rhinopithecus* species (Pocock, 1924:330; Thomas, 1928:140; Napier & Napier, 1967:295).

The species has short body hair (Dollman, 1912:503; Groves, 1970:570). Back and outer sides of limbs are black in adults, whereas inner sides of limbs, back of thighs and elbows

are creamy-white (Boonratana and Le, 1994:1; 1998a:208; Dollman, 1912:503; Le & Boonratana, 2006:10; Napier & Napier, 1967:296). The fur on the forehead and face is also creamy-white. the face around is naked the eyes and is described as flesh-coloured (Dollman, 1912:503), pale bluish white (Groves, 1970:570), or pale blue in colour (Boonratana & Le, 1994:2; 1998a:208; Le & Boonratana, 2006:10). Ears have creamy-white tufts arising from their inner sides (Dollman, 1912:503; Nadler et al. 2003:149). Lips are pink (Chaplin & Jablonski, 1998:90; Nadler, et al., 2003:149), and very prominent. There is bluish black coloration around the mouth and an orange patch on the throat; these colours are outstanding in adult males (Boonratana and Le, 1994:2; 1998a:208; Dollman, 1912:503; Le & Boonratana, 2006:10; Napier & Napier, 1967:296). Two prominent buffy white patches lie on the rump on either side of the tail (Dollman, 1912:503; Nadler et al. 2003:149)

Tail is longer than head and body (Groves, 1970:570; Napier & Napier, 1967:295) and has a creamy-white tuft (Boonratana and Le, 1994:2; 1998a:208). the dorsal surface of the tail is black, whereas it is ventrally creamy-white. Strands of long creamy-white hairs, which are most prominent in the adult males, are clearly seen from the base to just above the tufted tip when viewed from the rear (Boonratana and Le, 1994:2; 1998a:208; Le & Boonratana, 2006:10).

Pelage of infants and young juveniles is grey rather than black as in adults, and the orange throat patch and strands of cream-white hairs on their tails are absent. The dark region around the mouth is also inconspicuous (Boonratana and Le, 1994:2; 1998a:208; Le & Boonratana, 2006:10).

No information is made available for neonates of *R. avunculus*. Works by Chaplin and Jablonski (1998:21), however, suggested that neonates of the odd-nosed group have blue facial skin and white or grey coat which is not remarkably contrasting to their mothers.

Like other members of colobines, *R. avunculus* have a special digestive system with enlarged salivary glands that allows them to balance the acidity of the forestomach fluid (Oates & Davies, 1994:2); specialized dentition (higher cusps and longer crests) that enable

them to fold and cut leaves better than cercopithecines do (Oates & Davies, 1994:2; Lucas & Teaford, 1994:180); and an enlarged, complex ruminant-like stomach containing a diverse microflora that helps to ferment fibrous food such as leaves (Bauchop & Martucci, 1968:698; Chivers, 1994:205; Chivers & Hladik, 1980:343; Kavanagh, 1983, Kay and Davis, 1994:229).

1.1.2. Taxonomy

Rhinopithecus avunculus was first described by Dollman in 1912, and was later placed in its own genus *Presbytiscus* by Pocock (1924). Hence it has been variously known as *Presbyticus avunculus* (Pocock, 1924:330; Thomas, 1928:140), *Pygathrix* (*Rhinopithecus*) *avunculus* (Groves, 1970:570; 1989:148; Napier, 1985:; Oates et al.1994:58; Tohrington & Groves, 1970:641), *Rhinopithecus* (*Presbytiscus*) *avunculus* (Jablonski, 1998:14; Jablonski & Peng, 1993:36; Jablonski & Pan, 1995:251), and simply *Rhinopithecus avunculus* (Napier & Napier, 1967:295; Groves, 2000:; 2001:287). *Rhinopithecus avunculus* suggested by Groves (2001) will be used throughout this report.

1.1.3. Distribution

The Tonkin snub-nosed monkey is endemic to northern Vietnam. It is historically distributed throughout five provinces: Tuyen Quang, Cao Bang, Yen Bai, Bac Thai and Quang Ninh (MoSTE, 2000). More recent observations suggest that the species is restricted to Bac Kan, Tuyen Quang, Ha Giang, Quang Ninh and Thai Nguyen Provinces (La & Trinh, 2001; Le, 2001; Le & Simmons, 2002; Long & Le, 2001) (Figure 1.1). Unlike Chinese snub-nosed monkeys, *R. avunculus* live in tropical forests (mixed broadleaf and bamboo forests), at low elevations, ranging from 200m to 1200m (Le & Boonratana, 2006:10). Its current range is currently limited to the fragmented forest patches associated with limestone hills and is still dramatically reducing in size (Boonratana and Le, 1994:28; 1998b:318; Le & Boonratana, 2006:14; Nadler et al., 2003:161; Pham, 2002:77; Ratajszczak et al., 1990:30; 1992).

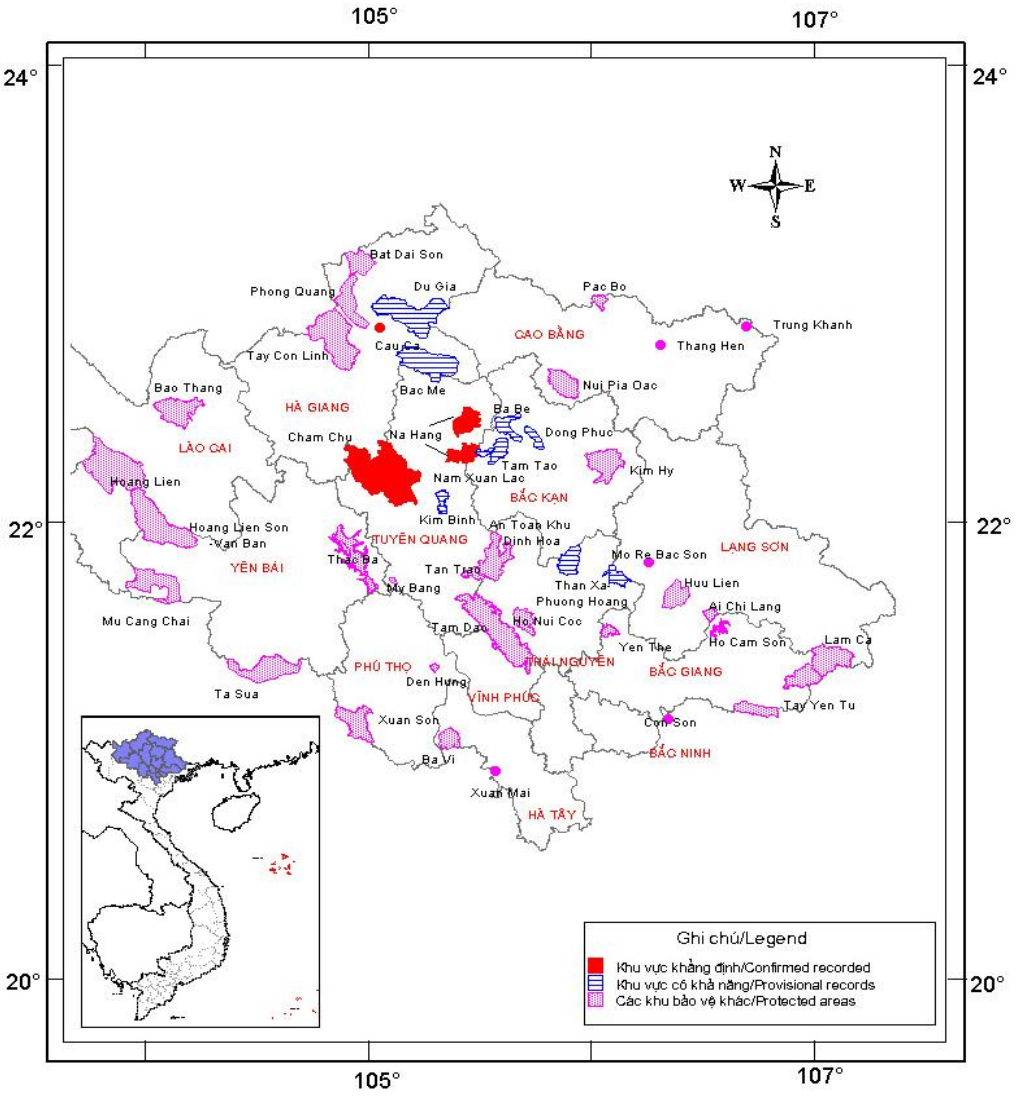


Figure 1.1. Ditribution map of Rhinopithecus avunculus in Vietnam
(source: Boonratana and Le, 2006)

1.1.4. Population and conservation status

Population status.

Total population estimates for *Rhinopithecus avunculus* have remained unclear and are largely based on local reports and short surveys. An exception is the estimation of a population of at least 130 animals in Na Hang Nature Reserve by Boonratana and Le in 1993. The highest estimate for the total population of *R. avunculus* is 350 (Cao & Pham, 1995:187). Further, review by Nadler et al (2003:159) estimates 307 individuals, with 95 to 135 animals in Na Hang Nature Reserve (in two sub-populations), 30 to 70 animals in

Cham Chu Nature Reserve, and 21 to 50 animals in Du Gia Nature Reserve. The most recent estimate for total world population of *R. avunculus* is 250 individuals according to Le & Boonratana (2006:14). They noted that the actual population may be higher than this figure since the possibility of the occurrence of the species at some provisionally recorded areas is likely.

Conservation status

Much attention has been paid by both Vietnamese government and international conservation communities to protect *Rhinopithecus avunculus* since Ratajszczack and his colleagues' rediscovery of a population of the species in Tuyen Quang in 1989.

At the national level, *R. avunculus* has been a fully protected species since 1994 under the Forest Resources Development and Protection Law, and is listed as "Endangered" in the Vietnam Red Data Book (2000), in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and in group IB of Decree No. 32/2006/ND/CP. A number of protected areas have been established primarily to protect the species, including Na Hang Nature Reserve in 1994 and Cham Chu Nature Reserve in 2001, and Khau Ca Forest is currently proposed as a Species/Habitat Conservation Area (Le & Boonratana, 2006:24).

At the international level, it is currently listed as "Critically Endangered" in the IUCN's red list of threatened animals (IUCN, 2004), and as one of the top 25 critically endangered primates of the world (Mittermeier et al., 2006). To take action, international conservation communities such as the World Wild Fund for Nature (WWF), Conservation International (CI), Primate Conservation Inc. (PCI), the International Union for the Conservation of Nature (IUCN), Fauna and Flora International (FFI), Munster Allwetter Zoo and others have provided both financial and technical support for the conservation of the species in Na Hang Nature Reserve and Cham Chu Nature Reserve in Tuyen Quang Province, Ba Be National Park in Bac Kan Province, and Khau Ca Forest in Ha Giang Province.

In addition to law enforcement, both short surveys and long-term studies have been conducted to reveal the population status of *R. avunculus*, and to better understand its

ecology and behaviour. The data gathered have assisted in developing conservation and management recommendations for the species and its habitats. Na Hang Nature Reserve, for instance, has been established and received enormous support from internal and external conservation organizations since Boonratana and Le' s study in 1993; and Fauna and Flora International (FFI) has been running field researches and conservation awareness raising programs at Khau Ca Forest where a new population of 55-60 individuals of *R. avunculus* was discovered by Le (2001).

Threats

Hunting and habitat destruction are major threats to the survival of *Rhinopithecus avunculus* in their range (Boonratana & Le, 1994; 1998b; Cao & Pham, 1995; Dong, et al., 2006; Le & Boonratana, 2006:14; Long & Le, 2001; Nadler et al., 2003).

1.1.5. Previous studies on ecology and behaviour of Rhinopithecus avunculus

Compared with other species of snub-nosed group, the ecology and behaviour of the Tonkin snub-nosed monkey is the least known and the species is poorly understood throughout most of its range. Details of social behaviour, feeding behaviour, locomotion, sleeping sites, home range and diet remain to be studied, although Boonratana and Le (1994; 1998a), Pham (1993; 1994; 2002), Ratajszczak et al.(1992), and Nguyen (2000) all presented preliminary data.

Social organization

Social organization of *R.avunculus* remains in dispute between authors. For example, Ratajszczak et al (1990:30; 1992) and Le et al (2006) reported that the basic social structure of *R. avunculus* consist of multi-male and multi-female units. In contrast, Boonratana and Le (1994:23; 1998a:212) and Dong and Boonratana (2006) postulated that the species lives in one-male units comprising a single full adult male, several adult females and young animals. Extra males form loosely-bonded all-male units. They further reported that the species lives in a fission-fusion society with the different units frequently coming together to sleep, travel and feed.

Group size of one-male units of *R. avunculus* is reported as similar to those of Chinese taxa. It ranges from 10 to 20 animals for one-male units at Na Hang (average: 14.8, Boonratana & Le, 1994:23). Band size however appears to be smaller than in Chinese species. Band sizes of *R. avunculus* at Khau Ca Forest range from 22 to 81 individuals (Dong & Boonratana, 2006), and between 23 and 72 animals at Na Hang (Boonratana & Le, 1998b:318). Bands of *R. avunculus* appear to be less cohesive than Chinese snub-nosed monkeys. subunits frequently coalesce or split up. The species frequently coalesces and splits up into small units (Boonratana & Le, 1994:26; 1998a:214), although factors that drive fission and fusion in *R. avunculus* remain unclear. Kirkpatrick (1998:176) suggested that the tropical forests of *R. avunculus* are more heterogeneous and may hold smaller food patches than the subtropical and temperate forests of *R. roxellana* and *R. brelichi*, thereby allowing *R. avunculus* to break up into small units.

Social behaviour

Information on social behaviour is poorly described. Grooming is high in *R. avunculus* at Na Hang (9.7%, Boonratana & Le, 1998a:212), compared with Chinese species (*Rhinopithecus bieti*: 6.1 %, Kirkpatrick, 1996:15). Most involves allogrooming, and adult females are the groomers on all occasions (Boonratana & Le, 1998a:212). Playing, which made up 2.9%, is found only in juveniles and infants. Vigilance contributes to 23.3% of *R. avunculus* total activity.

Feeding ecology

Tonkin snub-nosed monkeys have been reported to feed on leaves, fruits and seeds (Boonratana & Le, 1998a:213; Pham, 1993; 1994:4; Ratajszczak et al., 1990:30), but the proportion of plant parts eaten varies between authors. For example, Ratajszczak et al (1990:30) stated that *R. avunculus* is folivorous, primarily consuming leaves. In contrast, based on direct observations (n=34 feeding observations), Boonratana and Le (1994; p. 24; 1998a:213) documented that the diet at Na Hang comprises 62% of fruits and seeds, and 38% of leaves. Similarly, Pham (1994, p.4; 2002:58), suggested that *R. avunculus* rely

heavily on fruits rather than leaves. For instance, of 61 species eaten by *R. avunculus*, 52 species are fruit (63%) (Pham, 2002:58). These latter works are just based on local reports and six stomach examinations, and do not specify number of direct observations.

Range use and day range

Home range of *R. avunculus* appears to be smaller than Chinese snub-nosed monkeys. Boonratana and Le (1994:25; 1998a:213) suggested that home range size for the population in Tat Ke sector seems to be at least 10 km^2. Subunits of *R. avunculus* have great home range overlap.

Locomotion

Tonkin snub-nosed monkeys have been reported to be totally arboreal. Traveling accounted for 39.8% (n=82) of its total activity time. Quadrupedal walking, climbing and leaping were used to travel within trees. Leaping, arm-swinging, and brachiation were used to move between trees. Only adult males and females exhibited arm-swinging and brachiation (Boonratana & Le, 1994:24; 1998a:213).

Vocalization

Two types of vocalizations have been recorded to date. Adults and juveniles of *R. avunculus* display distinct and loud vocalizations "huu chhhk". The functions of these vocalizations can be alarm or contact calls, depending on given contexts. Continuous alarm calls were used when the monkey detected observers. During traveling, feeding and other activities, group members also occasionally emitted "huu chhhk" vocalizations, probably contact calls between members of a unit or between units (Boonratana & Le, 1994:24; 1998a:213)

Sleeping site

Tonkin snub-nosed monkeys usually select lower branches of trees that are close to steeper sides of mountains as sleeping sites. This may protect them from strong and cold northeast winds (Boonratana & Le, 1994:24; 1998a:214)

1.2. Aims of the study

Since there were no detailed ecological and behavioural studies of *R. avunculus*, the aims of the study was to find out this and that make comparisons with Chinese species and with other colobines and to draw attention to the critical conservation status of the species. The aims were:

1. To provide data on the population size of *R.avunculus* in Tat Ke Sector, Na Hang Nature Reserve and Khau Ca Forest.
2. To study the social organization and social behaviour of *R. avunculus* in relation to habitat and food availability.
3. To describe the botany of the karst mountain forests in Tat Ke Sector, Na Hang Nature Reserve, and in Khau Ca Forest.
4. To monitor and compare the phenology of the study sites, and to assess seasonal changes in food availability.
5. To assess current and potential threats to *R. avunculus* and its natural habitat.
6. To make appropriate conservation and management recommendations for the species and its habitat.

2. AREA DESCRIPTION

Study of *Rhinopithecus avunculus* was carried out at two sites, including Tat Ke Sector, Na Hang Nature Reserve, Tuyen Quang Province (from September 2004 to July 2005) and Khau Ca Forest, Ha Giang Province (between August 2005 and Oct 2006). These are two of the three known areas of occurrence of *R. avunculus*, the other being Ban Bung Sector, Na Hang Nature Reserve and Cham Chu Nature Reserve.

2.1. Tat Ke Sector

2.1.1. Location

Na Hang Nature Reserve, established in 1994, is located in Na Hang District, Tuyen Quang Province between $22^0$16'-$22^0$31'N and $105^0$22'-$105^0$29'E (Boonratana, 1998: 6), and consists of two sectors: Bang Bung to the south and Tat Ke to the north (Figure 2.1). It falls within biogeographical subdivision of the Tonkin (Delacour & Jabouille's, 1931, cited in Boonratana, 1999), or Thailandian Monsoon Forest (unit 4.10.4) (Udvardy, 1975, cited in Boonratana, 1999), or South China (unit 6a) of the Indo-Malayan Realm (Mackinnon & MacKinnon, 1986). The reserve covers an area of 41, 930 ha, comprising strictly protected area (27,500ha), forest rehabilitation area (12, 910 ha), and administration area (1,500 ha) (Le, H.B., 2003:7; Le, T.T., et al., 2004:2). It has border with five communes, including Con Lon, Khau Tinh, Vinh Yen, Son Phu and Thanh Tuong (Le, H.B., 2003:7).

Main study site was in Tat Ke Sector ($22^0$22'-$22^0$31'N and $105^0$22'-$105^0$29'E) which covers an area of 12, 500 ha. It is about 3 km to the north of Na Hang Town. The Sector is bordered by Gam River and Nam Vang Stream on the northwest and Nang River and Ta Lan Stream on the northeast (Figure 2.2).

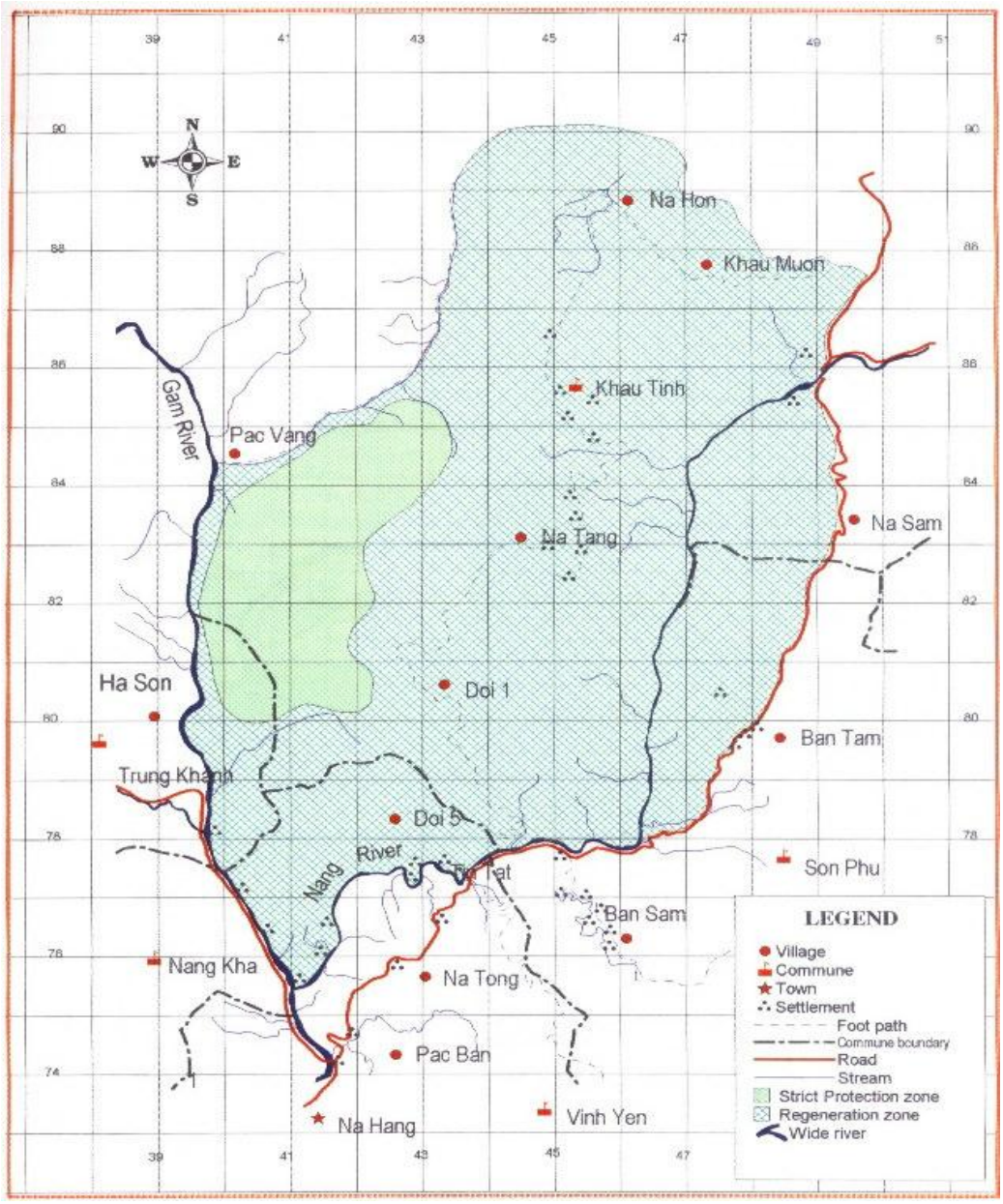


Figure 2.1. Map of Tat Ke Sector

2.1.2. Topography

The terrain of Tat Ke Sector was characterized by steep rugged limestone hills and mountains. Altitude ranges from 100 to ca. 1100m. The highest point in the Sector is the summit of Khau Tep 1064 m above sea level (F-48-31-D, 2001). There are several permanent and intermittent streams in the Sector drained into the Gam and Nang Rivers. Due to its limestone geology feature which allows much of the water surface quickly

absorbed into underground streams, there is shortage of surface water during the dry season. Some small floodplain areas exist in the sector that have been converted into cultivation areas, mainly rice (Boonratana, 1998:7; Dang, 1996:1).

2.1.3. Climate

Like other parts of the northern Vietnam, the Na Hang Nature Reserve climate is affected by monsoon tropical climate. There are four distinct seasons: spring, summer, autumn, and winter. However, it is possible to divide the climate here into two main seasons: cold and dry season from October to April and hot and wet season from May to September.

Cold and dry season (between October 2004 and April 2005) were characterized by lower temperature and less rainfall (figure 3.1). Maximum and minimum temperatures of 32.5^0C and 11.1^0C were recorded in October 2004 and in March 2005, respectively. Mean temperature was 14.9^0C. It rained for a total of 73 days and total rainfall was 293 mm. In contrast, from May 2005 to September 2005, there were 85 rainy days and total rainfall was 1247 mm. Temperatures ranged between 18.8^0C and 35.4^0C. Mean temperature was 30.4^0C. These months are referred to as hot and wet season.

Although cold and dry period lasts for 7 months and appears to be ideal time for observing the monkeys, the best time for observing the monkeys was in fact only in three months (between October and December). During the rest of the season (from January to April), there were heavy mist and fog which result in poor visibility.

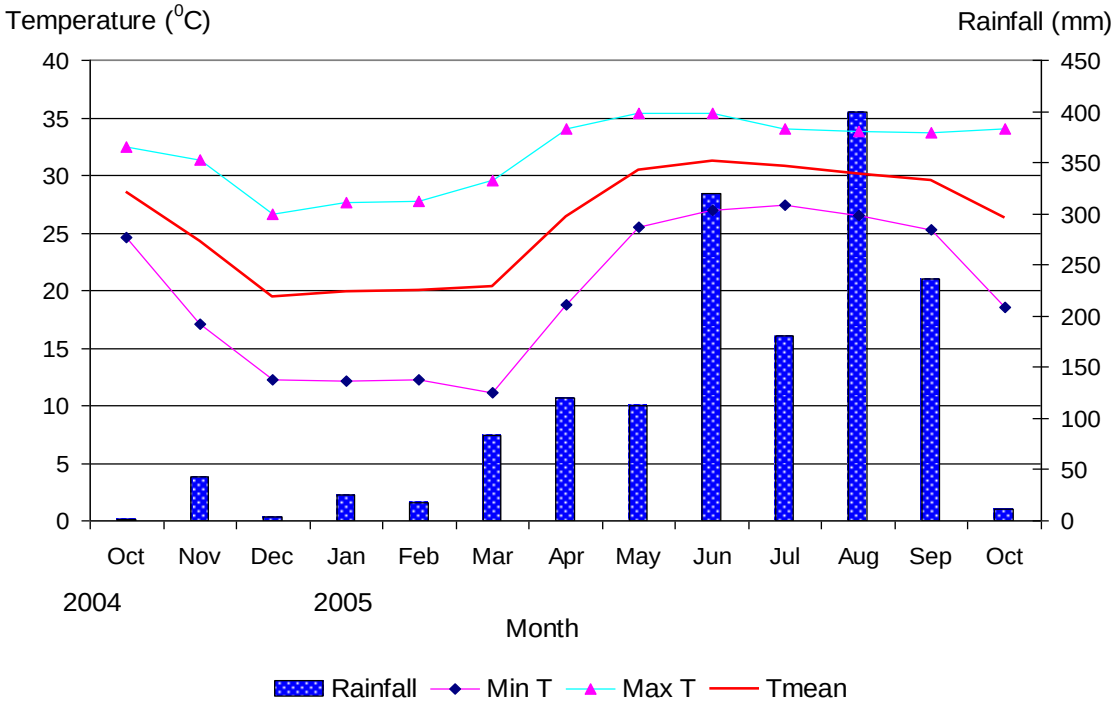


Figure 2.2. Mean monthly maximum and minimum temperatures, and mean monthly rainfall recorded at Tuyen Quang for 2004-2005.

2.2. Khau Ca Forest

2.2.1. Location

Khau Ca Forest has been reported to belong to Du Gia Nature Reserve (Le, K.Q., 2004: 59), but was later confirmed that the area was outside Du Gia Nature Reserve and an isolated area without any legal forest special use status (Dong & Boonratana, 2006; Le & Boonratana, 2006: 15). It is recently used by several names such as Khau Ca Area (Le, K.Q., 2006) and Khau Ca Tonkin snub-nosed monkey Conservation Area (T.V.Dam, Pers.comm., 2006). Khau Ca Forest will be used throughout of the thesis when refer to this area.

Khau Ca Forest is located near the Du Gia Nature Reserve, Ha Giang Province between $22^0$49'-$22^0$52'N and $105^0$05'-$105^0$09'E and is about 15-20km to the east of Ha Giang Town (figure 2.4). It covers an area of 1000ha and borders with three communes and two

districts: Minh Son, Yen Dinh Communes (Bac Me District) and Tung Ba Commune (Vi Xuyen District).

2.2.2. Topography

Relative to Tat Ke Sector, the terrain of Khau Ca Forest was characterised by limestone mountains, but was steeper and more rugged than Tat Ke Sector. It was also featured by deep and narrow valleys, and sharp and loose outcrops. Altitude varies greatly and is in the range of between 450m and 1339.9m. The highest point in the area is the summit of 1339.9m above sea level in the south east of the Khau Ca (F-48-43-C, 2001). The Khau Ca Forest can be divided in to two parts in terms of altitude: the higher part is in south east of the area with several peaks above 1000m and the lower part is in the north west of the area with peaks under 1000m above sea level. There was no water source inside the forest. All these features make Khau Ca Forest a very difficult study site and full day follow the monkeys were most unlikely on almost occasions.

2.2.3. Climate

The Khau Ca Forest has similar climate with Tat Ke Sector and other parts of northern Vietnam. It is characterized by a strong monsoon influence and has four distinct seasons: spring, summer, autumn, and winter. It is also possible to divide the climate here into two main seasons: cold and dry season from October to April and hot and wet season from May to September.

Mean temperature was high and variable between seasons during the course of the study (figure 2.3). The mean temperature ranged between 19.4^0C and 31.2^0C. The mean minimum temperature was lowest (12.2^0C) in January 2006 and the mean maximum temperature was highest (35.6^0C) in July 2006. The mean temperature during cold and dry period (from October 2005 to April 2006) was 22.9^0C and the mean temperature during hot and wet season (from May 2006 to September 2006) was 29.7^0C.

There were 222 rainy days and total rainfall was 1983 mm from August 2005 to September 2006. Rainy days and total rainfall varied greatly between seasons. It rained for a total of

88 days and total rainfall was 436 mm during cold and dry period (from October 2005 to April 2006), while these figures were 97 days and 1128 mm , respectively during hot and wet season (from May 2006 to September 2006). The lowest mean rainfall was in January 2006 (5.5mm) and the highest mean rainfall was in August 2006 (348mm).

Relative to Tat Ke Sector, the best time for observing the monkeys lasts for about three months (from October to December). The rest time of the year is rainy, heavy mist and fog which result in poor visibility and walking difficulties.

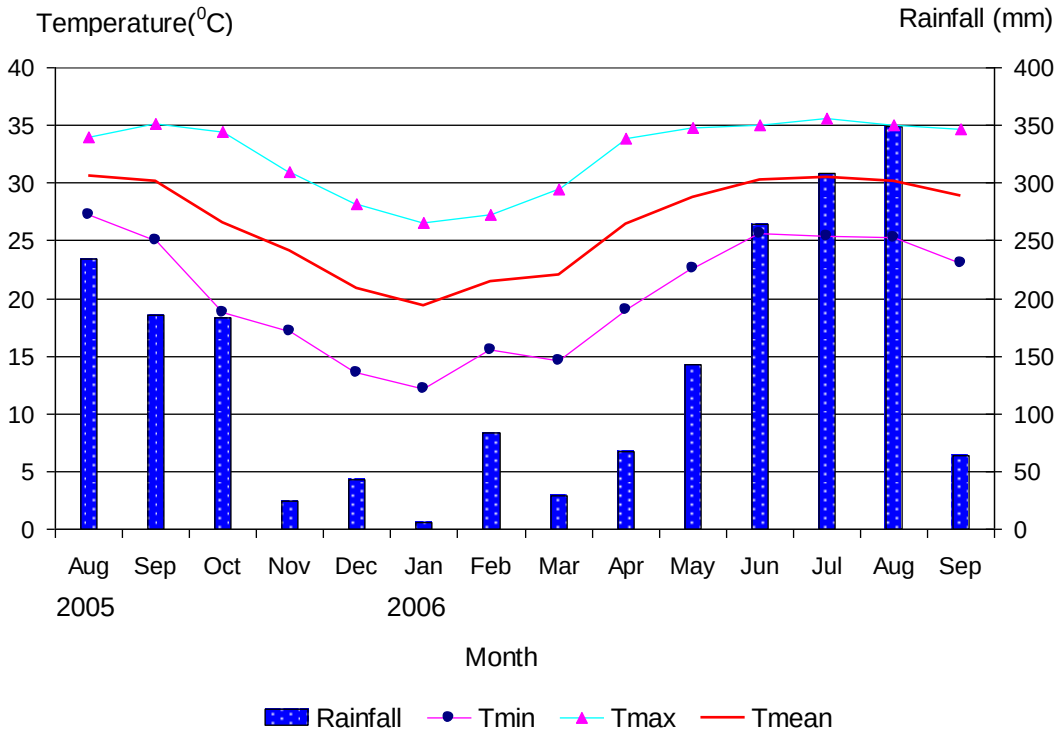


Figure 2.3. Mean monthly maximum and minimum temperatures, and mean monthly rainfall recorded at Ha Giang for 2005-2006.

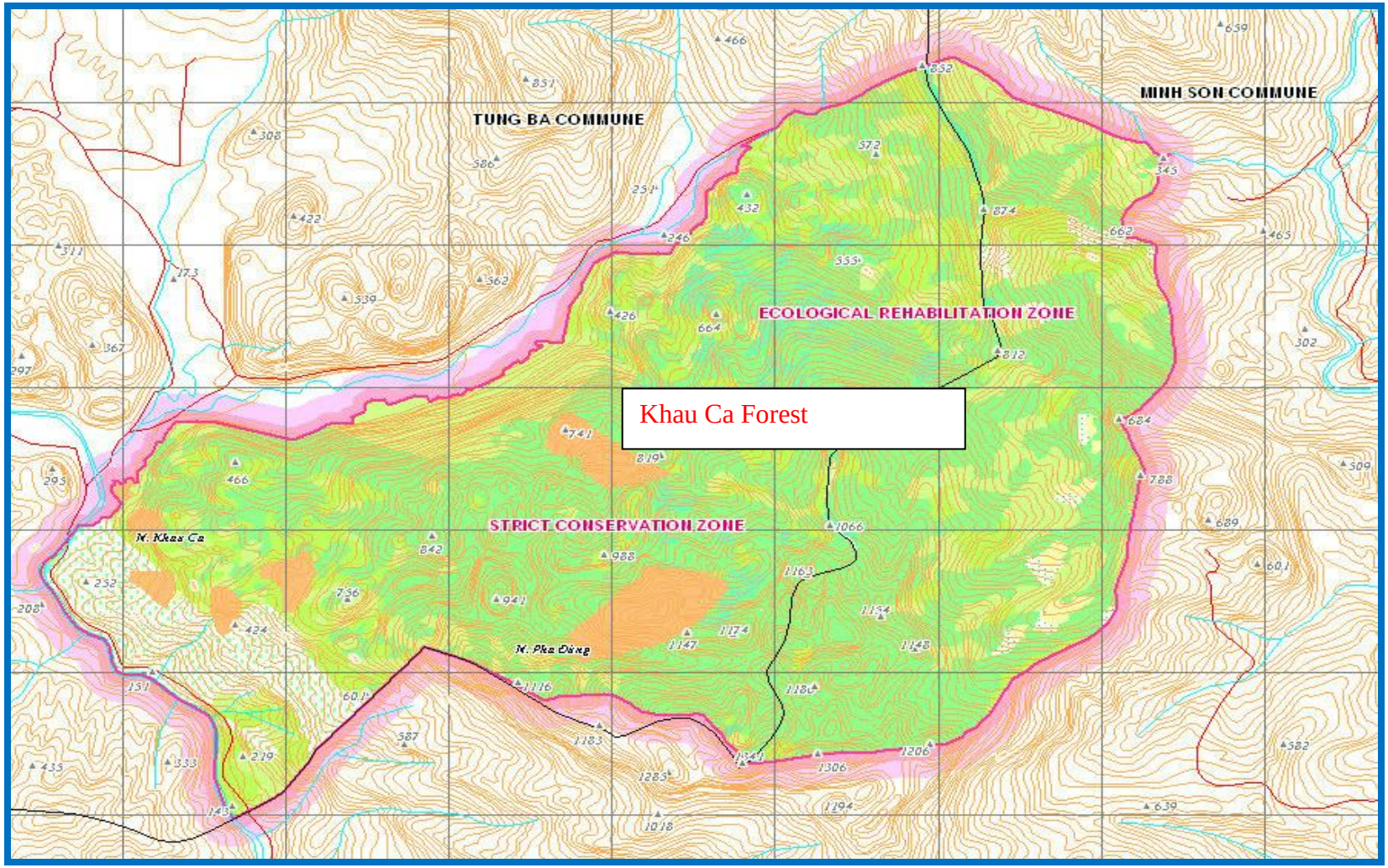


Figure 2.4. The topography map of Khau Ca Forest

3. METHODS

Field work was carried out between September 2004 and September 2006. Tat Ke Sector, Na Hang Nature Reserve, Tuyen Quang Province and Khau Ca Forest, Ha Giang Province were selected for the study.

3.1. Selection of site.

3.1.1. Tat Ke Sector

The choice of the first study site was made by the following reasons:

1. Tat Ke Sector, Na Hang Nature Reserve has been reported to hold largest population of *R. avunculus* in Vietnam until date (80 individuals, Boonratana & Le, 1994: 25; 1998b: 318).
2. Na Hang Nature Reserve has been established since 1994, and hunting pressure has been successfully controlled (Le, H.B., 2003: 7; Le, X.C., 2003: 81).
3. I had opportunity to work at the Na Hang Nature Reserve with Dr. Boonratana on "Na Hang rainforest conservation project" for three months in 1998. This would be a great advantage with regard of understanding study site and local people living in and around the Reserve.
4. At the time this study was carried out, there has been only six-month study by Boonratana and Le since 1993 in this area. Data gathered in this study, therefore, would elucidate social organization and behaviour, feeding ecology and range use as well as population and conservation status of *R. avunculus*.
5. Information on the presence of wildlife, other than *R. avunculus* , was also recorded during surveys. This would provide important information for making management and conservation plans in the Reserve.

3.1.2. Khau Ca Forest

The choice of the second study site was made by the following reasons:

1. After 11 month study in Tat Ke Sector, less than 10 contact hours was made and the population size there was proven to be smaller than we originally expected because of the

severe hunting pressure. Therefore, I decided to expand my study to another *R.avunculus'* known range, Khau Ca Forest, Ha Giang Province.

2. Khau Ca Forest has been reported to contain a population of 50-60 individuals and they live in a small area (ca. 1600 ha, Le, K.Q, 2004: 60). Therefore, the probability of encounter the monkeys are higher than other known range of *R. avunculus*.

3. The results collected from this site will be compatible with previous study site.

4. Information on the presence of wildlife, other than *R. avunculus*, was also recorded during surveys. This would provide important information for making management and conservation plans in the area studied.

3.2. Survey efforts

In Tat Ke, the survey team included 8 people: one researcher from Malaysia, four students from four universities: Australian National University, Cornel University, Vietnam Forestry University, Institution of Ecological and Biological Resources, four local people. The survey was carried over eleven-months in Tat Ke, with a total of about 1650 hours spent searching for the langur, and covered an area of about 32 km2 (figure 2.1).

In Khau Ca, the survey team comprised of 5 people including one researcher from Malaysia, one student from Australian National University, one student from Vietnam Forestry University, three local people. During the 12 month study, team members spent over 2000 hours searching and observing the langurs, covering an area of 10 km^2 (figure 2.4)

Transects and vantage points were used to obtain data on presence/ absence, sleeping sites, and threats to the species, as well as its habitat. Scan sampling were used to get information on social behavior and feeding behaviour (see detailed methods in this section).

3.3. Data collection

3.3.1. Interview

Interviews with villagers, hunters, forest rangers, and patrollers were conducted before the surveys took place. Key informants were determined by who had seen the *R. avunculus* in recent times. The purpose of interviews was to collect general information on the species in the target areas. The information gathered during interviews included current and past distribution of the species, number of groups, group sizes, threats to species and its habitats. Verbal reports, however, were used with care and only are added to the dataset after further verification in the field.

Figure 3.1. Interview with local people

3.3.2. Camp site

Base camps were established near or in the monkey's known habitat and also near a water source. This allowed us to observe and follow the monkeys from dawn to dusk whenever encountered, but most occasions were unlikely because of the shyness of the study subjects to the presence of the observers and the difficulty of the terrain. One based camp and three sub-camps were established at Tat Ke, whereas only one base camp was set up at Minh Son site, Khau Ca.

Figure 3.2. Base camp at Tat Ke Sector

Figure 3.3. Base camp at Khau Ca Forest

3.3.3. Climate

Rainfall and temperature data were first recorded at base camp during the first months of the study in Tat Ke Sector, but unfortunately the rain gauge was broken down during transportation and daily temperature was not recoded regularly since team members had to spend in short period of time between sub-camps to search for the monkeys. Therefore, climate data used in this thesis were recorded by the Tuyen Quang Weather Station (about 70 km from the Na Hang Nature Reserve) and Ha Giang Weather Station (about 20 km from the Khau Ca Forest). Based on field observations, there could be differences in climate between field sites and weather stations. Temperature, for example, was expected to be lower at field sites during winter season; the field sites appeared to receive more rain than the weather stations; heavy mist and fog days were more than expected from January to the early of April at two study sites; and humidity was high (more than 90% recorded during the first months of the study in Tat Ke Sector).

3.3.4. Botany

Figure 3.4. Team members establishing botanical plots

In order to describe the species and structural composition of the forest and to monitor the phenology of the trees and to compare the habitats of the two study sites, systematically placed botanical plots measuring (10 m x 10 m) were established at the study site during the first month of the study. Only 10m x 10m plots were feasible for the steep and karstic terrain of the habitats. All trees in the plots equal to or greater than 19 cm girth at breast height (equivalent to 6cm in diameter) t were tagged, measured, and identified. Sampled trees were identified by botanists from the Forestry University of Vietnam. Samples from trees that could not be identified in the field were collected and later identified at the Forestry University of Vietnam. The general

locations for each sample plot were selected to represent the monkeys' habitat. Voucher specimens were collected for all plant species encountered in plots, and for other species not found in plots.

3.3.5. Phenology

Figure 3.5. A team member monitoring phenological chracteristics

Observations were recorded monthly from October 2004 through August 2005 at Tat Ke Sector, Na Hang Nature Reserve and from September 2005 to September 2006 at Khau Ca Forest. Each tree in a plot was visited during the first day of the month and was recorded for their presence or absence of mature and young leaves, flower and flower buds, and ripe and unripe fruits. For some species, it was difficult to distinguish between ripe and unripe fruits. Unripe and ripe fruits were therefore combined as "fruits" in the data analyses. Flowering buds and flowers were also combined as "flowers" in data analyses to avoid missing flowering events of species with short blooming times since phenological characteristics were recorded only once a month.

3.3.6. Social behaviour

Given the species' low population size and rarity, both scan and *ad libitum* sampling methods (Altmann, 1974) were used to make full day observations from dawn to dusk, and to obtain information on its ranging and social behaviour. Scan samples were recorded during a 2 minute period every 15 minutes. Each observation was recorded three seconds after an individual was sighted so as to reduce bias towards individuals engaged in eye-catching activities.

Data recorded during each scan sample included:

1. Date
2. Location (name of area if known)
3. Weather
4. Location of the group encountered
5. Time
6. Age and sex of observed individual
7. Identity of observed individual, if known
8. Behaviour
9. Plant part and species, if known when feeding was observed
10. Age and sex of the individual nearest to the observed individual
11. The distance from the observed individual to the nearest neighbour
12. The number of other group members within 2.5 and 5m of the observed animal.
13. Height of observed individual above ground

Table 3.1. Activity categories used in this study
(adapted from Boonratana and Le, 1994)

Activity	Definition
Sitting	Subject sitting but not engaged in any other activity, except clinging (see clinging)
Standing	Subject standing on two or four limbs but not engaged in any other activity
Lying	Subject lying down and not engaged in any other activity
Traveling	Any movement between two points. Sub-divided into 1. Travel within the same tree; 2. Travel between trees; 3. Travel on the ground
Grooming	Any scratching or cleaning action using hands, feet or mouth. Sub-divided into 1. Autogroom; 2. Subject allogroom another; 3. Subject being allogroomed
Feeding	Subject manipulating, putting into mouth or masticating food items
Suckling	Subject with nipple of adult females in mouth
Clinging	Subject clinging to another individual with both hands. The subject's weight may or may not be supported by the other individual
Playing	Chasing, wrestling, exploratory and other movements which apparently are not goal-directed. Play can be solitary or social i.e. involving two or more individuals
Mounting	Subject positions itself behind and above another, with ventral-dorsal contact. Sub-divided into 1. Male mounting the female with penile penetration; 2. Female being mounted by the male with penile penetration; 3. Homosexual mounting without penile penetration; 4. heterosexual mounting without penile penetration
Agonistic	Subject delivers or receives act of aggression. Sub-divided into 1. Without physical contact e.g., deliver open-mouth facial threat; 2. with physical contact e.g., grab, lunge or bite.
Vocalisation	Any call produced by subjects. Includes "honk", grunt, bark, cough, squeal and scream.

Table 3.2. Age/sex categories used in this study

Category	Criteria
Adult male	The largest animal of group with robust head and large body. He has pink thick lips and dark coloration above upper lip. Face shape is square-like. The ears have creamy-white tufts. Hair on the back of head and neck is blackish brown. Orange patch on the throat is prominent. There is a blue V-shape on perineum region. Black penis is contrast with large creamy-white testicles. Tail is long with basically dorsal blackish gray and ventrally long white hairs arising from the base to just above white tufted tip.
Adult female	Large animals. Compared to adult male, she has a smaller size and slimmer body. Orange patches on either side of belly and inner thighs are conspicuous. Black nipples are contrast with creamy-white chest hair. There is no a blue V-shape on perineum region. White hairs on the ventral tail are shorter.
Sub-adult male	Male more than two-thirds of full body size of adult male but brown hair on the back of head and neck is not as conspicuous as adult male. Hairs on the tail are shorter and smoother.
Sub-adult female	Female more than two-thirds of full body size of adult female but brown hair on the back of head and neck is not as conspicuous as adult female. Hairs on the tail are shorter and smoother.

Table 3.2. Continued

Juvenile	Medium-sized animals. Orange patch on the throat is less prominent. Outer limbs are whitish gray, gradually turning black. Hairs on the tail are short and smooth. Tufted tip is not as hirsute as in adults. They are usually observed actively playing.
Infant	Small individuals. The naked facial skin around the eyes and mouth is pale bluish white. Orange patch on the throat is not conspicuous. Back of the head and back are from light grey to grey. Outer limbs are whitish gray. They were observed much playing with other infants or juveniles, but spend most of their time with their mothers.
Newborn	Smallest animals. Pelage is white with grayish white patches on the back of head and back. They were observed clinging their mothers at all time.

The presence of fauna, other than *R.(P.) avunculus*, were recorded both opportunistically and during monthly wildlife surveys.

3.3.7. Habituation

Attempts were made to habituate a group of *R. avunculus* but unsuccessful since the monkeys have experienced past and current high hunting pressure. To reduce bias when collecting data on behaviour and ecology, dull coloured clothes were worn so as to remain inconspicuous in the forest.

3.3.8. Human factors

Information on the presence of traps/snares, guns/crossbows, camps, hunting dogs, forest clearance, timber-cutting, huts, non-timber forest product collection, and livestock grazing were recorded during daily surveys to assess the human impact on *R.(P.) avunculus* and its habitat as well as on wildlife as a whole.

3.4. Constraints

Rhinopithecus avunculus are shy of observer presence, It is difficult to approach to the langurs at close distance. Dense vegetation and loose rock make observations and movement of the survey team very difficult and time consuming. The undulating terrain of the study area is very steep and rough in some areas making those areas virtually inaccessible. Lack of water sources inside the Khau Ca Forest made it very difficult for the survey team to approach to the Langur's habitat in the early morning, since base camps had to set up far away from monkey known habitat.

Figure 3.6. Team members during the survey at Tat Ke

4. RESULTS

4.1. Group size and composition

4.1.1. Tat Ke Sector, Na Hang Nature Reserve

Over the course of eleven-month study at Tat Ke Sector, only 9 contact hours were made. 7 out of which were visible. High human activities and reduced population size are likely to be main explanations for these small contact hours and sample sizes. Few data available on social organization and social behaviour of *Rhinopithecus avunculus* were therefore obtained.

Given the difficulty of observational conditions, opportunistic censuses were used to estimate the band sizes. All counts were made during the animals crossed open canopy gaps. For one-male units, it seemed to be relatively easy to see all of the individuals at one time, because they were rarely in more than one tree at a time. Further, one-male units sometimes traveled and foraged independently. The probability of missing individuals hidden under dense foliage during the counts, however, was unpreventable.

Sizes and age/sex composition of the band of *R. avunculus* at Tat Ke Sector are presented in table 4.1. The highest minimum count for the band at Tat Ke Sector is 17 individuals (estimate 22). Estimate is based on evidence of branch movements of about 4 to 5 animals traveling behind this band. This estimate is likely the population of *R. avunculus* at Tat Sector because there is no evidence of existence of other bands during the course of the study.

One-male unit sizes ranged from 5 to 7 individuals (table 4.2). Adult sex ratio was 1:3.5; Adult/immature was 1: 0.6; Infant/adult female was 1:0.1. On two occasions, all-male unit were observed to have 5 individuals, including 2 adult males and 3 juvenile males.

Table 4.1. The three highest counts of the band and their age/sex composition at Tat Ke (For definitions of age/sex classes, see table 3.2)

Name	Date	AM	AF	JM	JF	J?	IF	Newborn	Unknown	Size
Band	20 Feb 2005	2	7	0	0	4	2	0	1	17
Band	13 Nov 2004	3	5	0	0	3	2	0	1	14
Band	22 Nov 2004	4	5	0	0	4	2	0	1	16

Table 4.2. Age/sex composition different units of *R. avunculus* at Tat Ke (For definitions of age/sex classes, see table 3.2)

Name	AM	AF	JM	JF	J?	IF	Newborn	Unknown	Size
OMU1	1	4	0	0	0	1	0	0	6
OMU2	1	3	0	0	3	0	0	0	7
AMU	2	0	3	0	0	0	0	0	5

AM: Adult male AF: Adult female JM: Juvenile male JF: Juvenile female IF1: Infant ? Sex unknown

OMU: One-male unit AMU: All-male unit.

4.1.2. Khau Ca Forest

A total of 241 contact hours was made during the course of the thirteen-month study at Khau Ca Forest, 195 of which was visible. This accounted for 2397 observations. Although Khau Ca Forest is smaller area and hold lager population of *R. avunculus* than Tat Ke Sector, following the monkeys was impossible in most cases because of difficult terrain for walking, shyness of the monkeys, and observer fatigue. Given the difficulties of observational conditions, observations were often made from vantage points of the opposite hills and mountains at a distance of 30 to 100m which allowed the observers to see more animals at time than at close range and the monkeys to display normal behaviour.

Band sizes and their age/sex composition of *R. avunculus* based on "good counts" at Khau Ca Forest are presented in table 4.3. The size of the bands ranged from 22 to 81 individuals and appeared to be dependent on the number associations of one-male units. The highest minimum count for the band at Khau Ca was 81 individuals in April 2006, including 7 adult males, 25 adult females, and 6 newborns with white pelage. This count may be underestimated the band size because some infants clinging the females and animals traveling under dense foliage were miscounted. The estimate size of the band was probably about 90 individuals. The lowest minimum count for the band at Khau Ca was 22 individuals in April 2006, including 2 adult males, 7 adult females, and 2 newborns. All counts were made when the bands crossed the open canopy gaps.

The sizes and age/sex composition of one-male units of *R. avunculus* are presented in table 4.4. The figures presented in table 4.6 were selected from "good counts" of independent

one-male units during the course of the study. One-male group sizes ranged from 7 to 15 individuals per group and averaged 11.3 individuals per group. The age/sex ratio of the one-male units was 1 adult male, 3.8 adult females, 1.5 sub-adult females, 2.5 juvenile females and 2 infants. Only one all-male group of 7 individuals comprised of 1 adult male, 2 sub-adult males and 4 juvenile males was observed during the course of the study. The size of all-male unit was likely underestimated because this group often joined with large bands (more than one-male units) for traveling, feeding and resting; group spread was large; and it was very difficult to distinguish between juvenile males and females.

Table 4.3. Age/sex composition of the bands of *R. avunculus* at Khau Ca Forest (For definitions of age/sex classes, see table 3.2)

Date	AM	AF	SAM	SAF	JM	JF	J?	IF	Newborn	Unknown	Size
16 Sep 2005	2	12	0	5	0	2	4	4	0	2	31
16 Jan 2006	5	22	2	8	3	3	7	8	0	5	63
23 Mar 2006	4	15	0	8	0	5	4	5	3	3	47
11 Apr 2006	2	7	0	2	1	5	0	3	2	0	22
16 Apr 2006	7	25	4	10	4	2	6	12	6	5	81
15 May 2006	8	26	2	9	3	4	5	14	2	6	79

AM: Adult male AF: Adult female SAM: Sub-adult male SAF: Sub-adult female J?: Juvenile unknown sex

JM: Juvenile male JF: Juvenile female IF: Infant

Table 4.4. Age/sex composition of the one-male units of *R. avunculus* at Khau Ca Forest (For definitions of age/sex classes, see table 3.2)

Unit	Date	AM	AF	SAM	SAF	JM	JF	J?	IF	Newborn	Size
OMU1	13 Sep 2005	1	2	0	1	0	3	0	1	0	8
OMU2	1 Nov 2005	1	5	0	2	0	3	0	2	0	13
OMU3	9 Apr 2006	1	6	0	1	0	3	0	2	2	15
OMU4	17 Apr 2006	1	2	0	2	0	1	0	0	1	7
AMU*	16 Apr 2006	1	0	2	0	4	0	0	0	0	7

OMU: One-male unit AM: Adult male AF: Adult female JM: Juvenile male JF: Juvenile female ? Unknown age/sex

IF: Infant AMU: All-male unit

4.2. Social organization

The basic social unit of *R. avunculus* at both Tat Ke Sector and Khau Ca Forest was one-male unit. It is possible that Tat Ke band contain two one-male units (table 4.2) and one all-male unit including 2 adult males and 3 juvenile males. No solitary of *R. avunculus* was seen during the course of the study.

Figure 4.1. One-male unit of *R. avunculus* during resting time at Khau Ca

The Khau Ca band contained at least 5 to 6 OMUs and 1 all-male unit. It was relatively easy to recognize one-male units of *R. avunculus* when they foraged independently. However, the boundaries of one-male units were not clear when they, in most cases, associated with one or more one-male units and all-male units to form large bands for traveling and feeding. Independent one-male units of 7 to 15 individuals of *R. avunculus*

were sometimes encountered, but all-male unit was always seen in association with one or more one-male units.

On three occasions, solitary of adult males and sub-adult females were encountered at Khau Ca Forest. An individual was recorded as a solitary when it was away more than 20 m from the nearest conspecific (following Boonratana, 1994). Lone adult males (n=2) were seen traveling away from the band about 50 to 70 m. Sub-adult female was feeding alone (n=1).

4.3. Social behaviour

Because few scans were made at Tat Ke Sector, only scan data at Khau Ca Forest were used to calculate social behavior of *R. avunculus*. Proportion of behaviour were calculated for each scan. In each scan, there may be more animals engaging in conspicuous activities than in other insconspicuous activities. To reduce this bias, the number of individuals recorded in each scan was weighted by dividing each observation in a scan by the total number of observations made in that scan.

Considering all individuals, resting contributed the largest proportion of *R. avunculus* total activity time (32.1%); The next was traveling (19.8%); Vigilance and feeding made up almost equal amount of time in the total activity (14.8% and 13.9%, respectively). Grooming occupied (5.1%) and adult males, females and juveniles were observed to involve in this behaviour. Playing contributed (3.7%) to the total activity time and only infants and juveniles were observed to play. Agonistic interactions made up only (0.4%) and other activities were 0.2% (Figure 4.2).

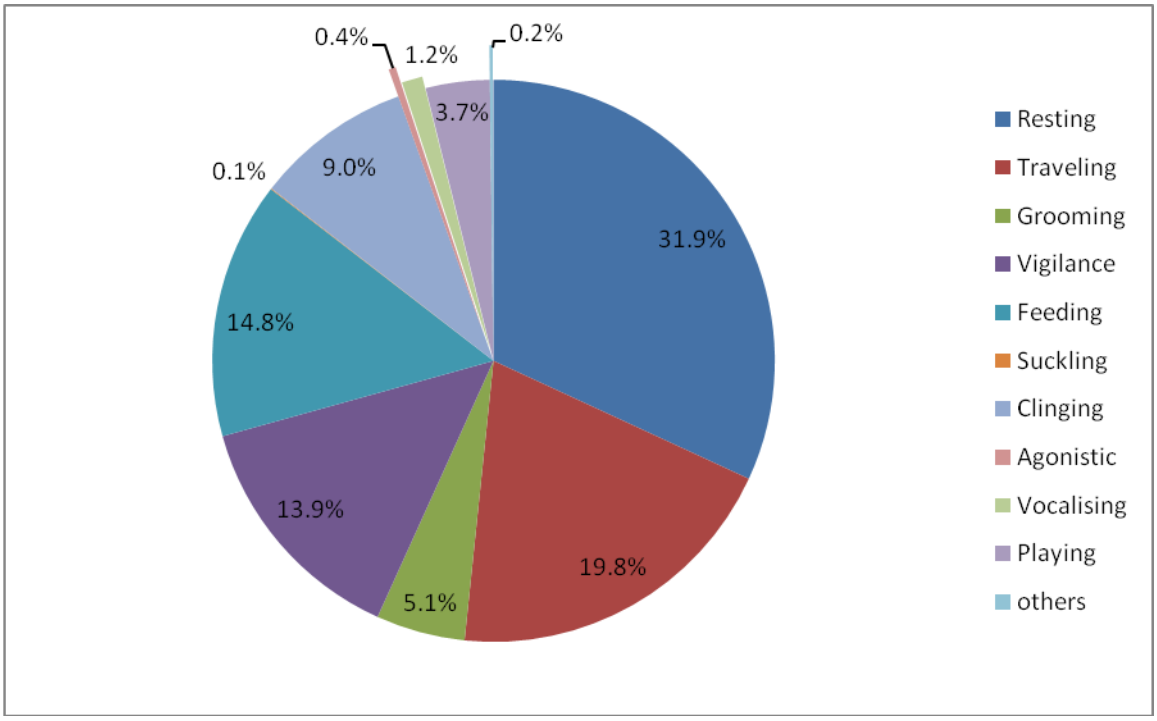


Figure 4.2. Activity budget of *Rhinopithecus avunculus* in Khau Ca

4.3.1. Rest and rest-huddling

Resting comprised of 31.9% of the total activity time. Of which 0.4% (n = 28) was rest-huddling. Rest-huddling was recorded when one or more individuals rest closely together while embracing another individual with their arms. All age/sex classes except for infants clinging adult females were seen huddling. The maximum number of individuals participated in huddling was 5. During rest-huddling, individuals sat on the long branches, lowered their head on the back of the front individual, and embraced another individual with arms from behind.

Figure 4.3. Members of *R. avunculus* exhibited rest-huddling during resting time

4.3.2. Allomothering

Allomothering by adult females were not recorded because without individually recognizable animals during the course of the study. On two occasions, alloparental care by juveniles was observed during *ad libitum* observations.

Figure 4.4. Infant clinging mother during traveling time

On the first occasion, a juvenile took the infant sitting next to an adult female and carried the infant for about 10 m before the adult female followed and took the infant back. On the second occasion, an adult female passed an infant to a juvenile. The juvenile carried the infant away from the adult female while the adult female was sitting and looking into juvenile and infant direction. Then after 1 minute, the adult female followed the juvenile, took the infant back, and went back to the last sitting tree.

4.3.3. Terrestriality

R. avunculus was the first time observed traveling, resting and feeding on the ground at Khau Ca Forest (n=6). All age/sex categories were exhibited this behavior (Figure 4.).

Figure 4.5. A group of *R. avunculus* resting on the ground at Khau Ca

4.3.4. Sexual behavior and births

Sexual copulation was observed only on one occasion at Tat Ke. The adult female apparently initiated the behavior, first by standing quadrupedally on a firm branch, and then raising her tail above and over her head. The adult male then positioned himself behind the adult female, rested his feet on the supporting branch. Then he held her midsection with both his hands, and began mounting. Upon penetration, the male made repeated thrusting movements that lasted for 43 seconds.

The Tonkin Snub-nosed Monkey does not seem to have any marked breeding season as infants were observed throughout the study. However, more infants were recorded in September and October 2005 and in March and April 2006. This apparently coincided with when fruits, flowers and young leaves are more abundant.

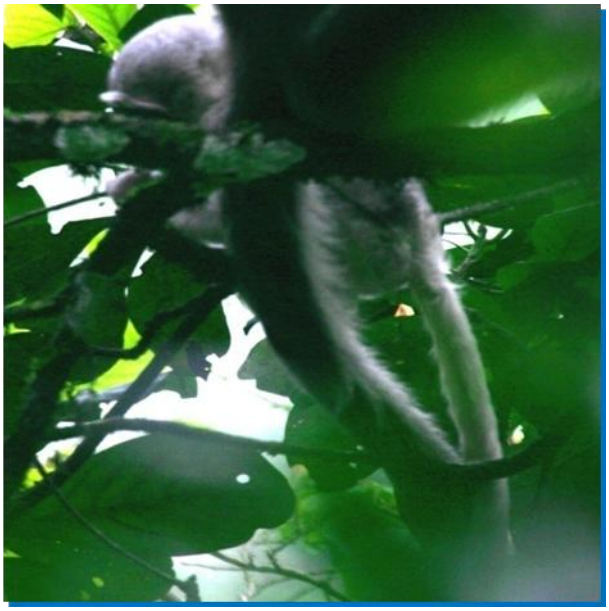


Figure 4.6. Newborn of *R. avunculus* at Khau Ca

The new observations on colour pelage of newborns are in contrast to previous reports *R. avunculus* (Le, H.H., 1973; Le, X.C., 2003) and differ from common pattern of newborn pelage in most colobine species (Newton & Dunbar, 1994). Le.H.H. (1973) and Le, X.C. (2003) described newborns of *R. avunculus* have yellowish and yellowish white pelage, respectively. *Ad libitum* observations show that newborns have white pelage with grayish white patches on the back of head and back, resembling adult female belly and chest's pelage. These patches gradually turn into grey in infants and black in juveniles and adults.

4.3.5. Vocalization

So far, 4 different types of vocalizations have been recorded with certainty; soft "hoos", soft "huchkks", loud and rapid "huchkks", and rapid "chits". Although it is too early to determine the exact functions of these calls, we can make some speculations based on the contexts when these calls were given. Firstly, soft "hoos" vocalizations seem to be used to regroup after the group was disturbed and had split up, and possibly to maintain group spacing. Secondly, soft "huchkks" vocalizations were used as "contact calls" if the group was spread over 5 meters or more. Thirdly, loud "huchkks" vocalizations were used as "alarm calls" whenever the monkeys detected the observers and other threats. Fourthly, rapid "chit" vocalizations were used when they were fleeing way from unexpected encounters with observers.

4.3.6. Locomotion

R. avunculus exhibited six types of locomotion, including climbing, quadrupedal walking, semi-brachiation, hanging, bipedal movement, leaping or jumping (figures 4.8; 4.9; 4.10; 4.11; 4.12). The monkeys appear to travel within the same tree by climbing, quadrupedal walking and semi-brachiation, bipedal movement and jumping. Hanging, leaping and jumping were used to travel between different trees. Sometimes the monkeys were observed to hang from the terminal branches of one tree with one hand and reach out to grasp the terminal of branches of other tree with the other hand.

4.3.7. Sleeping site

The Tonkin Snub-nosed Monkey does not appear to have any fixed sleeping sites. Valleys were often used for resting and sleeping. However, it was observed that the Tonkin Snub-nosed Monkey often come closer to the ground during resting and sleeping, usually 5 to 10 meters above the ground. During resting and sleeping, they would sit on the lower branches, frequently hidden within dense foliage and are very quiet. This may likely an adaptation to thermo-regulation and it may also be an anti-predator strategy.

Figure 4.7. A group of *R. avunculus* resting in resting trees

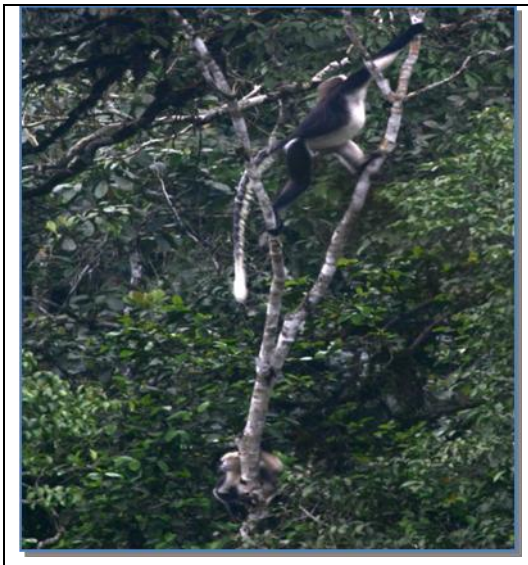


Figure 4.5. Vertical climbing

Figure 4.9. Hanging

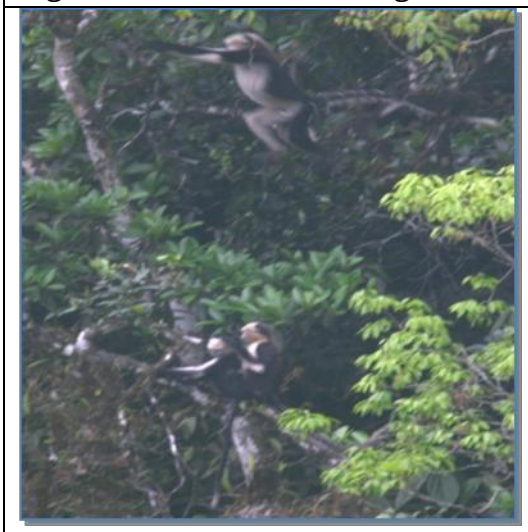


Figure 4.6. leaping

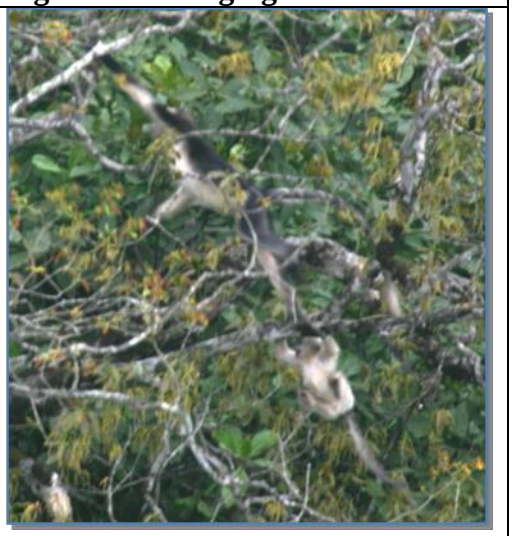


Figure 4.7. Semi-brachiation

Figure 4.8. Quadrupedal walking

4.4. Discussion

4.4.1. Population status of R. avunculus

The population size of *Rhinopithecus avunculus* at the Tat Ke Sector proved to be smaller than we originally expected. Compared to Boonratana and Le 1993's study, current population size was reduced by ca. 60 individuals (table 4.5). This is likely due to severe hunting pressure at Tat Ke Sector. At Khau Ca Forest, current population size and population density of *R. avunculus* were higher than those of previous study estimated by Le Khac Quyet, 2004 (table 4.5). There are some possible explanations for these differences. Firstly, population size of *R. avunculus* at Khau Ca Forest may grow over past 4 years. Secondly, previous study was conducted in a short period of time. Lastly, there may be differences in methods of population size estimate between studies.

Table 4.5. Comparision of population between previous and current study at Tat Ke Sector and Khau Ca forest.

Study sites	Population size (individuals)		Density (individuals/km^2)	
	Previous study (Individuals)	Current study (Individuals)	Previous study (Individuals)	Current study (Individuals)
Tat Ke Sector	72 (80)[1]	17 (22)	0.64[1]	0.18
Khau Ca Forest	55-60[2]	81 (90)	6[2]	9

[1]Boonratana and Le, 1993

[2] Le Khac Quyet, 2002; 2004

4.4.2. Social Organization

Relative to other members of genus *Rhinopithecus*, social organization of *R. avunculus* is characterized by two levels: the band and sub-units which were one-male units and all-male units. These observations supported Boonratana and Le 1993's study, but dismissed

Ratajsczak et al., 1992 and Le Khac Quyet 2006's observations that basic social unit of *R. avunculus* is multimale and multifemale.

Compared with previous study (14.8 individuals, Boonratana & Le, 1993: 23), current group sizes of *R. avunculus* at both study sites are smaller (5.6 individuals, Tat Ke Sector and 12.1 individuals, Khau Ca Forest) (table 4.2). These differences are likely partly because the populations of *R. avunculus* at both study areas were under high hunting pressure in the past and partly because *R. avunculus* may exhibit different types of group sizes at different study sites.

Table 4.6. Group and band size of *R. avunculus* at Tat Ke Sector and Khau Ca Forest

Sites	Group size for OMU[1] (individuals)		Band size	
	Previous studies	Current study	Previous studies	Current study
Tat Ke Sector	14.8[2]	5.6	72	17
Khau Ca Forest		12.1	60[3]	22-81

[1] OMU: One-male unit

[2] Boonratana and Le, 1993

[3] Le Khac Quyet, 2002; 2004

4.4.3. Social behaviour

Like other colobines, agonistic interactions were less in *R. avunculus*, members of *R. avunculus* spent only 0.67% of their time in this behaviour, which usually involved in male-male aggression during feeding and intergroup encounters.

4.4.4. Rest- huddling

Rest-huddling is a common behavior of temperate primates in which one or more individuals rest closely together while embracing another individual with their arms. This behaviour has been reported in *Rhinopithecus bieti*, but the factors (social and thermoregulation) that influence on it remained to be studied (Kirkpatrick, 1996: 19). Rest-

huddling behaviour of *R. avunculus* was recorded in winter and the early of spring season, but data was not sufficient enough to prove that this was a thermoregulatory strategy.

4.4.5. Infant caring

Allomothering behaviour has been reported in most colobines (McKenna, 1979: 818; Newton & Dunbar, 1994: 326; Yeager & Kool, 2000: 502). Juvenile and adult females are often involved in this behaviour. Possible functional explanations for this behavior are providing more feeding time for mothers (Poirier, 1968: 54), increasing the probability of an infant's adoption if its mothers should die or become disabled (Lancaster, 1971: 177), improving maternal skills for allomothers by handling infants and thereby enhancing the likelihood survival of her own future infants (Hrdy, 1977: 199), and reducing feeding competition for allomothers' offspring by abusive handler (Waser & Barash, 1981: 91). Only juveniles of *R. avunculus* were observed to carry infants since without individually-identified animals, we were unable to recognize females caring infants.

4.4.6. Terrestriality

To date, terrestriality has been reported for the all three species in China (*Rhinopithecus bieti*, Kirkpatrick, 1996: 54; Kirkpatrick & Long, 1994: 105; Kirkpatrick et al., 1998: 41; Long, et al., 1998: 283; Wu, 1993: 67; Zhao, et al., 1988: 283; *Rhinopithecus roxellana*, Ren et al., 2001: 97; Li et al., 2000: 384; Su et al, 1998: 266; *Rhinopithecus brelichi*, Bleisch et al., 1993, p.80). Terrestriality involves in crossing open areas, resting and feeding activity (Bleisch et al., 1993: 80; Kirkpatrick, 1996: 48; Long et al., 1998: 287; Su et al, 1998: 266; Wu, 1993: 68). Obtaining accurate data on terrestriality is difficult since observations from a long distance cause bias against animals on the ground (Kirkpatrick et al., 1998: 29; Su et al., 1998: 266). Like other members of snub-nosed monkeys, *R. avunculus* were observed traveling on the ground when crossing open areas and feeding on the ground. These observations are in contrast to early studies that *R. avunculus* is completely arboreal. However, because of dense vegetation and the shyness of study subjects, we were unable to obtain accurate data on terrestriality.

4.4.7. Sexual behavior

Sexual copulations initiated by females have been documented among colobines, especially Asian colobines (Kirkpatrick, 2007: 191; Newton & Dunbar, 1994: 313; Yeager & Kool: 502). Females display some behavioural patterns during solicitation, such as "head shake" in *S. entellus* (Hrdy, 1977: 49) and "crouch" in *R. roxellana* (Ren et al., 1991: 325; 1995: 137). *R. avunculus* was not an exception. Females initiated the behaviour and "crouch" pattern was exhibited before copulation.

4.4.8. Birth season

Birth and copulation seasons have also been found in some colobines (*Semnopithecus entellus*, Borries et al., 1999: 353; *Presbytis senex*, Rudran, 1973; *Presbytis pileata*, Stanford, 1991b: 45) and last for 2-6 months (Kirkpatrick, 2007: 192). Factors that control birth and copulation seasons remain poorly documented. Rudran (1973: 58) and Ziegler et al. (2000: 119) suggested that food quality and availability may regulate birth and breeding seasons of the two langurs: *Trachypithecus vetulus* and *Presbytis entellus*, respectively.

4.5. Botany

4.5.1. Tat Ke Sector

Forest Structure at Tat Ke Sector

A total of 612 trees were described in the study area, taken from 64 plots. The total plot covered an area of 0.64 ha. Thus, the density of trees of ≥ 19 cm at breast height (g.b.h.) was 956 per hectare. Most trees were between 19 and 110 cm girth at breast height, which contributed to 92.5% of the total tree sampled, with the girth ranging from 19 to 30 cm made up largest proportion of girth categories (34.9%) (Figure 4.12). There were few trees exceeding 120 cm which was only 7.5% of the total trees sampled. Maximum girth at breast height of 646 cm was recorded in *Excentrodendron tonkinensis* species. The mean girth of trees in the plots was 60 cm.

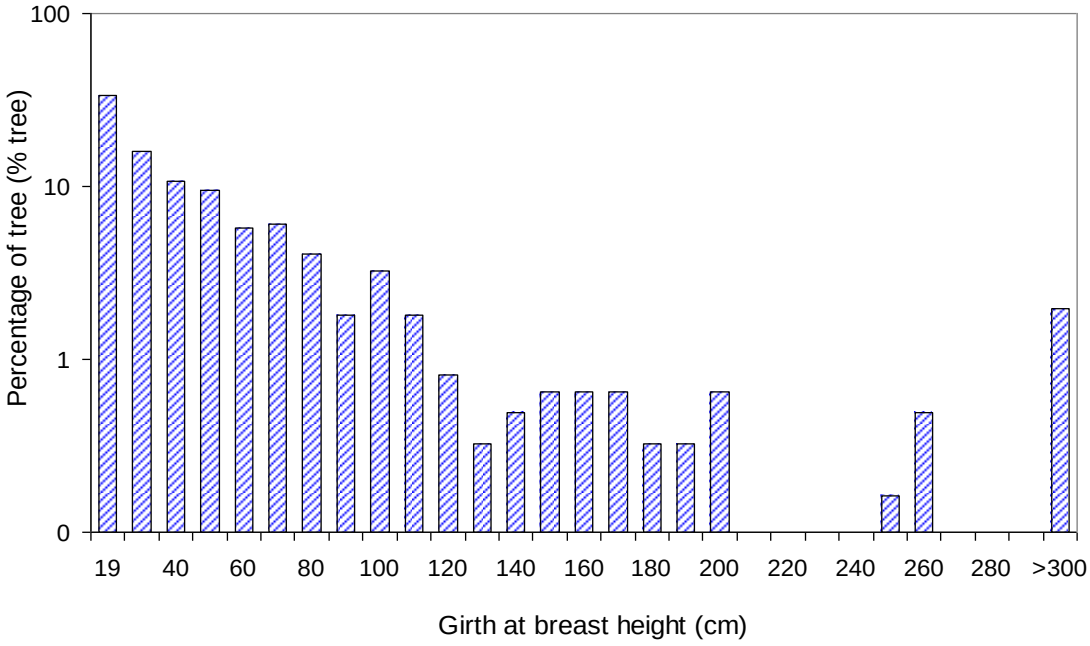


Figure 4.12. Frequency distribution of girths at breast height of plots at Tat Ke (n=612)

Species composition of the forest

Figure 4.13. Forests associated with limestone hills in Tat Ke

The list of the species, the number of stems and basal area of each are provided in Appendix I. Out of a total 612 tree sampled, 151 species were identified, belonging to 50 families, for a ratio of ca. 4 trees/species and 3 species/family. The maximum basal area of 33,280.88 cm^2 (*Aprosa sp*) were recorded and mean basal area for all trees was 616.57 cm^2. The area of plots sampled was 64,000 m^2 and had a total basal area of 37.73 m^2. Therefore, the total basal area per hectare was 58.95 m^2.

The number of trees and species per plot meeting the sample criterion of 19 cm girth at breast height averaged 10 (ranged from 3 to 30) and 6 (ranged between 1 and 21), respectively. For some plots (plot 39 and 45), there was only one species (*Streblus macrophyllus*) even though 6 trees were sampled. Plot 31 had the highest number of trees and species (30 trees and 21 species) (table 4.7).

Table 4.8 shows the abundance and basal area of tree families in botanical plots at Tat Ke Sector. Moraceae was the most abundant tree family in terms of stem-number (158 stems, 25.82%), followed by Lauraceae family (69 stems, 11.27%). The next were Euphorbiaceae and Ebenaceae which contributed almost equal proportion of stem-number to the total number of stems in the plots (42 stems, 6.86% and 41 stems, 6.70%, respectively). Other abundant families included Apocynaceae (25 stems, 4.08%), Rubiaceae (24 stems, 3.92%), and Annonaceae (20 stems, 3.27%). However, families that had a large number of trees do not mean they make up largest proportion of total basal area when basal area is considered. Tiliaceae, for instance, had only 6 stems in total, but it accounted for largest proportion of total basal area (25.68%) and basal area and mean basal area were 96882.89 and 16147.15

cm^2; Lauraceae with 69 stems (less than half of Moraceae) ranked second in terms of basal area (11.64%). The next were Moraceae and Ebenaceae which made up 10.44 and 8.70% of total basal area. A possible explaination for these differences is most of trees in Moraceae family had small g.b.h. (averaged 46.6 cm and ranged from 19.3 to 201cm), while g.b.h. of trees in Tiliaceae family had an average of 406.53 cm and in the range of between 157.6 and 646.7 cm.

The twenty eight commonest tree species in terms of stem-number and basal area was presented in table 4.9 (five or more individuals). They made up 63.07% of total stem-number and 57.89% of total basal area in 64 botanical plots. *Streblus macrophyllus* (Moraceae), which is 19.77% of the total number of trees ≥ 19cm g.b.h, was the commonest tree species in the (table 3.3). The next commonest tree species was *Diospyros susarticulata* (35 individuals, 5.72%, Ebenaceae), followed by *Ficus harmandii* (24 individuals, 3.92%, Moraceae), *Kitabalia macrophylla* (22 individuals, 3.59%, Apocynaceae), and *Miliusa filipes* (17 individuals, 2.78%, Annonaceae). If basal area is considered, *Excentrodendron tonkinensis* (Tiliaceae) was the commonest large tree though it ranked fifteenth in terms of number of stems (6 individuals). It accounted for highest proportion of basal area (25.68%), followed by *Diospyros susarticulata* (8.55%, Ebenaceae) and *Streblus macrophyllus* (5.49%, Moraceae).

Table 4.7. Species richness between plots at Tat Ke Sector

Plots	#ID	Species	Genus	Family	Plots	# IDs	# Species	Genus	Family
TK1	10	6	6	5	TK33	8	3	3	3
TK2	9	8	8	7	TK34	12	4	4	4
TK3	10	9	9	8	TK35	7	6	6	4
TK4	12	12	11	8	TK36	10	4	4	4
TK5	6	4	4	4	TK37	9	10	9	9
TK6	6	4	4	3	TK38	4	2	2	2
TK7	8	6	6	5	TK39	6	1	1	1
TK8	7	5	5	5	TK40	9	2	2	1
TK9	10	5	5	5	TK41	13	5	5	5
TK10	7	7	7	6	TK42	11	6	5	4
TK11	15	12	11	10	TK43	10	3	3	2
TK12	8	6	6	6	TK44	8	6	6	5
TK13	9	8	8	6	TK45	6	1	1	1
TK14	11	10	10	8	TK46	6	3	3	3
TK15	12	9	8	7	TK47	8	5	5	3
TK16	9	8	7	6	TK48	9	3	3	3
TK17	12	7	6	5	TK49	11	4	4	4

Table 4.7. Species richness between plots at Tat Ke Sector (continued)

Plots	#ID	Species	Genus	Family	Plots	# IDs	# Species	Genus	Family
TK18	12	7	7	6	TK50	10	4	4	4
TK19	10	8	6	5	TK51	7	3	3	3
TK20	11	8	8	8	TK52	10	4	4	4
TK21	11	8	7	7	TK53	8	3	3	3
TK22	4	4	4	4	TK54	13	5	5	5
TK23	7	5	5	5	TK55	4	3	3	3
TK24	6	5	5	5	TK56	6	5	5	5
TK25	5	5	5	5	TK57	8	8	8	8
TK26	10	7	7	7	TK58	8	6	6	6
TK27	13	6	6	6	TK59	11	6	6	6
TK28	7	6	5	5	TK60	12	9	8	8
TK29	14	12	11	9	TK61	13	11	11	10
TK30	19	14	12	11	TK62	4	3	3	3
TK31	30	21	16	11	TK63	9	6	6	6
TK32	14	13	12	12	TK64	8	3	3	3

IDs: number of Individuals

TK: Tat Ke

Table 4.8. Abundance and basal area of tree families in botanical plots at Tat Ke

Family	No. of stems	% of stems	BA	%TBA	Mean BA
Actinidiaceae	13	2.12	4582.83	1.21	352.53
Anacardiaceae	11	1.80	3553.25	0.94	323.02
Annonaceae	20	3.27	12215.17	3.24	610.76
Apocynaceae	25	4.08	2980.68	0.79	119.23
Aquifoliaceae	3	0.49	322.70	0.09	107.57
Araliaceae	9	1.47	1698.00	0.45	188.67
Asteraceae	1	0.16	524.69	0.14	524.69
Bigoniaceae	2	0.33	168.59	0.04	84.30
Burseraceae	1	0.16	43.57	0.01	43.57
Caesalpiniaceae	3	0.49	248.72	0.07	248.72
Clusiaceae	17	2.78	3885.28	1.03	228.55
Daphniphyllaceae	2	0.33	186.13	0.05	93.06
Dilleniaceae	1	0.16	761.14	0.20	761.14
Ebenaceae	41	6.70	32820.27	8.70	800.49
Elaeocarpaceae	5	0.82	1751.13	0.46	350.23
Euphorbiaceae	42	6.86	23419.85	6.21	557.62
Fabaceae	7	1.14	3278.58	0.87	468.37
Flacoutiaceae	2	0.33	616.44	0.16	308.22

Table 4.8. Abundance and basal area of tree families in botanical plots at Tat Ke (continued)

Family	No. of stems	% of stems	BA	%TBA	Mean BA
Icacinaceae	2	0.33	74.26	0.02	37.13
Iteaceae	1	0.16	82.51	0.02	82.51
Juglandaceae	4	0.65	619.15	0.16	154.79
Kygelariaceae	15	2.45	4550.05	1.21	303.34
Lauraceae	69	11.27	43931.79	11.64	636.69
Linnaceae	1	0.16	29.95	0.01	29.95
Magnoliaceae	4	0.65	1119.45	0.30	279.86
Meliaceae	4	0.65	10286.15	2.73	2571.54
Mimosaceae	3	0.49	532.31	0.14	177.44
Moraceae	158	25.82	39413.18	10.44	249.45
Myristicaceae	5	0.82	1446.44	0.38	289.29
Myrsinaceae	10	1.63	2108.84	0.56	210.88
Myrtaceae	18	2.94	4836.81	1.28	268.71
Oleaceae	4	0.65	896.40	0.24	224.10
Podocarpaceae	1	0.16	3091.45	0.82	3091.45
Proteaceae	1	0.16	94.72	0.03	94.72
Rosaceae	4	0.65	2976.68	0.79	744.17
Rubiaceae	24	3.92	21643.45	5.74	901.81
Rutaceae	2	0.33	1037.09	0.27	518.55

Table 4.8. Abundance and basal area of tree families in botanical plots at Tat Ke (continued)

Family	No. of stems	% of stems	BA	%TBA	Mean BA
Sapindaceae	5	0.82	3739.55	0.99	747.91
Sarcospermaceae	4	0.65	9911.63	2.63	2477.91
Simarubaceae	4	0.65	23085.84	6.12	5771.46
Stalhyllaceae	5	0.82	662.39	0.18	132.48
Staphyleaceae	1	0.16	100.85	0.03	100.85
Sterculiaceae	16	2.61	1990.33	0.53	124.40
Styracaceae	3	0.49	2271.68	0.60	757.23
Theaceae	8	1.31	2410.01	0.64	301.25
Tiliaceae	6	0.98	96882.89	25.68	16147.15
Ulmaceae	13	2.12	2320.99	0.62	178.54
Urticaceae	8	1.31	904.15	0.24	113.02
Verbenaceae	1	0.16	945.46	0.25	945.46
Xanthophyllaceae	3	0.49	289.21	0.08	96.40

BA: Basal area

%TBA: Percent of total basal area

Mean BA: Mean basal area (cm^2)

Table 4.9. Twenty eight commonest tree species in 64 plots at Tat Ke Sector

Family/species	No. of stems	% of stems	BA	%TBA
Moraceae				
Streblus macrophyllus	121	19.77	20734.49	5.49
Ebenaceae				
Diospyros susarticulata	35	5.72	32249.79	8.55
Moraceae				
Ficus harmandii Gagnep.	24	3.92	11490.51	3.05
Apocynaceae				
Kitabalia macrophylla	22	3.59	2786.07	0.74
Annonaceae				
Miliusa filipes	17	2.78	11863.55	3.14
Kygelariaceae				
Hydnocarpus hainanensis	15	2.45	4550.05	1.21
Sterculiaceae				
Sterculia lanceolata	14	2.29	1123.18	0.30
Actinidiaceae				
Saurauja tristylla	13	2.12	4582.83	1.21
Myrsinaceae				
Ardisia tsangii	10	1.63	2108.84	0.56
Myrtaceae				
Syzygium zeylanicum	10	1.63	3514.23	0.93
Anacardiaceae				
Drimycarpus racemosus	8	1.31	2434.25	0.65
Lauraceae				
Phoebe cuneata	8	1.31	2621.52	0.69
Urticaceae				
Pouzolzia sanguinea	8	1.31	904.15	0.24
Lauraceae				
Litsea balansae	7	1.14	1219.08	0.32

Table 4.9. Twenty eight commonest tree species in 64 plots at Tat Ke Sector (continued)

Family/species	No. of stems	% of stems	BA	%TBA
Tiliaceae				
Excentrodendron tonkinensis	6	0.98	96882.89	25.68
Clusiaceae				
Garcinia fagraeoides	6	0.98	2025.54	0.54
Myrtaceae				
Syzygium jambos var. sþvaticum	6	0.98	754.44	0.20
Araliaceae				
Trevesia palmata	6	0.98	1370.23	0.36
Euphorbiaceae				
Antidesma tonkinensis	5	0.82	848.71	0.22
Rubiaceae				
Canthium parvifolium	5	0.82	1256.95	0.33
Euphorbiaceae				
Chaetocarpus castanocarpus	5	0.82	2272.98	0.60
Lauraceae				
Cryptocarya lenticellata	5	0.82	669.51	0.18
Clusiaceae				
Garcinia bonii	5	0.82	590.72	0.16
Myristicaceae				
Knema conferta	5	0.82	1446.44	0.38
Lauraceae				
Neolitsea aurata	5	0.82	5368.45	1.42
Rubiaceae				
Pavetta graciliflora	5	0.82	800.37	0.21
Stalhyllaceae				
Turpinia nepalensis	5	0.82	662.39	0.18
Ulmaceae				
Ulmus sp	5	0.82	1335.61	0.35
Total	386	63.07	218467.73	57.90

BA: Basal area (cm^2)
%TBA: Percent of total basal area in plots

Phenology

Phenological characteristics of 333 tagged trees representing 150 species from the botanical plots were investigated in the Tat Ke Sector. Observations were recorded monthly from October 2004 through August 2005. Each tree was recorded for their presence or absence of mature leaves, young leaves, flowers, and fruits (figure 4.14).

The production of young leaves was high throughout the course of the study and reached a peak of 100% at the start of the dry season (October). Trees produced less young leaves from February to May and least in May (73.5%), corresponding to the end of the dry season and the early rainy season. There was weak correlation between young leave production and rain fall. Spearman's rank correlation between percent individuals in young leave each month and mean monthly rainfall (r_s = -0.369, n=11, p>0.05).

Flowering occurred year-round, but appeared to be more often at the start of the dry season (from October to December) and the early of the rainy season (from April to June) (Figure 4.14). There were two distinct peaks. The first peak was observed in November when 14.1% of trees bore flowers, coinciding with the early of the dry season. There was a suggestion of second, minor peak early in June when 9.6% of trees produced flowers, corresponding to early of the rainy season. There was a moderate correlation between young leave production and rain fall. Spearman's rank correlation between percent individuals in flower each month and mean monthly rainfall (r_s = -0.524, n=11, p>0.05).

Fruiting was also recorded throughout of the study and fruiting peaks seemed to follow the flowering peaks (Figure 4.14). Fruiting was also bimodal with a major peak occurring at the early of the dry season (November) when 18.2% of trees produced fruits and a minor peak during the middle of the rainy season (July 2006) when 7.2% of trees bore fruits. There was moderate correlation between young leave production and rain fall. Spearman's rank correlation between percent individuals in fruit each month and mean monthly rainfall (r_s = -0.642, n=11, p>0.05).

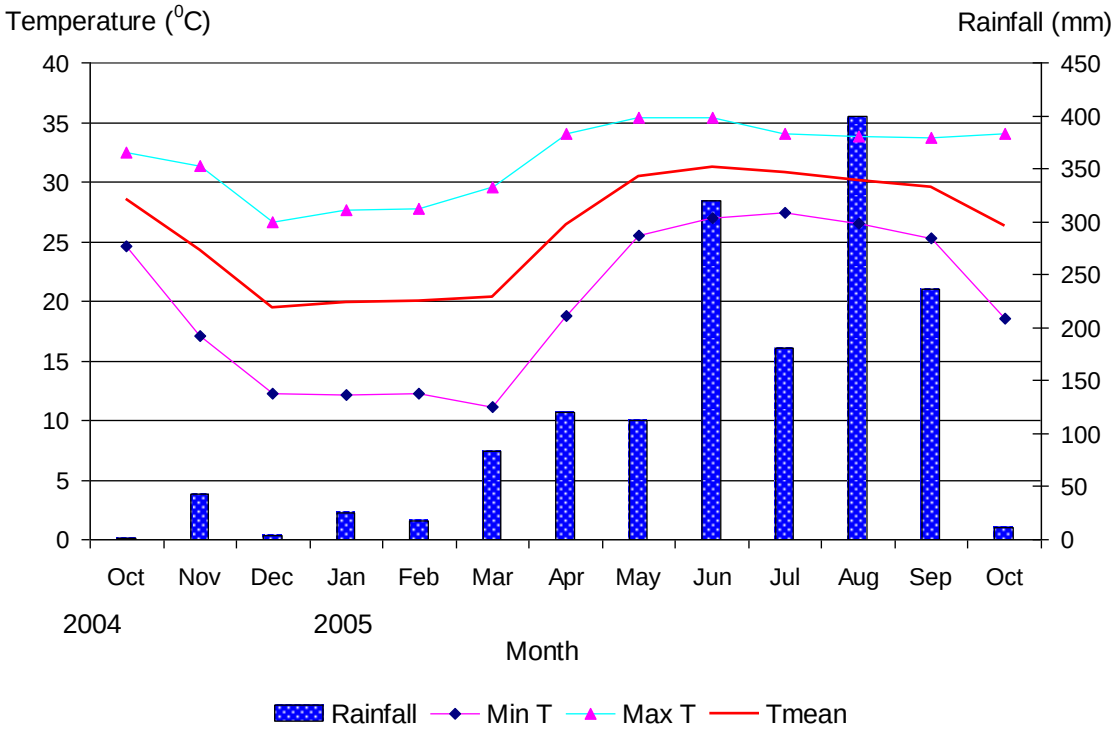


Figure 4.14. Phenological patterns at Tat Ke, Na Hang Nature Reserve (n= 333)

4.5.2. Khau Ca Forest

Forest structure

A total of 512 trees were sampled from 58 plots in the study area. The total plot covered an area of 0.58 ha. Thus, the density of trees of ≥ 19 cm at breast height (g.b.h.) was 882 per hectare. Most trees were between 19 and 130 cm girth at breast height, which accounted for 95.7% of the total tree sampled. Relative to Tat Ke Sector, the girth ranging from 19 to 30 cm made up largest proportion of girth categories (34.4%). There were only 4.3% of the total tree sampled exceeding 130 cm (Figure 4.15). Maximum girth at breast height of 442 cm was recorded in *Aprosa sp* species. The mean girth of trees in the plots was 54.7 cm.

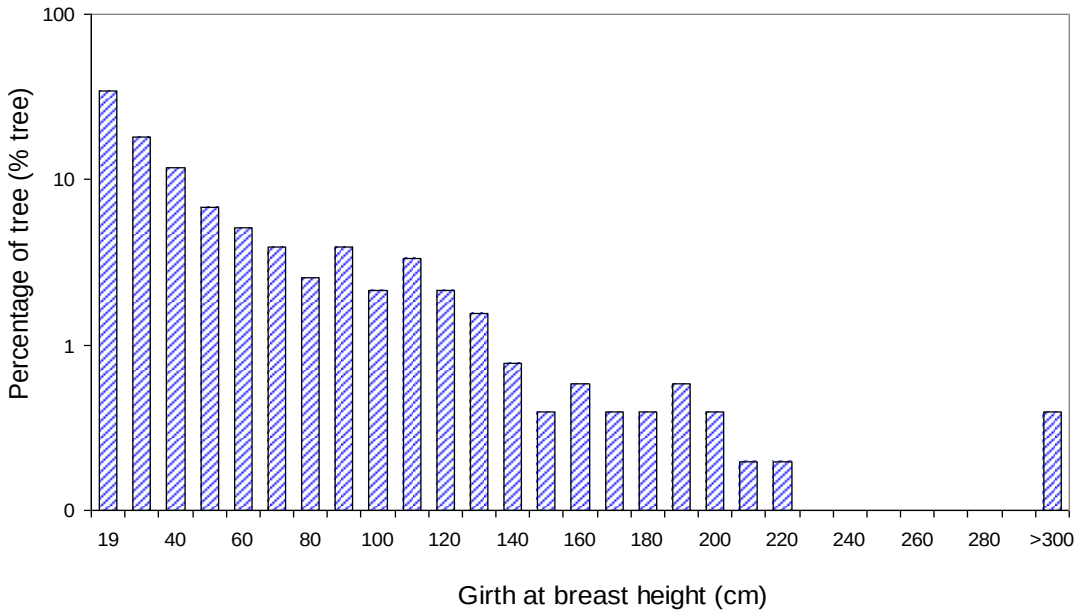


Figure 4.15. Frequency distribution of girths at breast height of plots at Khau Ca Forest (n=512)

Species composition of the forest

The list of the species, the number of stems and basal area of each in Khau Ca Forest are provided in Appendix II. Out of a total 512 tree sampled, 136 species were identified, belonging to 49 families, for a ratio of ca. 3.7 trees/species and 2.8 species/family. The maximum basal area of 15,546.54 cm^2 was recorded in *Aprosa sp* and mean basal area for all trees was 393.90 cm^2. The area of plots sampled was 58,000 m^2 and had a total basal area of 20.17 m^2. Therefore, the total basal area per hectare was 34.77 m^2.

Figure 4.15. Forests associated with limestone hills at Khau Ca

The number of trees and species per plot meeting the sample criterion of 19 cm girth at breast height averaged 9 (ranged from 1 to 25) and 7 (ranged between 1 and 19), respectively. There was only one tree and one species in plot 38. Plot 14 had the highest number of trees and species (25 trees and 19 species) (table 4.10).

Table 4.11 shows the abundance and basal area of tree families in botanical plots at Khau Ca Forest. Lauraceae was the most abundant tree family in terms of stem-number (87 stems, 16.99%), followed by Hamamelidaceae family (43 stems, 8.40%). The next were Fagaceae and Rubiaceae which contributed more than 30 stems to the total of stems sampled in the plots (38 stems, 7.42% and 35 stems, 6.84%, respectively). Other abundant

families included Urticaceae (22 stems, 4.30%), Myrtaceae (21 stems, 4.10%), Oleaceae (20 stems, 3.91%), Annonaceae (16 stems, 3.13%), Euphorbiaceae (16 stems, 3.13%). Similarly, Lauraceae was the most abundant tree family in terms of basal area (29.54%) when basal area is considered. Fagaceae ranked in second (9.50%). Other abundant families in terms of basal area were Euphorbiaceae (8.61%), Meliaceae (4.85%) and Ulmaceae (4.71%).

The twenty nine commonest tree species in terms of stem-number and basal area was presented in table 6.6 (five or more individuals). They made up 61.72% of total stem-number and 60.78% of total basal area in 58 botanical plots (table 4.12). *Mytilaria lasensis* (43 stems, 8.40%) was the commonest tree species. The next commonest tree species was *Machilus bonii* (33 stems, 6.45%), *Pouzolzia sanguinea* (22 stems, 4.30%), *Quercus chrysocalys* (18 stems, 3.52%). If basal area is considered, *Machilus bonii* (24,736.36 cm^2, 12.27%) was commonest tree, followed by *Neolitsea ellipsoids* (14,888.71 cm^2, 7.38%) though it ranked in nineteenth (6 stems) in terms of stem-number.

Phenology

Phenological characteristics of 512 tagged trees representing 136 species from the botanical plots were investigated in the Khau Ca Forest. Observations were recorded monthly from September 2005 through September 2006. Each tree was recorded for their presence or absence of mature leaves, young leaves, flowers, and fruits (figure 4.15).

The production of young leaves and leaf buds was high throughout the course of the study (more than 90% of trees produced leaves, figure 4.15). Young leaves were observed less in October 2005 and January 2006 (92.4% and 94.1%, respectively), corresponding to the early and middle of the dry season. There was little correlation between young leave production and rain fall. Spearman's rank correlation between percent individuals in young leave each month and mean monthly rainfall (r_s =0.284, n=13, p>0.05).

Flowering occurred year-round, but was intense during the dry season (from October to April, figure 1). A distinct peak flowering during the course of the study was at the end of the dry season (April 2006) when 19.73% of trees produced flowers. There was a second

peak early in the dry season (November 2005, 6.45%). Spearman's rank correlation between percent individuals in flower each month and mean monthly rainfall (r_s = -0.412, n=13, p>0.05).

Fruiting was also recorded throughout of the study, but more trees produced fruits during wet than during dry months (figure 1). Fruiting was also bimodal with a major peak occurring at the end of the rainy season (September 2006) when 19.4% of trees produced fruits, and a minor peak during the middle of the dry season (January 2006) when 6.4% of trees bore fruits. There was a moderate correlation between percent individuals in fruit each month and mean monthly rainfall (r_s =0.429, n=13, p>0.05).

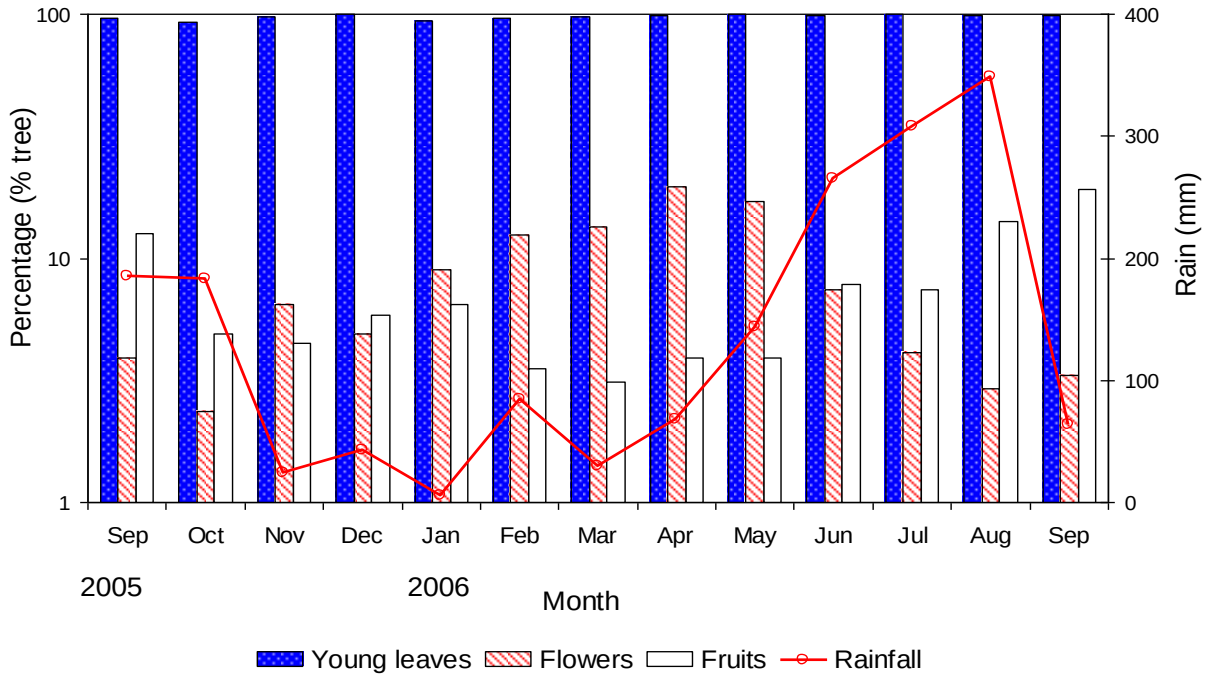


Figure 4.15. Phenological patterns at Khau Ca Forest (n=512)

Table 4.10. Species richness between plots at Khau Ca Forest

Plots	#IDs	Species	Genus	Family	Plots	#IDs	Species	Genus	Family
KC1	9	8	8	7	KC30	4	3	3	2
KC2	17	13	10	9	KC31	6	5	5	5
KC3	9	8	7	7	KC32	8	6	5	5
KC4	8	6	6	6	KC33	4	4	4	3
KC5	9	4	4	2	KC34	6	5	5	4
KC6	6	6	5	5	KC35	7	7	7	7
KC7	10	7	7	7	KC36	3	3	2	2
KC8	7	6	6	5	KC37	5	5	5	3
KC9	7	5	5	5	KC38	1	1	1	1
KC10	4	4	4	3	KC39	7	6	6	6
KC11	8	8	8	8	KC40	5	3	3	3
KC12	12	10	10	8	KC41	7	5	5	5
KC13	21	15	13	11	KC42	6	4	4	4
KC14	25	19	18	14	KC43	9	9	8	8
KC15	4	4	4	3	KC44	14	13	13	10
KC16	5	4	4	3	KC45	5	4	4	4
KC17	12	9	9	7	KC46	8	8	7	6
KC18	13	11	10	8	KC47	10	8	8	8
KC19	24	13	13	10	KC48	6	5	5	5
KC20	10	6	6	6	KC49	14	13	12	10
KC21	3	2	2	2	KC50	13	6	6	6
KC22	6	4	4	4	KC51	10	8	8	8
KC23	9	9	9	8	KC52	16	6	5	5

Table 4.10. Species richness between plots at Khau Ca Forest (continued)

Plots	#IDs	Species	Genus	Family	Plots	#IDs	Species	Genus	Family
KC24	2	2	2	2	KC53	20	10	9	8
KC25	4	4	4	4	KC54	14	7	7	7
KC26	4	4	4	4	KC55	11	9	8	7
KC27	5	3	3	3	KC56	10	8	7	7
KC28	2	2	2	2	KC57	11	7	7	5
KC29	8	6	4	4	KC58	9	7	6	3

KC: Khau Ca

#IDs: Individuals

Table 4.11. Abundance and basal area of tree families in botanical plots at Khau Ca

Family	No.of stems	% of stems	BA	%TBA	Mean BA
Aceraceae	7	1.37	1561.24	0.77	223.03
Actinidiaceae	7	1.37	2007.16	1.00	286.74
Altingiaceae	1	0.20	221.85	0.11	221.85
Annonaceae	16	3.13	3399.50	1.69	212.47
Apocynaceae	3	0.59	799.77	0.40	266.59
Araliaceae	7	1.37	1198.99	0.59	171.28
Bigoniaceae	2	0.39	1176.24	0.58	588.12
Burseraceae	1	0.20	43.95	0.02	43.95
Clusiaceae	10	1.95	1721.97	0.85	172.20
Dilleniaceae	2	0.39	200.40	0.10	100.20
Dipterocarpaceae	1	0.20	1217.67	0.60	1217.67
Ebenaceae	9	1.76	5287.07	2.62	587.45
Elaeocarpaceae	3	0.59	485.83	0.24	161.94
Euphorbiaceae	16	3.13	17357.81	8.61	1084.86
Fagaceae	38	7.42	19167.35	9.50	504.40
Hamamelidaceae	43	8.40	5732.25	2.84	133.31
Icacinaceae	5	0.98	930.17	0.46	186.03
Illiciaceae	1	0.20	34.43	0.02	34.43
Juglandaceae	6	1.17	1712.61	0.85	285.44
Kygelariaceae	2	0.39	1625.95	0.81	812.98
Lauraceae	87	16.99	59572.52	29.54	684.74
Magnoliaceae	4	0.78	1376.34	0.68	344.08
Melastomaceae	22	4.30	2028.58	1.01	92.21
Meliaceae	12	2.34	9778.69	4.85	814.89
Mimosaceae	2	0.39	824.21	0.41	412.11

Table 4.11. Abundance and basal area of tree families in botanical plots at Khau Ca (continued)

Family	No.of stems	% of stems	BA	%TBA	Mean BA
Moraceae	12	2.34	1398.39	0.69	116.53
Myricaceae	5	0.98	1503.95	0.75	300.79
Myristicaceae	1	0.20	45.84	0.02	45.84
Myrsinaceae	7	1.37	734.92	0.36	104.99
Myrtaceae	21	4.10	6401.24	3.17	304.82
Oleaceae	20	3.91	5648.98	2.80	282.45
Podocarpaceae	4	0.78	1034.90	0.51	258.72
Rhizophoraceae	1	0.20	48.55	0.02	48.55
Rosaceae	4	0.78	669.15	0.33	167.29
Rubiaceae	35	6.84	7707.00	3.82	220.20
Rutaceae	6	1.17	600.00	0.30	100.00
Samydaceae	1	0.20	32.79	0.02	32.79
Sapindaceae	6	1.17	2224.22	1.10	370.70
Sapotaceae	1	0.20	581.73	0.29	581.73
Sarcospermaceae	6	1.17	3530.64	1.75	588.44
Stalhyllaceae	3	0.59	559.03	0.28	186.34
Sterculiaceae	3	0.59	3598.98	1.78	1199.66
Styracaceae	11	2.15	881.49	0.44	80.14
Taxaceae	1	0.20	58.87	0.03	58.87
Theaceae	12	2.34	4294.96	2.13	357.91
Tiliaceae	1	0.20	1074.49	0.53	1074.49
Ulmaceae	11	2.15	9500.62	4.71	863.69
Urticaceae	22	4.30	2035.02	1.01	92.50
Verbenaceae	11	2.15	8046.70	3.99	731.52

Table 4.12. Twenty nine commonest tree species in 58 plots at Khau Ca

Family/Species	No. of stems	% of stems	BA	%TBA
Hamamelidaceae				
Mytilaria laosensis	43	8.40	5732.25	2.84
Lauraceae				
Machilus bonii	33	6.45	24736.36	12.27
Urticaceae				
Pouzolzia sanguinea	22	4.30	2035.02	1.01
Fabaceae				
Quercus chrysocalyx	18	3.52	10000.91	4.96
Melastomaceae				
Allomorphia arborescens	17	3.32	1793.48	0.89
Oleaceae				
Osmanthus pedulculatus	17	3.32	3626.66	1.80
Rubiaceae				
Gardenia sootepesis	14	2.73	3003.08	1.49
Annonaceae				
Polyalthia laui	11	2.15	914.11	0.45
Styracaceae				
Alniphyllum fortunei	11	2.15	881.49	0.44
Lauraceae				
Cryptocarya chinensis	10	1.95	8234.25	4.08
Ulmaceae				
Celtis sinensis	10	1.95	8877.35	4.40
Clusiaceae				
Garcinia fagraeoides	8	1.56	1586.47	0.79
Myrtaceae				
Syzygium cuminii	8	1.56	1627.63	0.81
Actinidiaceae				
Saurauja tristylla	7	1.37	2007.16	1.00
Ebenaceae				
Diospyros pilosula	7	1.37	4823.55	2.39
Fabaceae				
Quercus variabilis	7	1.37	5114.77	2.54
Myrtaceae				
Syzygium zeylanicum	7	1.37	3778.70	1.87
Verbenaceae				
Premna aff. chevalieri	7	1.37	5034.45	2.50

Table 4.12. Twenty nine commonest tree species in 58 plots at Khau Ca Forest

Family/Species	No. of stems	% of stems	BA	%TBA
Lauraceae				
Neolitsea ellipsoides	6	1.17	14888.71	7.38
Rubiaceae				
Canthium didinum	6	1.17	608.36	0.30
Wendlandia paniculata	6	1.17	921.11	0.46
Sarcospermaceae				
Sinosideroxylon wightianum	6	1.17	3530.64	1.75
Aceraceae				
Acer oliverianum	5	0.98	1376.43	0.68
Fabaceae				
Ormosia pinnata	5	0.98	288.64	0.14
Lauraceae				
Machilus sp	5	0.98	1610.29	0.80
Melastomaceae				
Memecylon ligustrium	5	0.98	235.10	0.12
Meliaceae				
Aglaia globosus	5	0.98	1753.08	0.87
Myricaceae				
Myrica sapida	5	0.98	1503.95	0.75
Sapindaceae				
Paranephelium chinense	5	0.98	2048.43	1.02

4.5.3. Comparison between Tat Ke Sector and Khau Ca Forest

Botanical structure

There were differences in the number of trees, densities and mean girth of trees between two study sites. Compared to Tat Ke Sector, the number of trees meeting the sample criterion of 19 cm g.b.h. in plots at Khau Ca Forest was less (512 compared with 612 trees). A possible explanation for this difference is Tat Ke Sector had a higher number of plots sampled than Khau Ca Forest (64 compared with 58 plots). Tat Ke Sector had a total of 956 trees per hectare, while this figure was 882 trees per hectare at Khau Ca Forest. The mean girth of trees at Tat Ke Sector (60 cm) was higher than Khau Ca Forest (54.7cm). Distribution of girths at breast height of trees sampled at Tat Ke Sector was closely similar to results from Khau Ca Forest. Most tress were in the range of from 19 to 110 (Tat Ke Sector) and 130 cm (Khau Ca Forest), which contributed to more than 90% of the total trees sampled.

Botanical composition

Although Tat Ke Sector had more species than Khau Ca Forest (151 species compared with 136 species), there was a small difference in number of families (50 and 49 families, respectively). The ratio of trees/species and species/family at Tat Ke Sector were closely similar to Khau Ca Forest (4 trees/species and 3 species/family compared with 3.7 trees/species and 2.8 species/family, respectively).

Tat Ke Sector had a smaller number of commonest families than Khau Ca Forest (24 and 29 families). Thirty-nine families were common to both areas in total. They accounted for about 89.87% of total stem-number and 84.02% of total basal area at Tat Ke Sector and 91.80% of total stem-number and 92.21% of total basal area at Khau Ca Forest. Moraceae (25.82%) contributed the highest proportion of stem-number to the total trees sampled at Tat Ke Sector, while this figure at Khau Ca Forest was Lauraceae (16.99%). If basal area is considered, Tiliaceae (25.68%) contributed the largest proportion of the basal area at Tat Ke Sector, whereas at Khau Ca it was Lauraceae (29.54%).

Tat Ke Sector had the number of common species considerable similar to Khau Ca Forest (28 and 29 species), but there was a distinct difference in sharing common species between sites. Both study sites shared only four species in common. They were *Garcinia fagraeoides* (Clusiaceae), *Pouzolzia sanguinea* (Urticaceae), *Saurauja tristylla* (Actinidiaceae), and *Syzygium zeylanicum* (Myrtaceae). This difference may result from the difference in geology and soil between sites. Khau Ca Forest is restricted only to limestone hills, whereas forest at Tat Ke Sector is distributed on both limestone hills and mountains. At Tat Ke Sector the commonest tree species in terms of stem-number was *Streblus macrophyllus* (Moraceae) and the tree with the largest proportion of total basal area was *Excentrodendron tonkinensis* (Tiliaceae). At Khau Ca the commonest tree in terms of stem-number was *Mytilaria laosensis* (8.40%) and the tree with largest proportion of total basal area was *Machilus bonii* (12.27%).

Phenology

The phonological patterns at Tat Ke Sector were close to results from Khau Ca Forest. The production of young leaves was high through the year. At Tat Ke Sector young leaves were observed less at the end of dry season (from March to May), where at Khau Ca trees produced less young leaves at the early and middle of the dry season (from October to January. There was no significant difference in young leaf production at the two sites (Mann-Whitney $U=23$, $n_1=11$, $n_2=13$, $p>0.05$). Similarly, there was no significant difference in flower production between two sites (Mann-Whitney $U=66$, $n_1=11$, $n_2=13$, $p>0.05$). Both areas exhibited bimodal flowering with a common peak at the early of the dry season (November) and other peaks in June (Tat Ke Sector) and in April (Khau Ca Forest). Fruiting was also bimodal at two sites, but fruiting peaks at Tat Ke Sector was considerable different from Khau Ca Forest. Major and minor peaks of fruiting at Tat Ke Sector were in November and July, while at Khau Ca Forest these peaks were observed in September and June, respectively. However, there was no significant difference in fruit production between two sites ($U=64$, $n_1=11$, $n_2=13$, $p>0.05$).

4.6. Feeding ecology

4.6.1. Diurnal pattern of feeding

Rhinopithecus avunculus spent 14.7 % of their total activity time in feeding and fed throughout the day. The distribution of feeding observations over the day during the course of the study is shown in figure 4.16. It was found that the monkeys began feeding at 6.00h, approximately 30 to 1 hour after dawn, and ended at 18.00h, about 30 minutes before dusk. There were two peak periods of feeding time during the day. The first peak period was found in the morning from 7.00 to 10.00h, accounting for ca. 34 % of the total daily feeding observations. The second one was between 14.00 and 16.00h in the afternoon, accounting for ca. 36% of the total daily feeding observations.

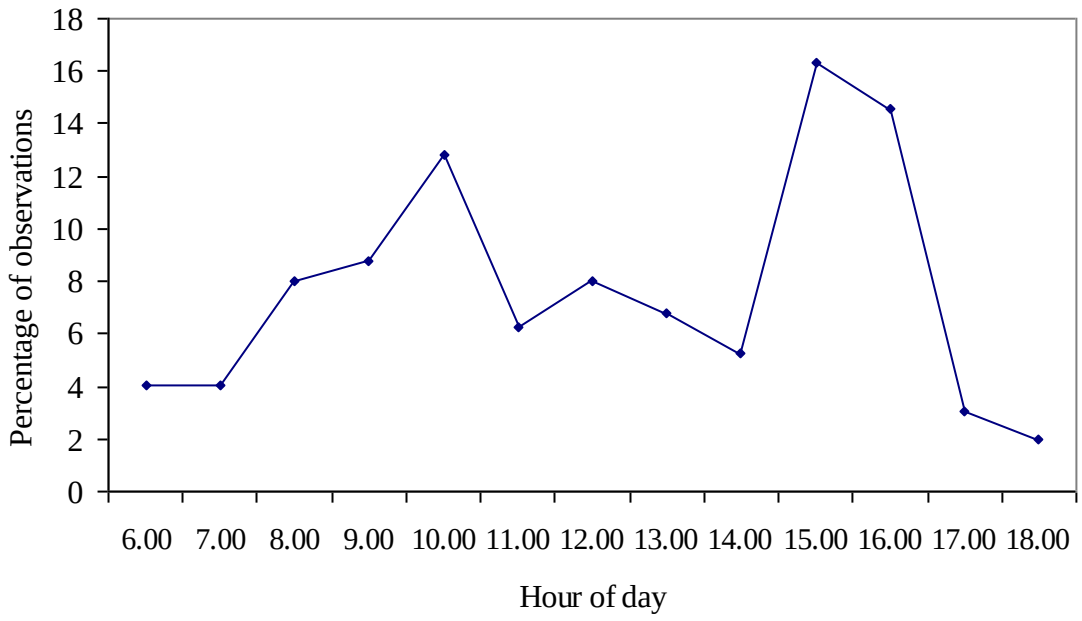


Figure 4.16. Diurnal variation in the percentage of feeding time of *R. avunculus* at Khau Ca (n = 401)

4.6.2. Diet

R. avunculus were observed feeding on 43 species of tree, 3 species of liana, and 2 species of orchid during feeding *ad libitum* and scan samples (table 4.14). Of which 39 were identified at the species level; 7 at the genus level; and one unknown tree species and two unknown liana species. This enumeration was likely underestimated because the monkeys appeared to feed on various items of liana species and some tree species during traveling that could not obtain from observations.

Rhinopithecus avunculus fed on variety of food types: young leaves, mature leaves, flowers and flower buds, ripe fruits and unripe fruits, seeds of ripe and unripe fruits, barks and young stems. The proportion of feeding time on different items by *R. avunculus* at Khau Ca during scan observations is presented in table 4.13.

Young leaves appeared to be important food items of *R. avunculus* which accounted for about 46.2 % of the total feeding time, whereas mature leaves were only 6.9 %. Leaves were eaten a part of blade (e.g. *Camellia sasamqua, Machilus bonii*), or petiole (*Premana balansae, Congea sp*), or whole young leaves (*Diospyros choboensis, Diospyros pilosula*).

Figure 4.17. *R. avunculus* fed on young leaves

Figure 4.18. *R. avunculus* fed on ripe fruits

Fruits contributed 24% of the total feeding time. Animals seemed to spend more time feeding on ripe fruits than unripe fruits (13.8 and 11.2%, respectively). In contrast, seeds of unripe fruits (4.7%) were consumed more than those of ripe fruits (2.5%). Fruits were eaten either whole (e.g. *Bridelia monoica, Berchemia floribunda*) or just seeds by breaking open fruits with teeth, eating seeds, and discarding fleshy epicarp (e.g. *Celtis sinensis, Scheffera delavayi*).

Flowers made up 11.2% of the total feeding time. Animals were seen eaten whole flowers and flower parts of *Diospyros choboensis, Diospyros pilosula, Aser chapaense.* In most flowering species eaten by the animals, flower and flower buds were quite difficult to distinguish from the distance because of their small size (e.g. *Acer chapaense,Diospyros choboensis)*. Further, animals were generally fed on both flower and flower buds at a time. For the purpose of scan and data analysis, flowers and flower buds were combined as "flower" if animals feeding on unclassified flowers or flower buds.

On several occasions, young leaves and mature leaves, ripe and unripe fruits could not distinguish with certainty. These were labeled as undetermined items (2%). Bark and young stems of *Cryptocarya sp,Trevesia palmate, Schefflera delavayi* were seen eaten by

adult of both sexes of *R. avunculus* during *ad libitum* observations. Young stems were broke off from branch by one or two hands, or bitten off by teeth, and chewed.

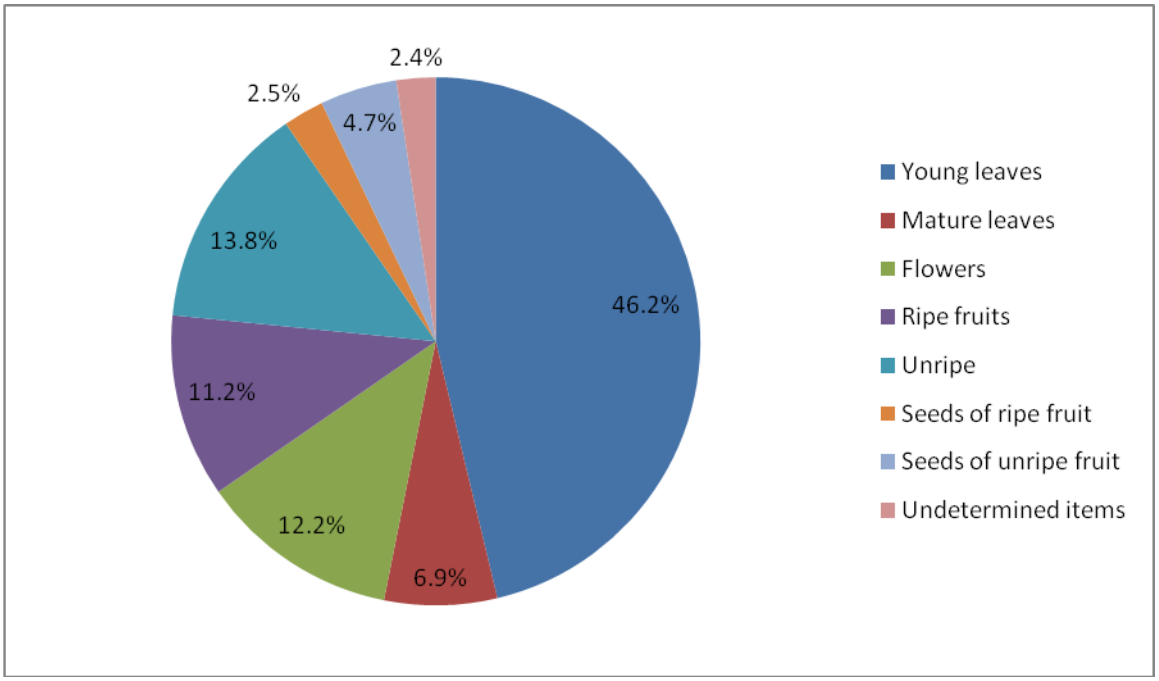


Figure 4.13. Percentage of different food items in *R. avunculus'* diet at Khau Ca

Like other members of genus *Rhinopithecus*, *R. avunculus* showed great diversity of food types and food items were variable between seasons. From these observations, it is clear that the Tonkin Snub-nosed Monkey is not totally folivorous but is frugivore-foliovore. It also appears that food selection depends on availability and abundance. These results are in contrast to Nhat 1994's study that *R. avunculus* was frugivorous.

Table 4.14. List of food plants and plant parts eaten by *R. avunculus* at Khau Ca

Species	Family	YL	ML	FL/FLB	RF	UF	SRF	SUF	Bark	Stem	UI
Acer tonkinensis	Aceraceae			+							
Acer chapaense	Aceraceae	+		+							
Choerospondias axillaris	Anacardiaceae	+									
Alphonsea tonkinensis	Annonaceae	+									
Limacia sp	Annonaceae		+								
Polyalthia sp	Annonaceae	+		+							
Ilex purpurea	Aquifoliaceae	+									
Ilex sp	Aquifoliaceae	+	+								Leaves
Ilex macrocarpa	Aquifoliaceae		+								
Trevesia palmate	Araliaceae	+				+		+		+	
Schefflera delavayi	Araliaceae	+		+		+		+		+	
Garcinia fagraeoides	Clusiaceae	+		+		+					Fruits
Garcinia tinctoria	Clusiaceae	+		+		+					
Diospyros choboensis	Ebenaceae	+		+							
Diospyros pilosula	Ebenaceae	+		+							
Bridelia monoica	Euphorbiaceae				+						
Bowringia callicarpa	Fabaceae			+							
Ormosia sp	Fabaceae							+			
Castanopsis tonkinensis	Fagaceae			+							
Quercus acutissima	Fagaceae	+									
Castanopsis chinensis	Fagaceae	+									
Anna submontana	Gesneriaceae	+									
Machilus bonii	Lauraceae	+									
Cryptocarya sp	Lauraceae								+	+	
Sandoricum kontape	Meliaceae			+							
Toona sinensis	Meliaceae	+									

Table 4.14. List of food plants and plant parts eaten by *R. avunculus* at Khau Ca (Continued)

Species	Family	YL	ML	FL/FLB	RF	UF	SRF	SUF	Bark	Stem	UI
Diplospora viridiflora	Menispermaceae					+					
Ardisia ramondiaeformis	Myrsinaceae			+							
Ardisia quinquegona	Myrsinaceae	+									
Ardisia crispa	Myrsinaceae	+									
Syzygium sp	Myrtaceae	+									
Syzygium zeylanicum	Myrtaceae	+	+								
Syzygium wightianum	Myrtaceae	+	+								
Bulbophyllum pectinatum	Myrtaceae	+								+	
Tropidia curculigoides	Myrtaceae	+								+	
Berchemia floribunda	Rhamnaceae				+						
Rubus moluccana	Rosaceae	+									
Pavetta tonkinensis	Rubiaceae	+									
Gardenia sootepesis	Rubiaceae	+		+							
Sinosideroxylon wightianum	Sapotaceae	+									
Sarcosperma laurium	Sapotaceae	+	+								
Camellia sasamqua	Theaceae	+									
Congea sp	Verbenaceae		+								
Premna balansae	Verbenaceae	+									
Premna flavescens	Verbenaceae		+								
Tetrastigma gaudichaudianum	Vitaceae				+	+					
Celtis sinensis	Ulmaceae						+				
Liana 1					+						
Liana 2								+			
Unknown					+						+

YL: Young leaves ML: Mature leaves FL/FLB: Flowers and flower buds RF: Ripe fruits UF: Unripe fruits

SRF: Seeds of ripe fruits SUF: Seeds of unripe fruits UI: Undetermined items

4.7. Conservation of Rhinopithecus avunculus

4.7.1. Threats

Hunting

Hunting is a severe problem throughout the range of *R.avunculus* in the past and presence. The use of guns is widespread and common. Surveys by Boonratana and Le (1994:30) in the vicinity of Na Hang Nature Reserve estimated that every household owned at least one gun and probably more than one. Although gun confiscation and conservation programmes have been carried out in the range of *R. avunculus*, and some reduction in hunting has been successfully reported (Ren, et al., 1998:308; Le, 2003: 81), it is evident that hunting pressure is still high. For instance, on a daily basis, the survey team would hear between five and seven gun shots in Tat Ke Sector, Na Hang Nature Reserve (H.T. Dong, pers. obs., 2005) and from three to ten gun shots in Cham Chu Nature Reserve (Dong et.al., 2006:16). Further, groups of two to five hunters, and both old and recent huts, were encountered during surveys (H.T. Dong, pers. obs, 2005-2006).

R. avunculus' meat has been known as "bad tasting" and it is not the target of the hunters, but they would kill them whenever encountered (Boonratana and Le, 1994:29; 1998b:319; Dong, et al., 2006:24). Meat of *R. avunculus* fried with ginger was used only for family consumption, and bones were made into traditional medicine called "Cao" (Dong, et al., 2006:24). The latter product and other body parts such as liver are sold at the market or traded to China (Boonratana and Le, 1994:29; 1998b:319)

In addition to the use of guns, a variety of hunting tools, such as crossbows or stone and metal traps, were widely used to catch other wildlife, especially small mammals such as Masked Palm Civet (*Paguma larvata*), Hoary bamboo rats (*Rhizomys pruinosus*), Large bamboo rats (*Rhizomys sumatrensis*), Asiatic Brush-tailed porcupine (*Atherurus macrourus*), Noisy rats (*Leopoldamys sabanus*) and others (Boonratana & Le, 1994:30; 1998b, 319; Dong, et al., 2006:17). For example, about 200 traps were found in Tat Ke Sector, placed along animal trails and in rock crevices; of these, more than 50% were successful per night (Boonratana & Le, 1998b:319).

Habitat destruction

Human activities such as past legal and illegal logging, shifting cultivation, mining exploitation, non forest timber product collection and dam construction have remarkable impact on suitable habitats of *R. avunculus* and other wildlife.

Historically, intensive and unsustainable legal loggings (now no longer in existence) by forest enterprises were operated over almost the whole range of *R. avunculus*. Consequently, habitats available for *R. avunculus* have been reduced, fragmented, and degraded (Le & Boonratana, 2006; Nadler et al., 2003:161; Pham, 2002:77; Ratajszczak et al., 1990:30). Illegal logging is currently still continuing in some nature reserves: Tat Ke Sector, Na Hang Nature Reserve (H.T. Dong, pers. obs., 2004-2005) and Cham Chu Nature Reserve and (Dong et al., 2006:19).

Figure 4.18. Illegal logging at Tat Ke

Shifting cultivation is a traditional practice of the ethnic minority groups living in and around the protected areas. Forests are replaced by orange farms and other crops such as rice, cassava and maize (Boonratana & Le, 1994:28; 1998:319; Dong, et al., 2006:19). This is considered wastefulness and has considerable impact on the population of *R. avunculus* since some replaced forests have been used and abandoned every three years.

Figure 4.19. Rice field inside the Forest at Tat Ke

Varieties of non timber forest products are collected by villagers. For instance, bamboo for making houses and household utensils; bamboo shoots for family consumption and sale; rattan for local use and sale; and a number of fruits of trees, especially *Dracontomelum dipreanum* and *Canarium album* (Boonratana & Le, 1994:28; 1998b:319). These products bring high income to local people. Each adult villager in Tat Ke Sector Na Hang Nature Reserve, on average, earns from four to five million Vietnam dong (equal to $ 250-310 USD) per bamboo season (H.T. Dong, pers. obs., 2005).

Mining has been reported to be a common activity at some of the known habitats of *R. avunculus* in the past. This has not only destroyed the forest, but increased demand for wildlife products (Boonratana & Le, 1994:29; 1998b:319; Nadler et al., 2003:161; Dang & Nguyen, 1999; Ratajszczak et al., 1992). Past gold mining operation in Na Hang Nature Reserve is a case in point. At some areas where gold mines are suspected, clearings in the forest were as large as 100 ha (Boonratana & Le, 1994:29; 1998b:319). Currently, mining exploitation is still operating in some areas adjoining or surrounding the *R. avunculus* habitats. Gold mining was seen on Pac Van and Gam Rivers bordering Na Hang Nature Reserve. Mining of zinc and aluminum based in Lung Vay area, Minh Son commune (about two kilometers away from Khau Ca Forest), emits a number of very loud explosions everyday at noon and in the late afternoon (H.T. Dong, pers. obs., 2004-2006).

Dam construction

Another major concern for *R.avunuculus* in Na Hang Nature Reserve is the construction of a dam that began in 2002. First, the population of Na Hang was increased by 8,500 workers, resulting in increased demand for wildlife and other forest products (Le & Boonratana, 2006:15; Nadler, et al., 2003:161, Mittermeier et al., 2006). Wild meat become available at Na Hang Town, and most is consumed by workers (H.T. Dong, pers. obs., 2004-2006). Second, some parts of Na Hang Nature Reserve along the Gam and Pac Van Rivers, about 220 hectares, have been or will be flooded by Na Hang Hydropower Plant (Le & Boonratana, 2006:15; Nadler, et al., 2003:161). Last, dam and road construction increase the accessibility of human activities to the reserve and noise that may have negative impact on the population dynamics of *R. avunculus* and other wildlife, affecting breeding patterns and causing the animals to avoid preferred feeding areas (Nadler, et al.,

2003:161).

4.8. Training and educational accomplishments

4.8.1. Students and local assistants

2 students from Forestry University, 1 student from Institute of Ecology and Biological Resources, 1 student from Cornel University and 7 local people recruited from villages and reserve's patrol groups were trained during the course of the study. Each local student just participated in the project for 4 months. Training was designed to provide the basic knowledge and skills in field techniques and in field primatology, which they can apply to the present and future in the reserve. These techniques included map reading and compass use, wildlife and human impact surveys, camping and use of field equipment, note taking and recording techniques and report -writing. For students who have higher education, we also provided them with techniques of collecting primate behaviour such as spot and scan sampling methods.

Figure 4.20. Team members at Tat Ke and Khau Ca

Table 4.15. List of participants of the project

No	Name of participants[1]	Sources	Responsibility
1	Mr.Dong Thanh Hai	Post-Graduate student-from The Australian National University Australia	Principal Investigator
2	Dr.Ramesh Boonratana	Primatologist from Malaysia (Secretary-General of the SouthEast Asian Primatological Association)	Field Supervisor
3	Dr. Le Xuan Canh	Primatologist from IEBR	Field Supervisor
4	Ms.Susan Hua	Student from USA	Assistant[2]
5	Mr. Vu Dang Qui	Post-graduate student from IEBR	Assistant
6	Mr. Vu Duc Kham	Post-student from Forestry University of Vietnam	Assistant
7	Mr. Nguyen Van Huong	Student from Forestry University of Vietnam	Assistant
8	Mr. Quan Van Tinh	Thanh Tuong commune	Assistant
9	Mr. Ma Van Tu	Thanh Tuong commune	Assistant[3]
10	Mr. Dong Khac Thanh	Thanh Tuong commune	Camp manager
11	Mr. Quan Van Thiet	Doi 1 village-Khau Tinh commune	Assistant
12	Mr. Nong Van Tinh	Patrol groups-Trung Khanh commune	Assistant[4]
13	Mr. Le Xuan Hiep	Patrol groups-Thanh Tuong commune	Assistant
14	Mr. Ma Van Huong	Patrol groups-Doi 1 village-Thanh Tuong commune	Assistant

[1] Name and number of participants have been changed as stated in the proposal because of the following reasons:

a. Some local students did not show interest and refused to work for the project with per diem stated in the budget

b. Because of personal and family problems, some local assistants left the project, so I have to recruit new ones to replace them.

[2] Susan Hua-student from Cornel University, USA work as a volunteer for the project

[3,4]Ma Van Tu and Nong Van Tinh-Patrol groups left the project and were replaced by Quan Van Thiet and Ma Van Huong.

4.8.2. Species and habitat protection

Monthly visits were made to villages living in and around the Nature Reserve to talk with village head men and villagers about wildlife, especially the past and current distribution of *Rhinopithecus avunculus* in the study area and to explain to them why it is important to protect and conserve this species. Also, we collected, destroyed traps and recorded human impacts on forest and then reported to Nahang Nature Reserve Management Board. Hunting pressure and illegal logging seemed to be reduced since our presence, but not to the extent desired.

4.8.3. Local benefits

The experience and knowledge obtained from this project enriched their understanding of the ecosystem in the area, and more importantly, enhanced their appreciation of the surrounding communities for the local flora and fauna. Also, the project created an alternative income source for some local people.

4.8.4. Involvement of local and international agencies

Contacts were made with the Forestry University, Vietnam's Institute of Ecology and Biological Resources, Vietnam's Forest Protection Department, Tuyen Quang's Forest Protection Department, Tuyen Quang People Committee, Nahang's Forest Protection Department, Nahang Nature Reserve Management Board, Ha Giang's Forest Protection Department, Du Gia Nature Reserve Management Board who are all support the project. Contacts were also made with various international agencies/institutions during the project to share information and discuss aspects of the project. These agencies/institutions included The Australian National University (ANU), BP Conservation Programme, Conservation International Foundation (CI), Primate Conservation Incorporated (PCI), Rufford Small Grant for Nature Conservation (RSG), Wildlife Conservation Society (WCS), Nahang Tonkin Snub-nosed Monkeys Conservation Project (TCP).

Dr. Ramesh Boonratana and Dr. Le Xuan Canh, the project's field supervisors were made four visits to the field. The purposes of the trips were to help us set up the study site and establish botanical plots, train team members as well as collect data on behaviour of Tonkin Snub-nosed Monkeys.

4.8.5. Improved prospects for future action

Information on current population status, social organization, feeding behaviour, and range use collected from the project resulted in Tonkin snub-nosed monkeys Conservation Action Plan in Vietnam. This is the guidelines for long term conservation and management of the species in Vietnam (see, Le & Boonratana, 2006). More importantly, trained local assistants and students are capable of monitoring phenology and the monkeys' population in the future. Lastly, knowledge and skills in conservation have been partly imparted to local people who are living in and around the reserve through monthly visit. This helped local people to increase their awareness of the importance of protecting the monkeys, its habitats and other wildlife as a whole.

4.8.6. Result dissemination

To disseminate the results of the project, at local level, workshop on Tonkin snub-nosed monkey Conservation Action Plan was held at Tuyen Quang Province with participants from surrounding villages Hang People's Committee, Na Hang Forest Protection Department, Na Hang Nature Reserve Board, Tuyen Quang People's Committee, and Ha Giang Forest Protection Department. At international level, the results of the project were widely disseminated through workshops and conferences (table 4.21). In addition, pictures of *R. avunculus* captured from the field were used to make 2007 calendar that were distributed to local people living around Khau Ca. In April 2009, the project associated with Vietnam National Television produced two episodes of ecology and behavior of *R. avunculus* in Vietnam.

Table 4.21. Result dissemination

Author/authors	Year	Titles
Dong Thanh Hai	2008	Feeding Ecology of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Khau Ca. Abstract at 22nd IPS Congress, Edinburgh, Scotland.
Dong Thanh Hai	2007	Population and Conservation status of Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Na Hang Nature Reserve. Abstract at 21st SCB Conference, South Africa.
Dong Thanh Hai	2006	Behavioral Ecology and Conservation of *Rhinopithecus (Presbytiscus) avunculus* in Nahang Nature Reserve, Northern Vietnam. Newsletter. PCI
Dong Thanh Hai and Boonratana	2006	Further Observations of Ecology and Behaviour of Tonkin Snub-nosed Monkeys in Vietnam. Abstract at 21st IPS Congress, Entebbe, Uganda.
Dong Thanh Hai	2006	Behavioural Ecology and Conservation of *Rhinopithecus avunculus* in Vietnam. Unpublished report to Ruffor Small Grant, UK.

4.9. Wildlife survey

The presence of fauna, other than *R. avunculus*, was recorded opportunistically during the surveys. 19 mammals and 34 birds were recorded during study period at Tat Ke and Khau Ca. The list of mammals and birds recorded is given in the appendix 3 and 4.

Another endangered primate, Francois' langur (*Trachypithecus francoisi*) has been reported to be in Tat Ke Sector (Boonratana & Le, 1994), but there is no sighting of *T. francoisi* in the areas surveyed during the course of the study. According to local report, the last animal of Francois' langur (*Trachypithecus francoisi*) was shot by a hunter several years prior to this study.

Sighting of macaques was quite rare in Tat Ke Sector. According to local informant, there were three species of macaques in this area, but only two species (Assamese macaque, *Macaca assamensis* and Rhesus Macaque, *Macaca mulata*) of macaques were seen during the survey at Pac Ta and Khau Tep areas. In contrast, the densities of macaques in Khau Ca are higher than Tat Ke and three species of macaques were observed. They are Assamese macaque, *Macaca assamensis*, Rhesus Macaque, *Macaca mulata*, Stump-tailed macaque *(Macaca arctoides).*

Other mammals

Signs of other mammals are few and appeared to be very low in the areas surveyed since the probability of encounter of them in the forest is low. Only 8 out of 18 species recorded were seen during surveys and the rest was based on other evidences such as tracks, feeding signs, reliable report (see table appendix 3 for more details). This is due to past and current hunting pressure in the forests surveyed.

Figure 4.21. A group of *Macaca assamensis* at Tat Ke

Figure 4.22. *Arctonyx collaris* at Tat Ke

Figure 4.22. *Megalaima franklinii* at Tat Ke

Figure 4.23. *Melanochlora sultanea* at Tat Ke

4.10. Recommendations

4.10.1. Tat Ke Sector

It is evident that the population sizes of *Rhinopithecus avunculus* at Tat Ke Sector are much smaller than previous reports. Hunting is identified as the main threat to the species. Therefore, conservation actions must target this threat as the first priority.

Improve management and protection for the species and habitats

Issues

1) Hunting and illegal logging are still going on in the reserve
2) Livestocks are still grazing in the langurs' known habitats
3) The forests can easily access in many ways
4) Lack of designed patrol routes for patrolling entire forests
5) Lack of field participation of forest rangers in patrolling forests and guiding patrollers
6) Unequal number of local participation between villages living in and around the reserve

Actions needed

1) Strengthen law enforcement in the reserve
2) Identify what people want from the forest and look for alternatives that could be developed outside the forest.
3) Develop zoning plans for livestock grazing to identify where livestock can graze.
4) Limit human access to forests
5) Design patrol routes for patrollers
6) Conduct regular patrols in the Langurs' known habitats with regular participation of forest rangers
7) Develop a "good" policy for recruiting patrollers

Conduct monitoring programs

Issues

1) Lack of update and reliable information on the population status of *R. avunculus*.
2) Lack of long-term monitoring programs since Boonratana and Le's study in 1994
3) Lack of manpower and trained people to conduct long-term monitoring program

Action needed

1) Develop long-term programs for the remaining populations of *R. avunculus* and its habitats. Given the small population sizes of the species and under high hunting pressures, monitoring programs should be conducted every six month.
2) Consult monitoring programs with experienced experts
3) Recruit and train local people and forest rangers ready to participate in these activities
4) Develop a raising fund program that can secure long-term monitoring activities

Conduct conservation education programs

Issues

1) Hunting is a tradition of ethnic communities living in and around the reserve
2) Public information available on *R. avunculus* in villages living in the reserve such as Doi1 Tat Ke, Na Tang and Khau Tinh villages are limited
3) Lack of local support in *R. avunculus* conservation
4) Tonkin snub-nosed monkeys and wildlife education programs are limited in villages and primary schools inside the reserves (Doi 1 Tat Ke, Na Tang and Khau Tinh villages)

Action needed

1) Develop wildlife education program to discourage hunting by local people in the reserve

2) Develop awareness materials (posters, radio programs, documentary) about *R. avunculus* in Na Hang
3) Recruit and involve local people in conservation programs to make positive use of their local knowledge and raise their proud of possession of rare species.
4) Develop a special education program for schools located in villages inside the reserve

4.10.2. Khau Ca Forest

Khau Ca Forest has currently held the largest population of *R. avunculus* among four known sites. The population there appeared to be growing and under a good management. Like Tat Ke, long-term monitoring and conservation education programs should be carried out in the Khau Ca Forest. In addition, to make sure the long term survival of the population, some of the following recommendations should be taken into account.

Improve management and protection for the species and habitats

Issues

1) Khau Ca has not had a legal status until now
2) Lack of management board
3) Khau Ca Forest boundary is still unclear
4) Khau Ca Forest area is small (ca. 10 km^2)

Actions needed

1) Prepare relevant documents to submit to higher authorities for getting a legal status for Khau Ca
2) Establish management board right after it has the legal status
3) Assess boundary of Khau Ca Forest
4) Expand Khau Ca Forest area by including adjacent remaining primary forests, regenerating poor forests, or reforesting bare areas.

Continue conducting long-term research on ecology and behavior of *R. avunculus*

Issues

Information on behavior and ecology of *R. avunculus* are still limited
The presence of researchers may reduce human activities in areas studied
Research will provide useful information towards a management and conservation action plan of the species

Action needed

Encourage students and researchers to get involved in long-term research programs
Develop funding sources available for relevant research
Recruit and train park staff and local people to involve in these activities
.

5. CONCLUSION

The population size in Tat Ke and Khau Ca are 17 and 81 individuals (estimate 22 and 90 individuals, respectively). These estimations are different from previous works. Tat Ke populations are smaller than early reports (22 compared with 72 individuals), whereas Khau Ca populations increase by 30 animals compared with Le Khac Quyet, 2004 report (60 animals).

Basic social structure of *R. avunculus* at both sites is one-male unit. These one-male units frequently come together for traveling, feeding, resting and sleeping. These results support Boonratana and Le, 1994 study, but do not agree with Ratajszczak, 1992 and Le Khac Quyet, 2006 findings.

R. avunculus allocate their time for each activity as follows: resting contributed the largest proportion of *R. avunculus* total activity time (32.1%); The next was traveling (19.8%); Vigilance and feeding made up almost equal amount of time in the total activity (14.8% and 13.9%, respectively). Grooming occupied (5.1%) and adult males, females and juveniles were observed to involve in this behaviour. Playing contributed (3.7%) to the total activity time and only infants and juveniles were observed to play. Agonistic interactions made up only (0.4%) and other activities were 0.2%.

R. avunculus shows terrestrial behavior. All ages/sexes participated in this behavior. This finding contrast to previous report that *R. avunculus* is completely arboreal. Allomothering, rest-huddling is the first time observed in the species.

The Tonkin Snub-nosed Monkey does not seem to have any marked breeding season as infants were observed throughout the study. However, more infants were recorded in September and October 2005 and in March and April 2006. This apparently coincided with when fruits, flowers and young leaves are more abundant.

In contrast with previous report, neonate of *R. avunculus* has a white pelage rather than yellow colour.

There were differences in the number of trees, densities and mean girth of trees between two study sites (see detailed in section 4.5). In Tat Ke, out of a total 612 tree sampled, taken from 64 plots, 151 species were identified, belonging to 50 families, for a ratio of ca. 4 trees/species and 3 species/family. Most trees were between 19 and 110 cm girth at breast height, which contributed to 92.5% of the total tree sampled.

In Khau Ca, out of a total 512 tree sampled, 136 species were identified, belonging to 49 families, for a ratio of ca. 3.7 trees/species and 2.8 species/family. Most trees were between 19 and 130 cm girth at breast height, which accounted for 95.7% of the total tree sampled.

Phenological characteristics of tagged trees from the botanical plots were investigated in both Tat Ke and Khau Ca. Observations were recorded monthly from September 2004 through September 2006. Each tree was recorded for their presence or absence of mature leaves, young leaves, flowers, and fruits. The phonological patterns at Tat Ke Sector were close to results from Khau Ca Forest. The production of young leaves was high through the year (see detailed in section 4.5).

Rhinopithecus avunculus spent 14.7 % of their total activity time in feeding and fed throughout the day. The first peak period was found in the morning from 7.00 to 10.00h, accounting for ca. 34 % of the total daily feeding observations. The second one was between 14.00 and 16.00h in the afternoon, accounting for ca. 36% of the total daily feeding observations.

R. avunculus were observed feeding on 43 species of tree, 3 species of liana, and 2 species of orchid. *Rhinopithecus avunculus* fed on variety of food types: young leaves, mature leaves, flowers and flower buds, ripe fruits and unripe fruits, seeds of ripe and unripe fruits, barks and young stems. The proportion of feeding time on different items by *R. avunculus* at Khau Ca during scan observations is presented in section 4.6.2.

The main threat to populations of *R. avunculus* in Tat Ke is hunting. Habitat loss poses threats to populations of *R. avunculus* at both sites.

Finally, the study gives some recommendations to better management and conservation of the species and its habitat (see detailed in section 4.10).

REFERENCES

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behavior*, *49*, 227-265.

Bennett, E. L., & Davies, A. G. (1994). The ecology of Asian colobines. In A. G. Davies & J. F. Oates (Eds.), *Colobine Monkeys: their ecology, behaviour and evolution*. Cambridge: Cambridge University Press.

Bleisch, W. V., & Jiahua, X. (1998). Ecology and Behaviour of the Guizhou Snub-nosed Langur (*Rhinopithecus [Rhinopithecus] brelichi*), with a Discussion of Socioecology in the Genus. In N. G. Jablonski (Ed.), *The Natural History of the Doucs and Snub-nosed*

Boonratana, R., & Le, X.C. (1998a). Preliminary observation on the ecology and behaviour of the Tonkin snub-nosed monkey (*Rhinopithecus [Presbyticus] avunculus*) in Northern Vietnam. In N.G. Jablonski (ed.), *The Natural History of the Doucs and Snub- nosed Monkeys*. World Scientific Publishing, Singapore.

Boonratana, R., & Le, X.C. (1998b). Conservation of Tonkin snub-nosed monkeys (*Rhinopithecus [Presbyticus] avunculus*) in Vietnam. In N.G. Jablonski (ed.), *The Natural History of the Doucs and Snub- nosed Monkeys*. World Scientific Publishing, Singapore.

Boonratana, R., & Le, X.C. (1994). A report on the ecology, status, and conservation of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in northern Vietnam. WCS/IEBR, New York/Hanoi.

Brockelman, W. Y., & Ali, R. (1987). Methods of Surveying and Sampling Forest Primate Populations. In C. W. Marsh & R. A. Mittermeier (Eds.), *Primate Conservation in the Tropical Rain Forest* (pp. 23-62). New York: Alan R. Liss, Inc.

Caton, J. M. (1999). Digestive Strategy of the Asian Colobine Genus Trachypithecus. *Primates, 40*(2), 311-325.

Clutton-Brock, T. H. (1997). Methodology and Measurement. In T. H. Clutton-Brock (Ed.), *Primate Ecology: Studies of feeding and ranging behaviour in lemurs, monkeys and apes* (pp. 585-589). London, New York, San Francisco: Academic Press.

Clutton-Brock, T. H., & Harvey, P. H. (1997). Species Differences in Feeding and Ranging Behaviour in Primates. In T. H. Clutton-Brock (Ed.), *Primate Ecology: Studies of feeding and ranging behaviour in lemurs, monkeys and apes* (pp. 557-579). London, New York, San Fracisco: Academic Press.

Council, N. R. (1981). *Techniques for the Study of Primate Population Ecology*. Washington D.C., USA: National Academy Press.

Covert, H.H., Le.K.Q., & Wright, B.W. (2006, June). A preliminary report of the positional behavior of the critically endangered Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) at Du Gia Nature Reserve, Ha Giang Province, Vietnam. Poster session presented at the Meeting of International Primatological Society, Entebe, Uganda.

Cowlishaw, G., & Dunbar, R. (2000). *Primate Conservation Biology*. Chicago: The University of Chicago Press.

Dang, N.C., & Nguyen, T.S. (1999). *Field report on Tonkin snub-nosed monkey (Rhinopithecus avunculus) in Bac Kan, Thai Nguyen and Tuyen Quang Provinces*. Fauna & Flora International - Indochina Programme, Hanoi, Vietnam.

Davies, A. G. (1994). Colobine population. In A. G. Davies & J. F. Oates (Eds.), *Colobine Monkeys: their ecology, behaviour and evolution*. Cambridge: Cambridge University Press.

Dong, T.H. (2006). News from the field. *Newsletter*. Primate Conservation Inc

Dong, T.H., & Boonratana, R. (2006, June). Further information on Ecology and Behaviour of Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) in Vietnam. Paper presented at the Meeting of the International Primatological Society, Entebe, Uganda.

Fooden, J. (1996). Zoogeography of Vietnamese primates. *International Journal of Primatology, 17* (5), 845-899.

IUCN (2004). *2004 Red List of Threatened Species*. Cambridge: IUCN.

Jablonski, N. G. (1998). The Evolution of the Doucs and Snub-nosed Monkeys and the Question of the Phyletic Unity of the Odd-nosed Colobines. In N. G. Jablonski (Ed.), *The Natural History of the Doucs and Snub-nosed Monkeys* (Vol. 4, pp. 13-52). Singapore: World Scientific Publishing.

Jablonski, N. G., & Pan, R. (1995). Sexual Dimorphism in the Snub-Nosed Langurs (Colobinae : Rhinopithecus). *American Journal of Physical Anthropology, 96*, 251-272.

Kay, R.N.B., & Davies, A.G. (1994). Digestive physiology. In A.G. Davies and J.F. Oates, (ed.), *Colobine Monkeys: Their Ecology, Behaviour and Evolution*. Cambridge University Press, Cambridge.

Kirkpatrick, R. C. (1996). *Ecology and Behavior of the Yunna Snub-nosed Langur (Rhinopithecus bieti, Colobinae).* University of California, Davis.

Kirkpatrick, R. C. (1998). Ecology and Behaviour in Snub-nosed and Douc Lagurs. In N. G. Jablonski (Ed.), *The Natural History of the Doucs and Snub-nosed Monkeys* (Vol. 4, pp. 155-190). Singapore: World Scientific Publishing.

Kirkpatrick, R. C. (2007). The Aisian Colobines Diversity among Leaf-eating Monkeys. In C. J. Campbell, A. Fuentes, K. C. MacKinnon, M. Panger & S. K. Bearder (Eds.), *Primates in Perspective* (pp. 186-200). London: Oxford University Press.

Lê, Q. K. (2006). *Nghiên cứu một số đặc điểm sinh thái của voọc mũi hếch (Rhinopithecus avunculus Dollman 1912) ở khu vực Khau Ca, tỉnh Hà Giang.* Trường Đại Học Khoa Học Tự Nhiên, Hà Nội.

Le.K.Q., Covert, H.H., & Wright, B.W. (2006, June). Status of the critically endangered Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) at Du Gia Nature Reserve, Ha Giang Province, Vietnam. Paper presented at the Meeting of International Primatological Society, Entebe, Uganda.

Le,X.C., Do, H.T., & Nguyen., V.S. (2000). *Results of survey on biodiversity and socio-economic conditions in Cham Chu mountain area, Tuyen Quang Province*. Institute of Ecology and Biological Resources, Hanoi, Vietnam.

Le, K.Q. (2004). Distribution and conservation of Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Du Gia Nature Reserve, Ha Giang Province, northeast Vietnam. In T. Nadler, U. Streiher, and T.L.Ha, (ed.), *the Conservation of primates in Vietnam*. Haki Publishing, Vietnam.

Le, K.Q. (2001). *Exploratory survey of Wildlife in Ha Giang Province, Vietnam*. Fauna & Flora International - Indochina Programme. Hanoi, Vietnam.

Le, K.Q., & Simmons, S.P. (2002). *Assessment and proposal for the immediate conservation of primate fauna in Du Gia nature reserve, Ha Giang province, northeast Vietnam*. Fauna and Flora International - Vietnam Programme. Hanoi, Vietnam.

Li, Y. (2006). Seasonal Variation of Diet and Food Availability in a Group of Sichuan Snub-Nosed Monkeys in Shennongjia Nature Reserve, China. *International Journal of Primatology, 68*, 217-233.

Lippold, L. K., & Vu, T. N. (1998). Primate Conservation in Vietnam. In N. G. Jablonski (Ed.), *The Natural History of the Doucs and Snub-nosed Monkeys* (Vol. 4). Singapore: World Scientific Publishing.

Liu, Z. H., & Zhao, Q. K. (2004). Sleeping sites of *Rhinopithecus bieti* at Mt. Fuhe, Yunnan. *Primates, 45*, 241-248.

Long, Y., Kirkpatrick, R. C., Xiao, L., & Zhong, T. (1998). Time Budgets of the Yunnan Snub-nosed Monkey (*Rhinopithecus [Rhinopithecus] bieti*) In N. G. Jablonski (Ed.), *The Natural History of the Doucs and Snub-nosed Monkeys* (Vol. 4, pp. 279-292). Singapore: World Scientific Publishing.

Lucas, P. W., & Teaford, M. F. (1994). Functional morphology of colobine teeth. In A. G. Davies & J. F. Oates (Eds.), *Colobine Monkeys: their ecology, behaviour and evolution*. Cambridge: Cambridge University Press.

Ministry of Science, Technology and Evironment (2000). *Red Data Book of Vietnam* (Volume 1. Animals), in Vietnamese. Science and Technics Pulishing House, Hanoi.

Mittermeier,R.A.,Valladares-Padua.C., Rylands.B.A., Eudey.A.A., Butynski.M.T., et al. (2006). Primates in peril: The world's 25 most endangered primates, 2004-2006. *Primate Conservation*. 20: *1-28*.

Nadler, T., Momberg, F., Nguyen, X.D., & Lormee, N. (2003). Vietnam primate conservation status review 2002, part 2: Leaf Monkeys. Fauna and Flora International – Vietnam program and Frankfurt Zoological society, Hanoi, Vietnam.

Oates, J. F., & Davies, A. G. (1994). What are the colobines? In A. G. Davies & J. F. Oates (Eds.), *Colobine Monkeys: their ecology, behaviour and evolution*. Cambridge: Cambridge University Press.

Peng, Y.Z., Zhang, Y.P., Ye, Z.Z., & Liu, R.L. (1983). Study on the stomachs in three species of snub-nosed monkeys. *Zoological Research*. 4, 167- 175.

Ratajszczak, R., Cox, R., & Ha, D.D. (1990). *A preliminary survey of primates in north Vietnam*. Unpublished report.

Ratajszczak, R., Dang, N. C., & Pham, N. (1992). *A survey for Tonkin snub-nosed monkey (Rhinopithecus avunculus) in North Vietnam*. Gland: World Wildlife Fund for Nature.

Wright, B.W., Le.K.Q., & Covert, H.H.(2006, June). The dietary ecology of the Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) at Du Gia Nature Reserve, Ha Giang Province, Vietnam. Paper presented at the Meeting of International Primatological Society, Entebe, Uganda.

APPENDIX

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Actinidiaceae					
	Saurauja tristylla DC	13	2.12	4582.83	1.21
Anacardiaceae					
	Allospondias lakonensis Pierre	1	0.16	795.77	0.21
	Drimycarpus racemosus Hook	8	1.31	2434.25	0.65
	Mangifera longipes Griff.	1	0.16	82.51	0.02
	Toxicodendron succedaneum (L.) Moladenke	1	0.16	240.72	0.06
Annonaceae					
	Annona sp1	1	0.16	55.46	0.01
	Miliusa filipes Merr	17	2.78	11863.55	3.14
	Polyalthia cerasoides Benth et Hook	1	0.16	233.77	0.06
	Polyalthia sp1	1	0.16	62.39	0.02
Apocynaceae					
	Kitabalia macrophylla (Pierre)Woodson	22	3.59	2786.07	0.74
	Kitabalia microphylla (Pitard)Woodson	3	0.49	194.61	0.05
Aquifoliaceae					
	Ilex crenata Thumb.	2	0.33	97.47	0.03
	Ilex cinerea Champ	1	0.16	225.22	0.06
Araliaceae					
	Heteropanax fragrans Hem	1	0.16	88.77	0.02
	Schefflera heptaphylla (L.) Fordin	2	0.33	239.00	0.06
	Trevesia palmata (Roxb) Vig	6	0.98	1370.23	0.36

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Asteraceae					
	Vernonia arborea Buch - Ham	1	0.16	524.69	0.14
Bigoniaceae					
	Fernandoa brilletti Steenis	1	0.16	104.86	0.03
	Rhadermachera boniana P.Dop.	1	0.16	63.73	0.02
Burseraceae					
	Canarium album (Lour) Raeusch	1	0.16	43.57	0.01
Caesalpiniaceae					
	Saraca dives Pierre	3	0.49	248.72	0.07
Clusiaceae					
	Garcinia bonii Pitard	5	0.82	590.72	0.16
	Garcinia cowa Roxb	1	0.16	29.34	0.01
	Garcinia fagraeoides A.Chev	6	0.98	2025.54	0.54
	Garcinia gracilis Pitard	2	0.33	195.93	0.05
	Garcinia obolongifolia Benth et Champ	3	0.49	1043.76	0.28
Daphniphyllaceae					
	Daphniphyllum calicinum Benth	2	0.33	186.13	0.05
Dilleniaceae					
	Dillenia indica L	1	0.16	761.14	0.20
Ebenaceae					
	Diospyros choboensis Lec.	2	0.33	147.01	0.04
	Diospyros eryantha Champ	2	0.33	312.68	0.08
	Diospyros pillosella Wall	1	0.16	66.46	0.02
	Diospyros pilosula (A.DC.) Hiern.	1	0.16	44.32	0.01

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Diospyros susarticulata Lec.	35	5.72	32249.79	8.55
Elaeocarpaceae					
	Elaeocarpus balansae D.C	2	0.33	990.81	0.26
	Elaeocrpus griffithii (Wight) A Gray	2	0.33	725.23	0.19
	Elaeocrpus hainanensis Oliv	1	0.16	35.09	0.01
Euphorbiaceae					
	Antidesma delicatulum Hutchinson	2	0.33	969.93	0.26
	Antidesma fordii Hemsl.	1	0.16	35.09	0.01
	Antidesma montanum Blume	4	0.65	958.83	0.25
	Antidesma tonkinensis Gagnep	5	0.82	848.71	0.22
	Aprosa mycrocalyx Hassk	2	0.33	1827.76	0.48
	Baccaurea sapida Muell-Arg	1	0.16	74.51	0.02
	Bischofia javanica Bl	3	0.49	10655.99	2.82
	Bridelia monoica (Lour) Merr	2	0.33	421.93	0.11
	Bridelia multiflora Hook	3	0.49	2181.34	0.58
	Bridelia polanei Gagnep.	1	0.16	264.02	0.07
	Chaetocarpus castanocarpus Thw.	5	0.82	2272.98	0.60
	Cleistanthus myrianthus Kurz	1	0.16	382.17	0.10
	Croton sp	1	0.16	260.36	0.07
	Croton tiglium L	2	0.33	145.89	0.04
	Croton yunnanesis W.	1	0.16	64.64	0.02
	Deutzianthus tonkinensis Gagnep	1	0.16	61.50	0.02
	Glochidion venutinum Wight	2	0.33	238.85	0.06
	Mallotus japonicus Muell.Arg	1	0.16	194.98	0.05

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Mercuralis leiocarpa Siebold et Zucc	3	0.49	379.82	0.10
	Vernicia montana Lour	1	0.16	1180.55	0.31
Fabaceae					
	Ormosia balansae Drake	1	0.16	359.36	0.10
	Ormosia pinnata (Lour) Merr	1	0.16	157.58	0.04
	Castanopsis fobri Hance	2	0.33	1572.71	0.42
	Lithocarpus henryi	3	0.49	1188.93	0.32
Flacoutiaceae					
	Flacourtia ratmonchii L Herit	2	0.33	616.44	0.16
Icacinaceae					
	Gomphandra mollis Merr	2	0.33	74.26	0.02
Iteaceae					
	Itea chinensis Hook.et Arn	1	0.16	82.51	0.02
Juglandaceae					
	Cayra tonkinesis Lec	2	0.33	519.95	0.14
	Engelhardia chrysolepis Hance	1	0.16	68.32	0.02
	Engelhardtia roxburghiana Lindl er Wall.	1	0.16	30.88	0.01
Kygelariaceae					
	Hydnocarpus hainanensis (Merr) Sleum	15	2.45	4550.05	1.21
Lauraceae					
	Beilchmiedia percoriaceae Allen.	3	0.49	4608.62	1.22
	Beilschmiedia balasae H.Lec	4	0.65	906.39	0.24
	Beilschmiedia laevis Allen	1	0.16	58.01	0.02
	Carydaphnosis tonkinensis (H.Lec.) Airy-Shaw	4	0.65	3877.55	1.03

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Cinnamomum bejolghota (Buch-Ham) Sweet	1	0.16	319.87	0.08
	Cinnamomum iners Reinw	1	0.16	499.16	0.13
	Cryptocarya imppreses Mig	1	0.16	35.09	0.01
	Cryptocarya lenticellata H.Lec	5	0.82	669.51	0.18
	Cryptocarya maclurei Merr	3	0.49	785.75	0.21
	Litsea aff glutinosa (Lour) C.B Roxb	1	0.16	83.02	0.02
	Litsea balansae H.Lec	7	1.14	1219.08	0.32
	Litsea baviensis H.Lec	1	0.16	41.73	0.01
	Litsea rotundiflora Hemsl.	3	0.49	916.32	0.24
	Litsea umbellata (Lour.) Merr.	2	0.33	75.38	0.02
	Litsea verticillata Hallee	3	0.49	11721.27	3.11
	Machilus grandifolia S.K.Lee et F.N.Wei.	4	0.65	7086.26	1.88
	Neolitsea aurata (Hayata) Koidz.	5	0.82	5368.45	1.42
	Neolitsea ellipsoides Allen	1	0.16	852.45	0.23
	Neolitsea umbelliflora Bl	1	0.16	198.94	0.05
	Nothaphoebe baviensis H.Lec	2	0.33	343.11	0.09
	Nothaphoebe umbelliflora Bl	2	0.33	143.72	0.04
	Phoebe cuneata B.	8	1.31	2621.52	0.69
	Phoebe pallida Ness	4	0.65	992.77	0.26
	Phoebe petelotii Kosterm.	2	0.33	507.82	0.13
Linnaceae					
	Ixonanthes chinensis Champ	1	0.16	29.95	0.01

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Magnoliaceae					
	Magnolia aff. coco (Lour.) DC	3	0.49	877.85	0.23
	Michelia balansae (A.DC) Dandy	1	0.16	241.60	0.06
Meliaceae					
	Aglaia gigantea (Pierre) Pellegr.	2	0.33	9342.16	2.48
	Aglaia globosus Piere	1	0.16	875.67	0.23
	Aphanamixis polystachya (Wall.) R. N. Parker	1	0.16	68.32	0.02
Mimosaceae					
	Archidendron balansae (Oliv) I. Niels	3	0.49	532.31	0.14
Moraceae					
	Antiaris toxicaria Leschen	3	0.49	444.05	0.12
	Artocarpus masticata Gagnep	2	0.33	266.55	0.07
	Artocarpus styracifolius Pierre	1	0.16	3215.00	0.85
	Artocarrpus tonkinensis A.Chev	1	0.16	175.79	0.05
	Ficus glaberrima Blume	1	0.16	164.02	0.04
	Ficus harmandii Gagnep.	24	3.92	11490.51	3.05
	Ficus lacor Hamilt	4	0.65	2817.35	0.75
	Streblus macrophyllus Bl	121	19.77	20734.49	5.49
	Taxotrophis ilicifolia Vidal	1	0.16	105.44	0.03
Myristicaceae					
	Knema conferta Warbg	5	0.82	1446.44	0.38
Myrsinaceae					
	Ardisia tsangii Walk.	10	1.63	2108.84	0.56

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Myrtaceae					
	Syzygium chanlos Gagnep.	2	0.33	568.14	0.15
	Syzygium jambos var. sþvaticum (Gagnep.) Merr. & Perry	6	0.98	754.44	0.20
	Syzygium zeylanicum (L.) DC.	10	1.63	3514.23	0.93
Oleaceae					
	Osmanthus pedulculatus Gagnep	4	0.65	896.40	0.24
Podocarpaceae					
	Dacycarpus imbrricatus (Bl.) De Laub	1	0.16	3091.45	0.82
Proteaceae					
	Helicia grandifolia Lecomte	1	0.16	94.72	0.03
Rosaceae					
	Photinia benthamiana Hance	1	0.16	30.26	0.01
	Pygeum arboreum Endl	3	0.49	2946.42	0.78
Rubiaceae					
	Aidia oxyodonta Drake	1	0.16	2621.45	0.69
	Canthium didinum var rostata Thw	2	0.33	131.56	0.03
	Canthium parvifolium Roxb	5	0.82	1256.95	0.33
	Mussaenda pubescens Ait.f	1	0.16	63.28	0.02
	Pavetta graciliflora Wall	5	0.82	800.37	0.21
	Pavetta tonkinensis Brem.	3	0.49	791.49	0.21
	Psychotria reevesii Wall	3	0.49	3365.29	0.89
	Randia acuminatissima Hance.	1	0.16	12328.19	3.27
	Randia pycnantha Drake	2	0.33	250.43	0.07

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Randia spinosa (Thb) Poir	1	0.16	34.43	0.01
Rutaceae					
	Evodia bodinieri Dode	2	0.33	1037.09	0.27
Sapindaceae					
	Euphoria frugifera Gagnep	1	0.16	3399.93	0.90
	Michocarpus sundaicus Blume	2	0.33	148.96	0.04
	Nephelium chryseum Blume	1	0.16	141.71	0.04
	Xerospermum tonkinensis Radlk	1	0.16	48.94	0.01
Sarcospermaceae					
	Sinosideroxylon wightianum (Hook. et Arn.) Aubr.	4	0.65	9911.63	2.63
Simarubaceae					
	Ailanthus altissima Swingl	4	0.65	23085.84	6.12
Stalhyllaceae					
	Turpinia nepalensis Wall	5	0.82	662.39	0.18
Staphyleaceae					
	Turpinia indochinensis Merr.	1	0.16	100.85	0.03
Sterculiaceae					
	Reevesia thyrsoidea Lindl	2	0.33	867.15	0.23
	Sterculia lanceolata Cav	14	2.29	1123.18	0.30
Styracaceae					
	Alniphyllum fortunei (Hemsl) Makino	3	0.49	2271.68	0.60

Appendix I: Tree species and their proportions in the botanical plots at Tat Ke Sector (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Theaceae					
	Adinandra glischroloma Hand -Mazz var hirta (Gagnep.) Kob	1	0.16	137.71	0.04
	Adinandrra integerrima T. And. Ex Dye	2	0.33	174.80	0.05
	Eurya ciliata Merr.	4	0.65	1896.96	0.50
	Gordonia axillaris (D.Don) Dietr	1	0.16	200.54	0.05
Tiliaceae					
	Excentrodendron tonkinensis (Gagnep.) Chang & Miau	6	0.98	96882.89	25.68
Ulmaceae					
	Celtis philippinensis Blanc	3	0.49	406.32	0.11
	Celtis sinensis Person	4	0.65	287.78	0.08
	Ulmus sp	5	0.82	1335.61	0.35
	Ulmus tonkinensis Gagnep	1	0.16	291.27	0.08
Urticaceae					
	Pouzolzia sanguinea (Blume) Merr	8	1.31	904.15	0.24
Verbenaceae					
	Vitex quinata F.N. Will	1	0.16	945.46	0.25
Xanthophyllaceae					
	Xanthophyllum eberhardii Gagnep	3	0.49	289.21	0.08

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Aceraceae					
	Acer chapaense Gagnep	2	0.39	184.81	0.09
	Acer oliverianum Pax. In Hook.	5	0.98	1376.43	0.68
Actinidiaceae					
	Saurauja tristylla DC	7	1.37	2007.16	1.00
Altingiaceae					
	Altingia chinensis (Benth.) Oliv ex Hance(R)	1	0.20	221.85	0.11
Annonaceae					
	Alphonsea tonkinensis D.C	3	0.59	473.04	0.23
	Miliusa filipes Merr	2	0.39	2012.35	1.00
	Polyalthia laui Merr.	11	2.15	914.11	0.45
Apocynaceae					
	Kitabalia macrophylla (Pierre)Woodson	2	0.39	677.49	0.34
	Alstonia scholaris R.Br.	1	0.20	122.28	0.06
Araliaceae					
	Schefflera delavayi (Fr.) Harms var. pubinervis Grushv. & Skorts.	3	0.59	106.78	0.05
	Schefflera obovotifoliolata C.B Schang	1	0.20	28.73	0.01
	Trevesia palmata (Roxb) Vig	3	0.59	1063.48	0.53
Bigoniaceae					
	Markhamia stipullata Seem	2	0.39	1176.24	0.58
Burseraceae					
	Canarium parvum Leenh+	1	0.20	43.95	0.02
Clusiaceae					
	Calophyllum membranaceum Gardn.& Champ.	1	0.20	50.94	0.03

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Garcinia fagraeoides A.Chev	8	1.56	1586.47	0.79
	Garcinia gracilis Pitard.	1	0.20	84.57	0.04
Dilleniaceae					
	Dillenia turbinata Finet rt Gagnep.	2	0.39	200.40	0.10
Dipterocarpaceae					
	Hopea chinensis (Merr.) Hand-Mazz.	1	0.20	1217.67	0.60
Ebenaceae					
	Diospyros choboensis Lec.	2	0.39	463.53	0.23
	Diospyros pilosula (A.DC.) Hiern.	7	1.37	4823.55	2.39
Elaeocarpaceae					
	Elaeocarpus petiolatus (Jack.) Wall.	3	0.59	485.83	0.24
Euphorbiaceae					
	Antidesma delicatulum Hutchinson	4	0.78	504.83	0.25
	Antidesma fordii Hemsl.	2	0.39	186.81	0.09
	Antidesma montanum Blume	1	0.20	100.85	0.05
	Aprosa mycrocalyx Hassk	1	0.20	34.76	0.02
	Aprosa sp	1	0.20	15546.54	7.71
	Bischofia javanica Bl	2	0.39	116.66	0.06
	Chaetocarpus castanocarpus Thw.	1	0.20	557.49	0.28
	Cleistanthus myrianthus Kurz	1	0.20	75.98	0.04
	Mallotus japonicus Muell.Arg	1	0.20	47.38	0.02
	Sapium discolor (Champ) Muell-Arg.	2	0.39	186.51	0.09
Fabaceae					
	Lithocarpus sp	1	0.20	137.71	0.07

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Lithocarpus vesticatus A.Camus	3	0.59	2139.43	1.06
	Ormosia pinnata (Lour) Merr	5	0.98	288.64	0.14
	Quercus acutissima Caruth.	2	0.39	1418.43	0.70
	Quercus chrysocalyx Hickel et A.Camus	18	3.52	10000.91	4.96
	Quercus variabilis Blume	7	1.37	5114.77	2.54
Fagaceae					
	Castanopsis fabri Hance	2	0.39	67.46	0.03
Hamamelidaceae					
	Mytilaria laosensis Lec	43	8.40	5732.25	2.84
Icacinaceae					
	Gomphandra mollis Merr	3	0.59	300.92	0.15
	Stemonurus sp	2	0.39	629.24	0.31
Illiciaceae					
	IIIicium petelotii A.C Sm	1	0.20	34.43	0.02
Juglandaceae					
	Engelhardtia chrysolepis Hance	3	0.59	507.18	0.25
	Platycarya strobilifera Sieb. et Zucc.	3	0.59	1205.43	0.60
Kygelariaceae					
	Hydnocarpus hainanensis (Merr) Sleum	2	0.39	1625.95	0.81
Lauraceae					
	Actinodaphne sinensis Benth.	1	0.20	1108.03	0.55
	Beilchmiedia percoriaceae Allen.	1	0.20	33.12	0.02
	Beilschmiedia balasae H.Lec	3	0.59	2542.24	1.26
	Beilschmiedia laevis Allen	1	0.20	64.64	0.03
	Cinnamomum parthenoxylon (Jack) Meinsl.	1	0.20	97.48	0.05
	Cryptocarya chinensis (Hance.) Hemsl.	10	1.95	8234.25	4.08
	Cryptocarya sp	1	0.20	282.67	0.14
	Crytocarya impreses Mig	1	0.20	150.58	0.07
	Lindera communis Hemsl.	4	0.78	1384.96	0.69

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Lindera polyaltha Boerl.	3	0.59	478.10	0.24
	Litsea aff glutinosa (Lour) C.B Roxb.	1	0.20	74.03	0.04
	Litsea balansae H.Lec	3	0.59	1454.24	0.72
	Litsea rotundiflora Hemsl.	2	0.39	926.61	0.46
	Machilus bonii H. Lec.	33	6.45	24736.36	12.27
	Machilus grandifolia S.K.Lee et F.N.Wei.	1	0.20	145.09	0.07
	Machilus sp	5	0.98	1610.29	0.80
	Machilus velutina Champ	2	0.39	121.52	0.06
	Neolitsea ellipsoides Allen	6	1.17	14888.71	7.38
	Nothaphoebe baviensis H.Lec	4	0.78	721.02	0.36
	Nothaphoebe umbelliflora Bl	2	0.39	227.61	0.11
	Phoebe pallida Ness	1	0.20	229.48	0.11
	Phoebe sp	1	0.20	61.50	0.03
Magnoliaceae					
	Manglietia dandyi (gagnep.) Dand.	2	0.39	1122.75	0.56
	Manglietia insignis (Wall.) Blume	1	0.20	166.92	0.08
	Michelia faveolata Merrill	1	0.20	86.66	0.04
Melastomaceae					
	Allomorphia arborescens Guillaumin	17	3.32	1793.48	0.89
	Memecylon ligustrium Champ. et Benth.& Hook.	5	0.98	235.10	0.12
Meliaceae					
	Aglaia globosus Pierre	5	0.98	1753.08	0.87
	Amoora gigantea Pierre	4	0.78	6840.26	3.39
	Chisocheton sp	1	0.20	839.32	0.42
	Chisocheton thorelii Pierre	2	0.39	346.02	0.17
Mimosaceae					
	Archidendron balansae (Oliv) I. Niels	2	0.39	824.21	0.41
Moraceae					

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
	Ficus altissima Blume	2	0.39	127.87	0.06
	Ficus harmandii Gagnep.	2	0.39	619.35	0.31
	Ficus hirta Vahd	2	0.39	99.07	0.05
	Ficus hispida L.f	4	0.78	411.23	0.20
	Ficus variegata Bl	1	0.20	82.00	0.04
	Morus sp	1	0.20	58.87	0.03
Myricaceae					
	Myrica sapida Wall. var. chevalieri Dode	5	0.98	1503.95	0.75
Myristicaceae					
	Horsfieldia amygdalina Warbg	1	0.20	45.84	0.02
Myrsinaceae	*Ardisia arborescens Wall. ex A. DC.*	2	0.39	78.95	0.04
	Ardisia tsangii Walk.	1	0.20	133.12	0.07
	Rapanea neriifolia (Siebold & Zucc.) Mezz.	4	0.78	522.85	0.26
Myrtaceae					
	Syzygium brachyatum Miq.	2	0.39	759.08	0.38
	Syzygium cuminii (L.) Skeels	8	1.56	1627.63	0.81
	Syzygium jambos var. sþvaticum (Gagnep.) Merr. & Perry	2	0.39	173.75	0.09
	Syzygium sp	1	0.20	31.20	0.02
	Syzygium wightianum Wight	1	0.20	30.88	0.02
	Syzygium zeylanicum (L.) DC.	7	1.37	3778.70	1.87
Oleaceae					
	Fraxinus chinensis Roxb	3	0.59	2022.32	1.00
	Osmanthus pedulculatus Gagnep	17	3.32	3626.66	1.80
Podocarpaceae					
	Nageia fleuryi (hickel) de Laub.	4	0.78	1034.90	0.51
Rhizophoraceae					
	Carallia lancaefolia Roxb	1	0.20	48.55	0.02

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Rosaceae					
	Photinia beauverdiana Schneid	1	0.20	214.35	0.11
	Rhaphiolepis indica (Lindl) ex ker	3	0.59	454.80	0.23
Rubiaceae					
	Adina globiflora Salisb var tonkinensis Pitard.	1	0.20	772.08	0.38
	Canthium didinum var rostata Thw	6	1.17	608.36	0.30
	Gardenia sootepesis Hutch.	14	2.73	3003.08	1.49
	Mussaenda pubescens Ait.f	1	0.20	1151.65	0.57
	Pavetta tonkinensis Brem.	3	0.59	181.29	0.09
	Psychotria reevesii Wall	1	0.20	52.97	0.03
	Randia pycnantha Drake	3	0.59	1016.46	0.50
	Wendlandia paniculata DC.	6	1.17	921.11	0.46
Rutaceae					
	Atalantia roxburghiana Hook.f.	3	0.59	362.09	0.18
	Evodia bodinieri Dode	1	0.20	67.39	0.03
	Acronychia peduncunata (L.) Miq	1	0.20	138.38	0.07
	Micromelum falcatum Tanaka	1	0.20	32.15	0.02
Samydaceae					
	Casaeria balansae Gagnep.	1	0.20	32.79	0.02
Sapindaceae					
	Paranephelium chinense Merr.et.Chun	5	0.98	2048.43	1.02
	Dinocarpus fumatus spp indochinensis Leenh.	1	0.20	175.79	0.09
Sapotaceae					
	Eberhardtia tonkinensis H.Lec	1	0.20	581.73	0.29
Sarcospermaceae					
	Sinosideroxylon wightianum (Hook. et Arn.) Aubr.	6	1.17	3530.64	1.75

Appendix II: Tree species and their proportions in the botanical plots at Khau Ca Forest (continued)

Family	Latin name	No. of stems	% of stems	Basal area (cm^2)	% of total basal area of plots
Stalhyllaceae					
	Turpinia nepalensis Wall.	2	0.39	402.86	0.20
	Turpinia indochinensis Merr.	1	0.20	156.17	0.08
Sterculiaceae					
	Sterculia lanceolata Cav	1	0.20	122.28	0.06
	Sterculia nobilis Smith.	1	0.20	3344.24	1.66
	Reevesia thyrsoidea Lindl.	1	0.20	132.47	0.07
Styracaceae					
	Alniphyllum fortunei (Hemsl) Makino	11	2.15	881.49	0.44
Taxaceae					
	Amentotaxus yunnaensis H.L.Li	1	0.20	58.87	0.03
Theaceae					
	Camellia sasamqua Nakai	4	0.78	1945.11	0.96
	Gordonia axinaris (Roxb.) Dietz.	3	0.59	1312.56	0.65
	Gordonia tonkinensis Pit.	1	0.20	108.94	0.05
	Terstroemia gymnanthera (Wight.et Arn.) Sprague	4	0.78	928.34	0.46
Tiliaceae					
	Grewia hirsuta wahl.	1	0.20	1074.49	0.53
Ulmaceae					
	Celtis sinensis Person	10	1.95	8877.35	4.40
	Ulmus sp	1	0.20	623.27	0.31
Urticaceae					
	Pouzolzia sanguinea (Blume) Merr	22	4.30	2035.02	1.01
Verbenaceae					
	Callicarpa arborea Roxb	1	0.20	83.02	0.04
	Gmelina arborea Roxb	3	0.59	2929.23	1.45
	Premna aff. chevalieri P.Dop	7	1.37	5034.45	2.50

Appendix III List of mammals

Evidence:

1. Sighting
2. Tracks
3. Scat/Dung
4. Nests
5. Scrapes/Claw Marks
6. Feeding Signs
7. Vocalisation
8. Antler/horn marks
9. Reliable report

	Common name	**Scientific name**	**Sites/Evidences**
1.	Black giant squirrel	*Ratufa bicolor*	A(1,7)
2.	Red-bellied squirrel	*Callosciurus erythraeus*	A, B (1)
3.	Common Palm Civet	*Paradoxurus hermaphroditus*	A, B(1,9)
4.	Little Indian Civet	*Viverricula indica*	A(1,9)
5.	Large Indian civet	*Viverra zibetha*	A, B(9)
6.	Marked palm civet	*Paguma larvata*	A, B(9)
7.	Owston's palm civet	*Chrotogale owstoni*	A(9)
8.	Asiatic Brush - tailed porcupine	*Atherurus macrourus*	A(2,9)
9.	Malayan Porcupine	*Hystrix brachyura*	A(2,9)
10.	Noisy rats	*Leopodalmus sabanus*	A, B(2)
11.	Hoary bamboo rat	*Rhizomys pruinosus*	A(2)
12.	Large Bamboo rat	*Rhizomys sumatrensis*	A(2)
13.	Hog Badger	*Arctonyx collaris*	A (1)
14.	Wild pig	*Sus scrofa*	A, B(1,2)
15.	Barking deer	*Muntiacus muntjak*	A, B(1,2,3)
16.	Serow	*Capricornis sumatraensis*	A, B(1)
17.	Rhesus Macaque	*Macaca mulata*	A(9, 1), B(1)
18.	Stump-tailed Macaque	*Macaca arctoides*	A(9), B(1)
19.	Assamese Macaque	*Macaca assamensis*	A(9, 1), B (1)

A: Tat Ke Sector
B: Khau Ca Forest

Appendix IV List of Bird

Evidence**: 1:** Sighting; 2: Nests 3: Reliable report

	Common name	**Scientific name**	**Site/Evidence**
1.	Red Jungle fowl	*Gallus gallus*	A, B(1)
2.	Silver Pheasant	*Lophura nycthemera*	A(1)
3.	Grey Peacock-Pheasant	*Polyplectron bicalcaratum*	A(1)
4.	Thick-billed Pigeon	*Treron curvirostra*	A(1)
5.	Green-billed Malkoha	*Phaenico phaeustristic*	A(1)
6.	Greater Coucal	*Centropus sinensis*	A(1)
7.	Indian Cuckoo	*Cuculus micropterus*	A(1)
8.	Green-eared Barbet	*Megalaima faiostricta*	A(1)
9.	Great Barbet	*Megalaima virens*	A(1)
10.	Golden-throated barbet	*Megalaima franklinii*	A (1)
11.	Red-headed Drongo	*Harpactes erythrocephalus*	A, B (1)
12.	Greater Yellownape	*Picus flavinucha*	A, B(1)
13.	Bay Wood pecker	*Blythipicus pyrrhotis*	A, B(1)
14.	Long-tailed Broadbill	*Psarisomus dalhousiae*	A(1)
15.	Yellow Wagtail	*Motacilla flava*	A(1)
16.	Scarlet Minivet	*Pericrocotus flameus*	A(1)
17.	Red-wiskered Bulbul	*Pycnonotus jocosus*	A(1)
18.	Chestnut Bulbul	*Hamixos castanonotus*	A(1)
19.	Sooty-headed Bulbul	*Pycnonotus aurigaster*	A(1)
20.	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	A(1)
21.	Black Drongo	*Dicrurus macrocercus*	A(1)
22.	Sultan Tit	*Melanochlora sultanea*	A, B(1)
23.	Limestone Wren-Babbler	*Napothera crispifrons*	A(1)
24.	Black-throated Laughingthrush	*Garrulax merulus*	A(1)
25.	Oriental Magpie Robin	*Copsychus saularis*	A(1)
26.	White-tailed Robin	*Cinclidium leucurum*	A(1)
27.	Blue Whistling Thrush	*Myiophoneus caeruleus*	A(1)
28.	Long-tailed Shrike	*Lanius schach*	A(1)
29.	Fork-tailed Sunbird	*Aethopyga christinae*	A(1)
30.	Mr. Gould's Sunbird	*Aethopyga gouldiae*	A(1)
31.	Common Stonechat	*Saxicola torquata*	A, B(1)
32.	Blue Whistling Thrush	*Myophonus caeusleus*	A(1)
33.	White-throated Fantail	*Rhipidura albicollis*	A(1)
34.	Grey-checked Fulvetta	*Alcippe mourinsonia*	1
35.	Yellow-checked Tit	*Paurus spilonotus*	A, B(1)

A: Tat Ke Sector

B: Khau Ca Forest