**Project title:**

# BEHAVIOURAL ECOLOGY AND CONSERVATION OF *Rhinopithecus avunculus* IN VIETNAM


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**Tonkin Snub-nosed Monkeys (*Rhinopithecus avunculus*) at Khau Ca**
**Photo: Dong Thanh Hai**

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## 1. Introduction

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. This is the first long-term study of its ecology and behaviour. The primary goal is to elucidate information on the species' social organization and behaviour, feeding ecology, and habitat and range use. The information gathered will result in conservation and management recommendations for the species and its habitats.

### 1.1. Taxonomy and distribution

#### *1.1.1. Colobines in Vietnam*

Viet Nam has been known harbour a great diversity of primates. To date, twenty-five species and subspecies have been recognized belonging to three families: Lorisidae (2 species), Cercopithecidae (17 species), and Hylobatidae (6 species) (Groves, 2004). There are eleven taxa in three genera of leaf monkeys in Vietnam, six of which are endemic to Vietnam: *Rhinopithecus avunculus*, *Trachypithecus* [cf. *poliocephalus*] *poliocephalus*, *Trachypithecus delacouri*, *Trachypithecus hatinhensis, Trachypithecus germaini caudalis*, and perhaps *T.margarita* (see Roos et al., 2005); *Trachypithecus ebenus* is found in Vietnam and Laos; *Pygathrix cinerea*, *Pygathrix nemaeus*, and *Pygathrix nigripes* are found in Laos, Vietnam and Cambodia; *Trachypithecus francoisi* in Vietnam and China; *Trachypithecus germaini germaini* in southern Vietnam, Thai Land, Cambodia and Burma (Groves, 2001: 265-287, Roos et al.2005).

The most obvious feature of the leaf monkeys in Vietnam is their limited distribution. *Trachypithecus poliocephalus*, for example, only occurs in the Cat Ba Island (Groves, 2001:272; Fooden, 1996:863). *Rhinopithecus avunculus* is restricted to northeast parts of

Vietnam on fragmented forest associated with limestone hills (Boonratana & Le, 1998a:207; Fooden, 1996:865; Groves, 2001:287; Pham, 2002:59; Ratajszczak et al., 1990:28). *Trachypithecus delacouri* is currently found at nineteen fragmented locations in three provinces: Ninh Binh, Thanh Hoa, Hoa Binh (Groves, 2001:273; Nadler et al., 2003:73; Pham, 2002:51).

Table 1.1. Classification of Vietnam Colobines

| Common name | Scientific name | Distribution |
|---|---|---|
| Indochinese Silvered Langur | *Trachypithecus germaini germaini* (Milne-Edwards, 1876) | Southern Vietnam, west of Mekong |
| | *Trachypithecus germaini caudalis* (Dao, 1977) | Northern Vietnam? |
| | *Trachypithecus margarita* | East of Mekong |
| Francois' langur | *Trachypithecus francoisi* (Pousargues, 1898) | |
| Hatinh langur | *Trachypithecus hatinhensis* (Dao, 1970) | Vietnam |
| White-headed Langur or Cat Ba langur | *Trachypithecus poliocephalus poliocephalus* (Trouessart, 1911) | Vietnam |
| Delacour's Langur | *Trachypithecus delacouri* (Osgood, 1932) | Vietnam |
| Indochinese Black Langur | *Trachypithecus ebenus* (Brandon-Jones, 1996) | Vietnam and Laos |
| Red-shanked Douc | *Pygathrix nemaeus* (Linnaeus, 1771) | Vietnam, Laos, and Cambodia |
| Black-shanked Douc | *Pygathrix nigripes* (Milne-Edwards, 1876) | Vietnam, Laos, and Cambodia |
| Grey-shanked Douc | *Pygathrix cinerea* (Nadler, 1997) | Vietnam |
| Tonkin Snub-nosed Langur | *Rhinopithecus avunculus* (Dollman, 1912) | North Vietnam |

Source: Groves (2001); Roos et al. 2005

### *1.1.2. Tonkin snub-nosed monkey Rhinothecus avunculus*

*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.

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).

## 1.2. Description

### *1.2.1. General discription*

The colobines or leaf-eating monkeys are different from cercopithecines in many aspects of their anatomy and morphology which greatly influence on their feeding strategies and social behaviour (Chivers & Hladik, 1980:338; Oates & Davies, 1994:1). The main distinguishing feature is that the colobines 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). Further, the colobines lack cheek pouches, whereas this feature is conspicuous in that of Cercopithecines (Groves, 1989:147; Oates & Davies, 1994:2). Last, the colobines have long legs, reduced or absent thumbs, and longer hindlimbs which are related to arboreality and leaping (Groves, 1989:147; Fleagle, 1988:180; 1999:207; Napier & Napier, 1985:; Strasser, 1992:207).

*1.2.2. Tonkin snub-nosed monkey Rhinopithecus avunculus*

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.

## 1.3. Population and conservation status of Rhinopithecus avunculus

### *1.3.1. 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.

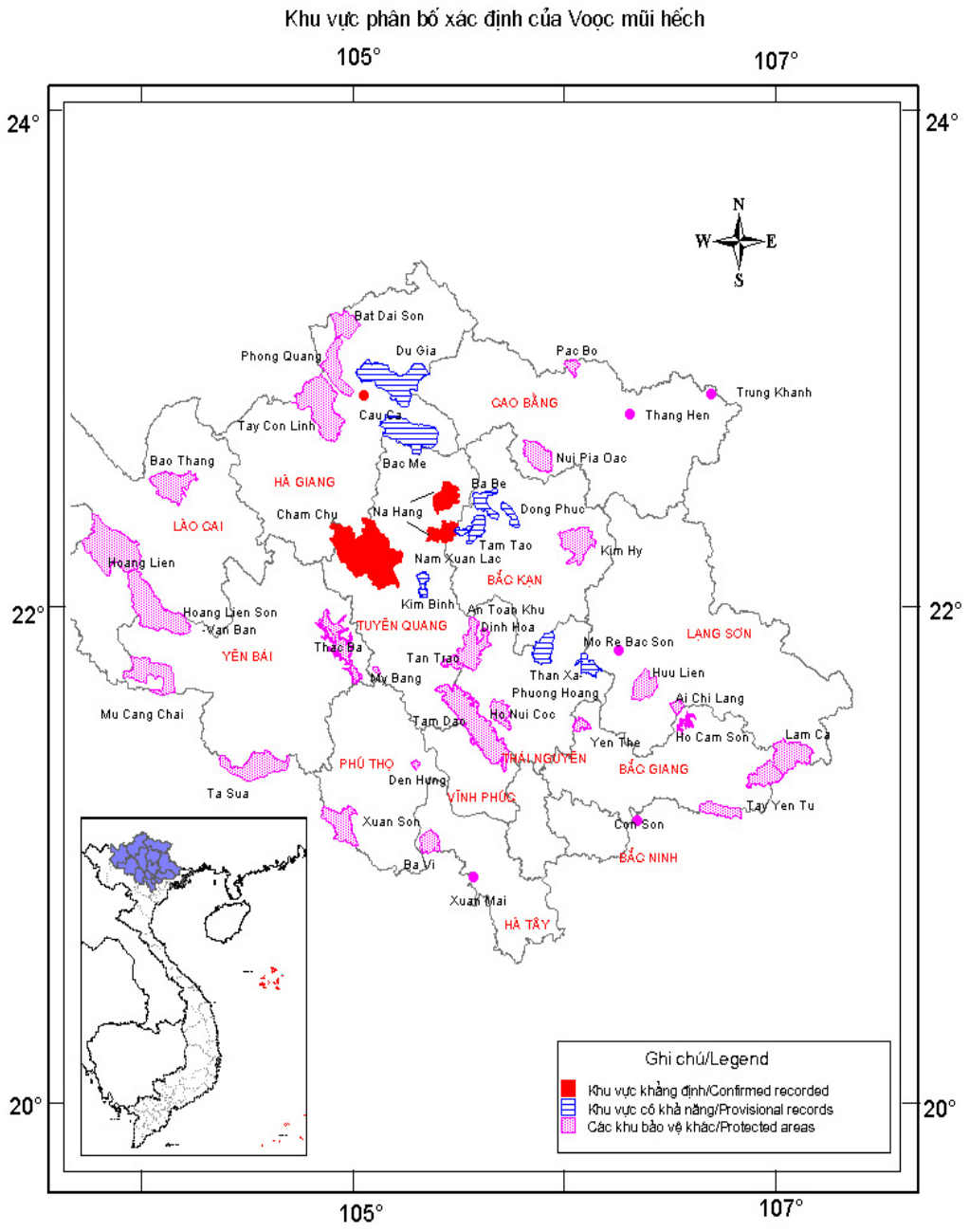
*1.3.2. Conservation status*

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).




Source: Le and Boonratana, 2006

Figure 1.1. Map of distribution of Tonkin snub-nosed monkey in Vietnam

*1.3.4. Threats*

Hunting and habitat destruction are major threats to the survival of *Rhinopithecus avunculus* in their range (Boonratana & Le, 1994:28-30; 1998b:318-319; Cao & Pham, 1995:187; Dong, et al., 2006:16-19; Le & Boonratana, 2006:14; Long & Le, 2001:11; Nadler et al., 2003:159).

## 1.4. Studies on ecology and behaviour of Tonkin snub-nosed monkey

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 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)

1.5. 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 describe the botany of the karst mountain forests in Tat Ke Sector, Na Hang Nature Reserve, and in Khau Ca Forest.
2. To monitor and compare the phenology of the study sites, and to assess seasonal changes in food availability.
3. To provide data on the population size of *R.avunculus* in Tat Ke Sector, Na Hang Nature Reserve and Khau Ca Forest.
4. To study the social organization and social behaviour of *R. avunculus* in relation to habitat and 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. Methods

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

### 2.1. Selection of site.

#### *2.1.1. 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.

#### *2.1.2. 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.

2.2. Data collection

**Interview**

Interviews with villagers and hunters were conducted to determine the most likely places for encountering the species. These interviews also provided information on the current and past distribution of the species in the study areas.

**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. At Tat Ke Sector base camp was located at Khau Tep area (0542716E/2482100N). At Khau Ca base camp were set up at Minh Son site (  )

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).

Botany

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.

Phenology

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.

**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 2.1. 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. |

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

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.

**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. Study area

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.

### 3.1. Tat Ke Sector

#### *3.1.1. 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 3.1).

### *3.1.2. Topography*

The terrain of Tat Ke Sector was characterised 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).

### *3.1.3. 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 $32.5^0$C and $11.1^0$C were recorded in October 2004 and in March 2005, respectively. Mean temperature was $14.9^0$C. 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 $18.8^0$C and $35.4^0$C. Mean temperature was $30.4^0$C. 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.

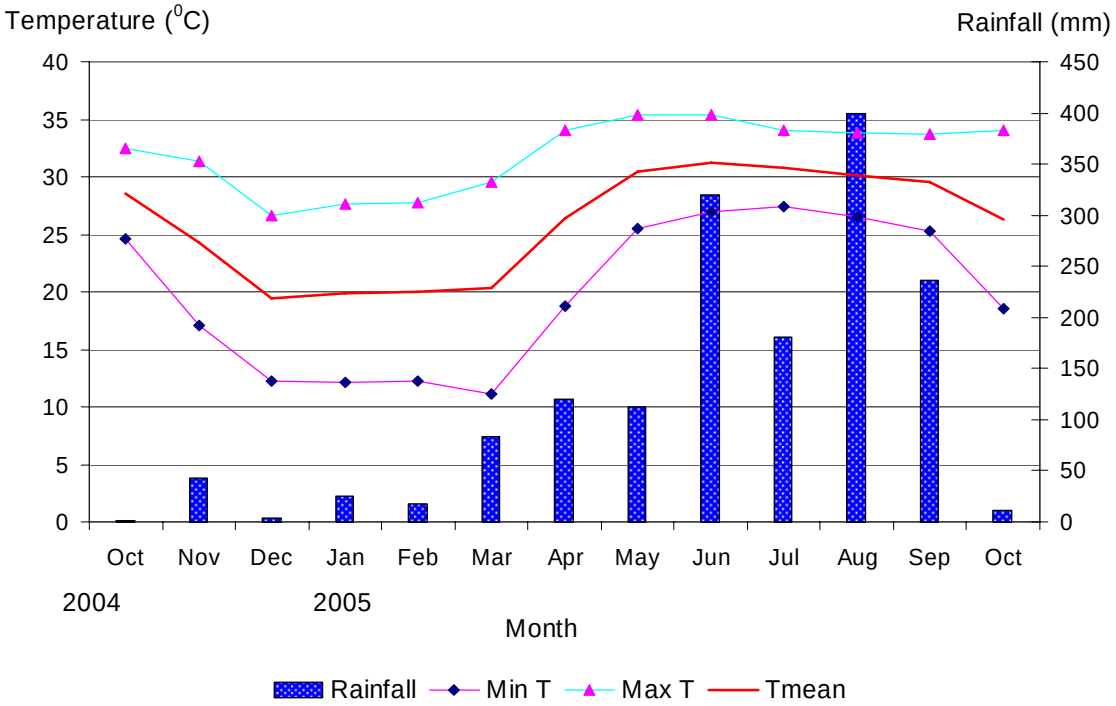
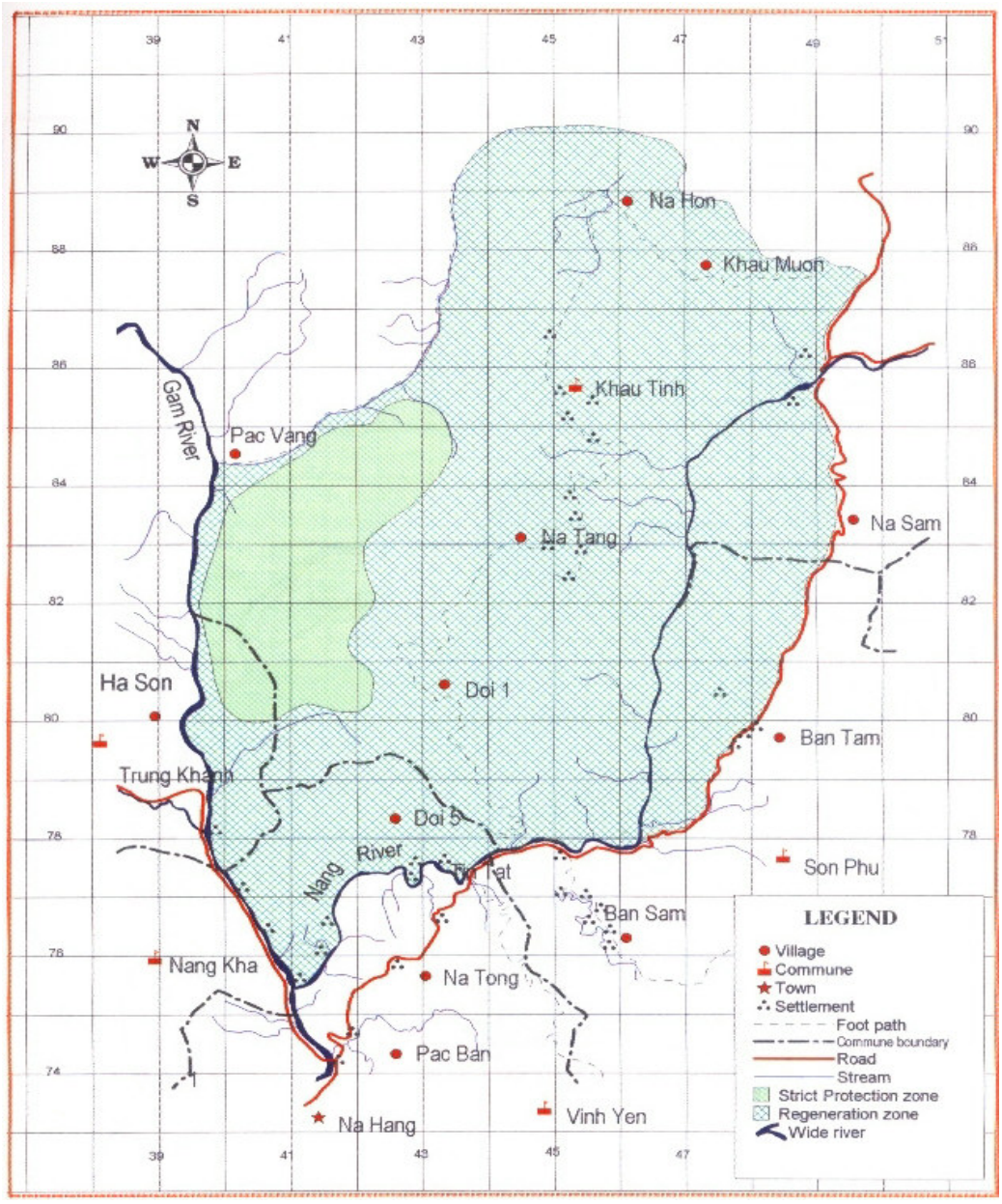



Figure 3.1. Mean monthly maximum and minimum temperatures, and mean monthly rainfall recorded at Tuyen Quang for 2004-2005.

Figure 3.2. Map of Tat Ke Sector



## 3.2. Khau Ca Forest

### 3.2.1. 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. 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).

### *3.2.2. 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.

*3.2.3. 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 3.5). The mean temperature ranged between $19.4^0$C and $31.2^0$C. The mean minimum temperature was lowest ($12.2^0$C) in January 2006 and the mean maximum temperature was highest ($35.6^0$C) in July 2006. The mean temperature during cold and dry period (from October 2005 to April 2006) was $22.9^0$C and the mean temperature during hot and wet season (from May 2006 to September 2006) was $29.7^0$C.

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.

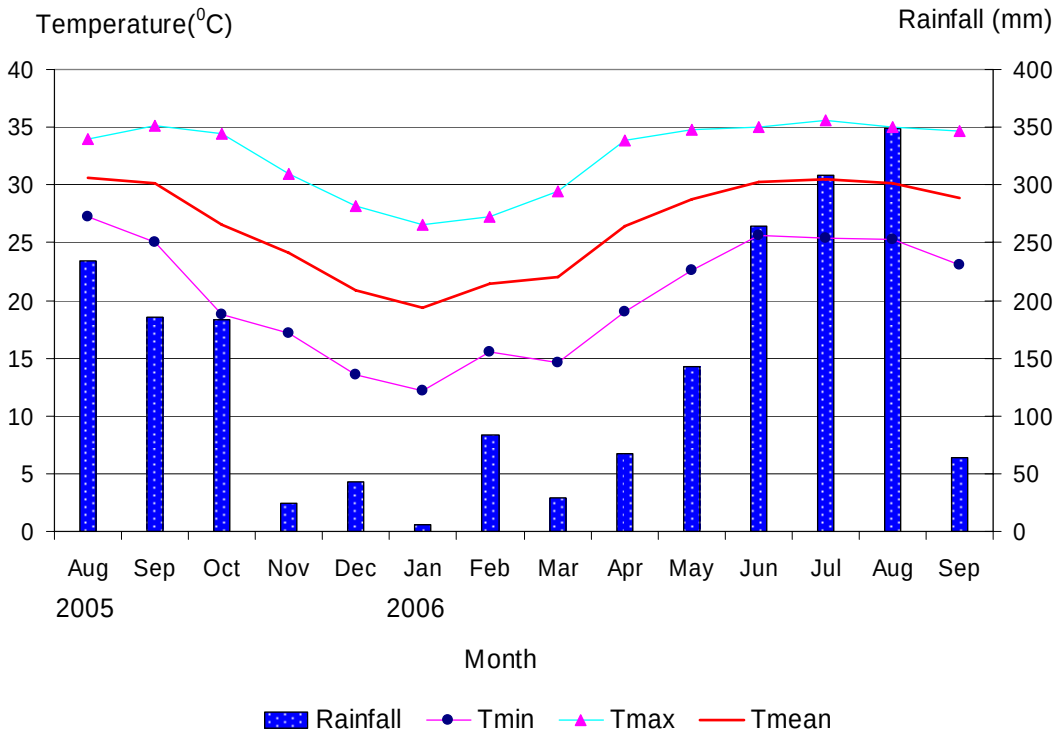



Figure 3.3. Mean monthly maximum and minimum temperatures, and mean monthly rainfall recorded at Ha Giang for 2005-2006.

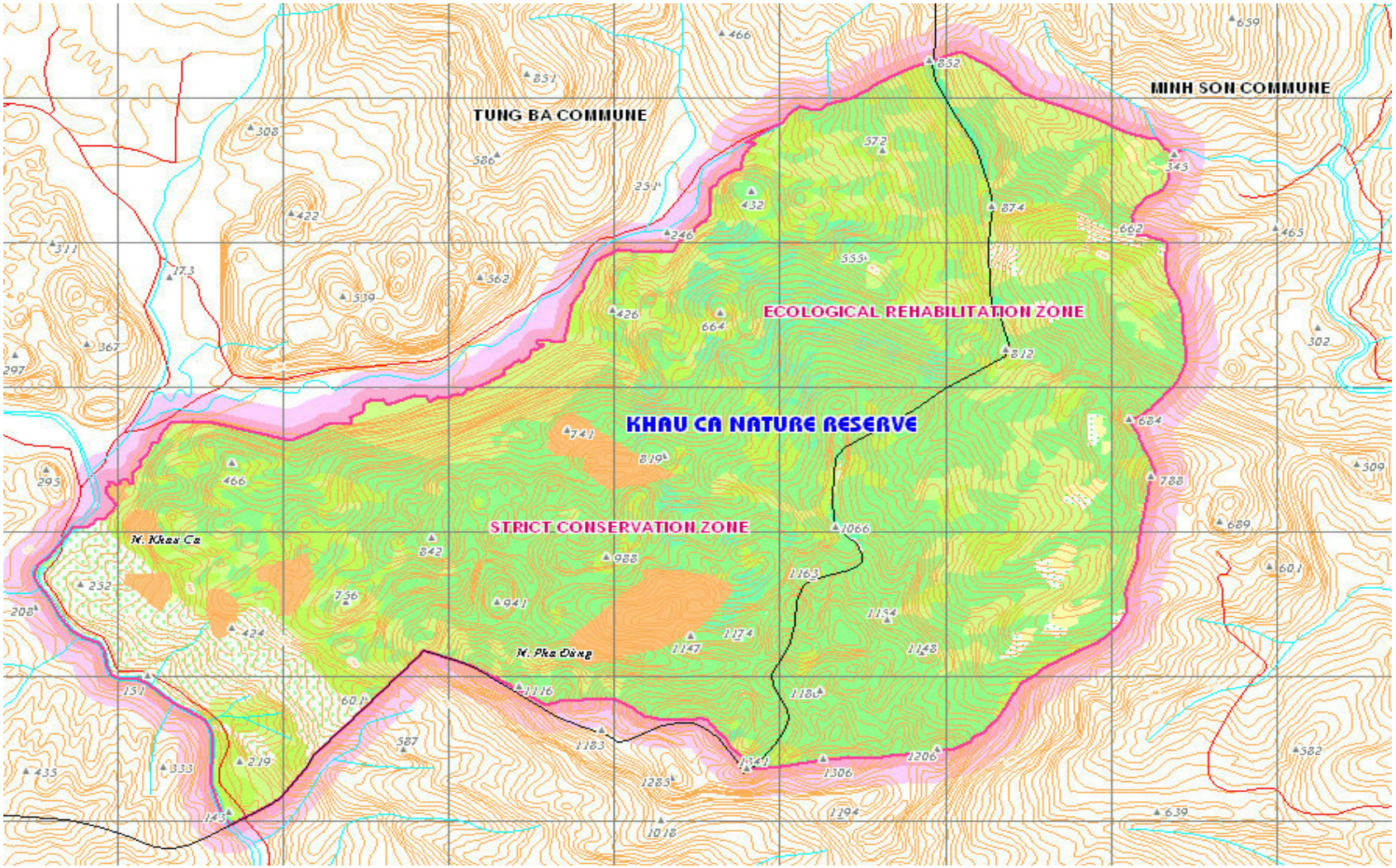



**Figure 3.4. The topography map of Khau Ca Forest**

## 4. Results

A total of 200 contact hours was made over the course of the main study, including 1731 observations. Although our research team has faced some difficulties in studying the behaviour and ecology of the Tonkin Snub-nosed monkeys, our efforts have not been wasted and we have made considerable progress in widening our knowledge about the behaviour and ecology of *R. avunculus*. A total of 200 contact hours was made over the course of the main study, including 1731 observations. Some preliminary results of our research are discussed below.

### 4.1. Tonkin snub-nosed monkey population status

The highest count of a single band at Tat Ke Sector was 17 individuals and the number estimated was 22 individuals. The counts of individual groups were in the range of 5-7 individuals. Therefore, current population density estimated was 0.18 indiviudals/$km^2$. At Khau Ca Forest, the largest number of *R. avunculus* observed during a single count was 81 individuals and the number estimated was 90 individuals. Therefore, the population density estimated was 9 individuals/$km^2$.

### 4.2. Social Organization

The basic social unit of *R. avunculus* at both Tat Ke Sector and Khau Ca Forest was a one-male unit, comprising one adult male, a number of adult females and their offspring. Extra males apparently formed loosely-bonded all-male units. Different units frequently come together to sleep, travel and feed, and exhibited a secondary level of social organization – the band, with fission-fusion of stable one-male units within bands. These observations supported Boonratana and Le 1993's study, but dismissed Ratajsczak, 1992 and Le Khac Quyet 2006's observations that basic social unit of *R. avunculus* is multimale and multifemale.

At Tat Ke Sector, there were two one-male units and one all male unit at Tat Ke Sector. The average size of one-male unit at was 5.6 (range 5-7, n=5). At Khau Ca Forest, five one-male units were recorded and the average size was 12.1 (table 5.2). On one occasion, a group of five individuals of all-male unit was observed at Tat Ke Sector, including two sub adult males and three juveniles. A group of three juvenile males was also observed at Khau Ca Forest during feeding time.

At Tat Ke Sector, band size of *R. avunculus* was 17 individuals, while band size of *R. avunculus* was observed to range from 22 to 81 individuals.

## 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 (33.04%); The next was traveling (19.21%); Vigilance and feeding made up almost equal amount of time in the total activity (14.83% and 14.78%, respectively). Grooming occupied (4.34%) and adult males, females and juveniles were observed to involve in this behaviour. Playing contributed (3.19%) to the total activity time and only infants and juveniles were observed to play. Agonistic interactions made up only (0.67%) and other activities were 9.97% (Figure 5.1).

## 4.4. Rest- huddling

Huddling behavior was the first time recorded in *R. avunculus* at Khau Ca Forest. On five occasions rest huddling were observed, all of which were recorded during the winter and early part of spring.

### 4.5. Infant caring

Juveniles carrying infants were observed on two occasions. The adult females were observed to hand over the infants to juveniles, and the juveniles carried the infants for about 10 meters before the adult females took the infants back again.

### 4.6. Terrestriality

*R. avunculus* was observed traveling, resting and feeding on the ground on seven occasions at Khau Ca Forest. All age/sex categories were observed to exhibit this behavior.

### 4.7. 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.

## 4.8. 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.

## 4.9. Locomotion

*R. avunculus* exhibited six types of locomotion, including climbing, quadrupedal walking, semi-brachiation, hanging, bipedal movement, leaping or jumping. 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.

## 4.10. 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.

4.11. Feeding ecology

*R.avuculus* was observed to feed on young and mature leaves, follower and flower buds, ripe and unripe fruits, petiole of young and mature leaves, seeds of ripe and unripe fruits. At 42.37%, young leaves apparently make up the bulk of its diet. Within young leaves, the monkeys were observed to consume the upper parts of young leaves more than 4 times that of petiole and the lower parts of young leaves. In addition to young leaves, the monkeys consumed flowers at 13.56%, young stems at 10.17%, and unripe fruits at 6.78%. The monkeys consumed an equal amount of flower buds, upper parts of mature leaves, petiole and lower parts of mature leaves and seeds of unripe fruit at 5.8%. At 3.39%, ripe fruits and seeds of ripe fruits contributed to smallest proportion of its diet (Figure 5.2)

## 5. Discussion

### 5.1. 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 5.1). 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 ). 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 5.1. 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

### 5.2. 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 5.2). 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 5.2. 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

## 5.3. 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.

## 5.4. 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.

## 5.5. 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.

## 5.6. 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.

### 5.7. 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.

### 5.8. 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.

### 5.9. Feeding ecology

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.

Figure 5.1. Activity budget of *R. avunculus* at Khau Ca Forest

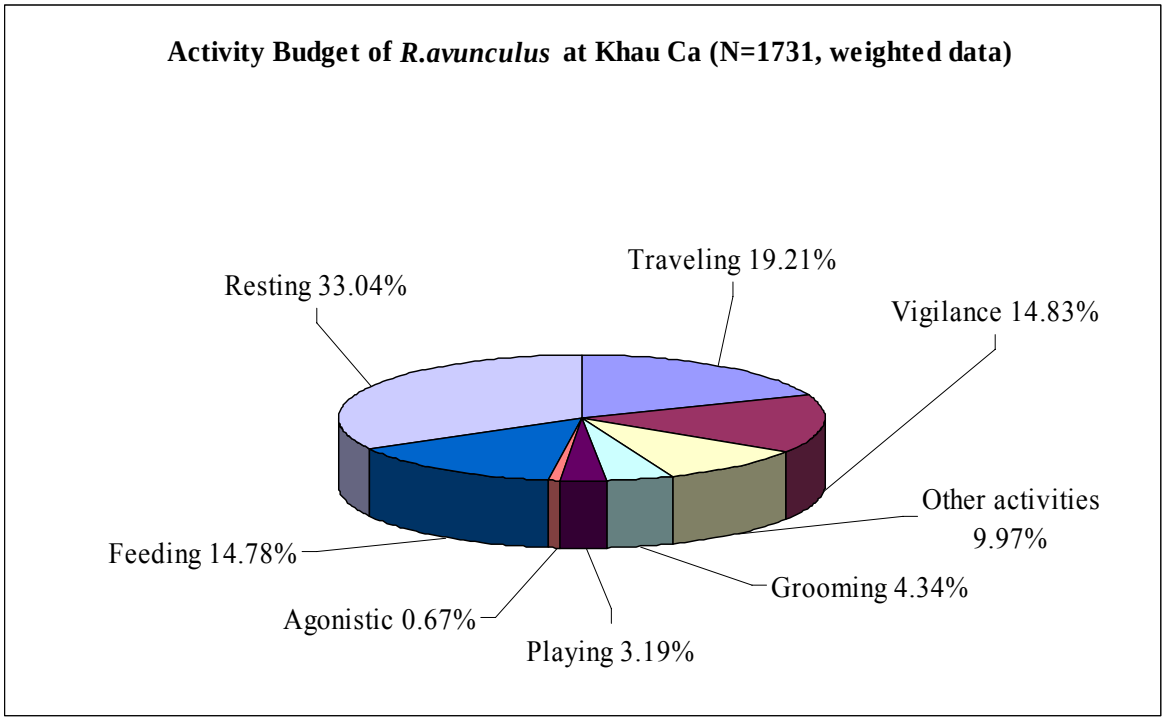
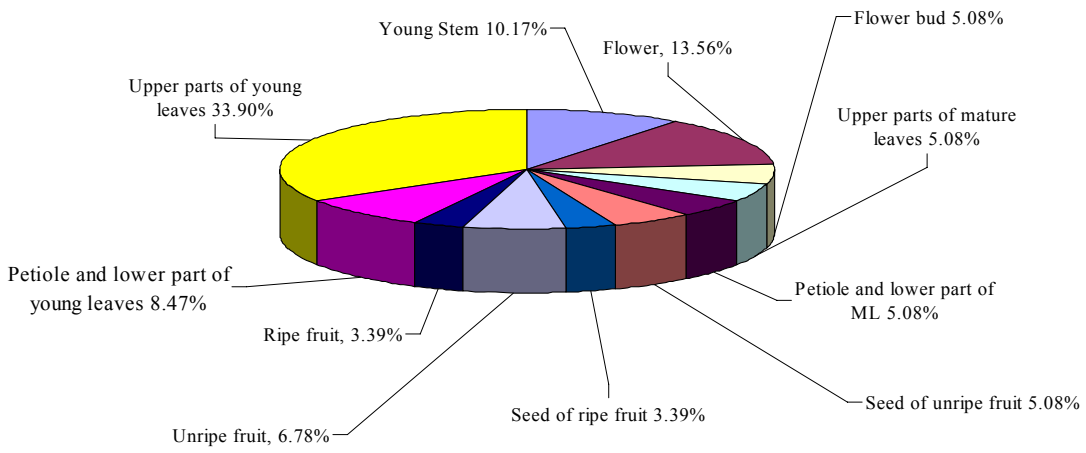



Figure 5.2. Percentage of differenct items in *R. avunculus*'s diet at Khau Ca

**Percentage of different items in *R.avunculus'* diet at Khau Ca (n=59, unweighted data)**



## 6. Botany

### 6.1. Tat Ke Sector

#### *6.1.1. 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 6.1). 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.

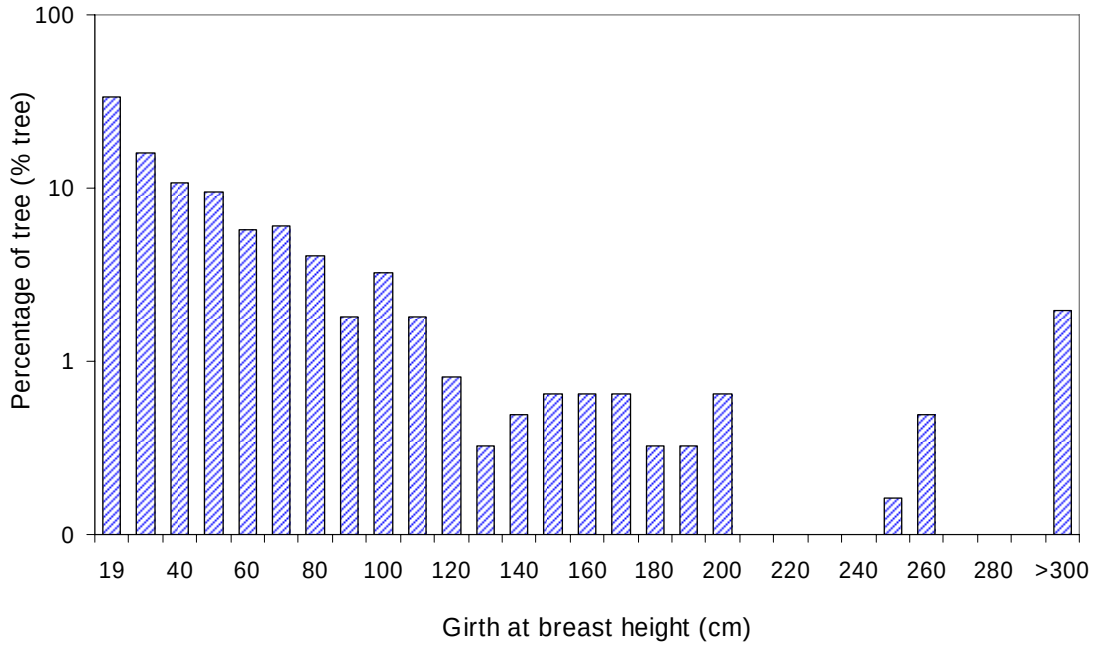



Figure 6.1. Frequency distribution of girths at breast height of plots at Tat Ke Sector (n=612)

*6.1.2. Species composition of the forest*

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 6.1).

Table 6.2 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 6.3 (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 6.1. 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 6.1. 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 6.2. Abundance and basal area of tree families in botanical plots at Tat Ke Sector

| 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 6.2. Abundance and basal area of tree families in botanical plots at Tat Ke Sector (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 6.2. Abundance and basal area of tree families in botanical plots at Tat Ke Sector (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 6.3. 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 6.3. 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

*6.1.3. 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 3.4).

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 3.4). 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 3.4). 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).

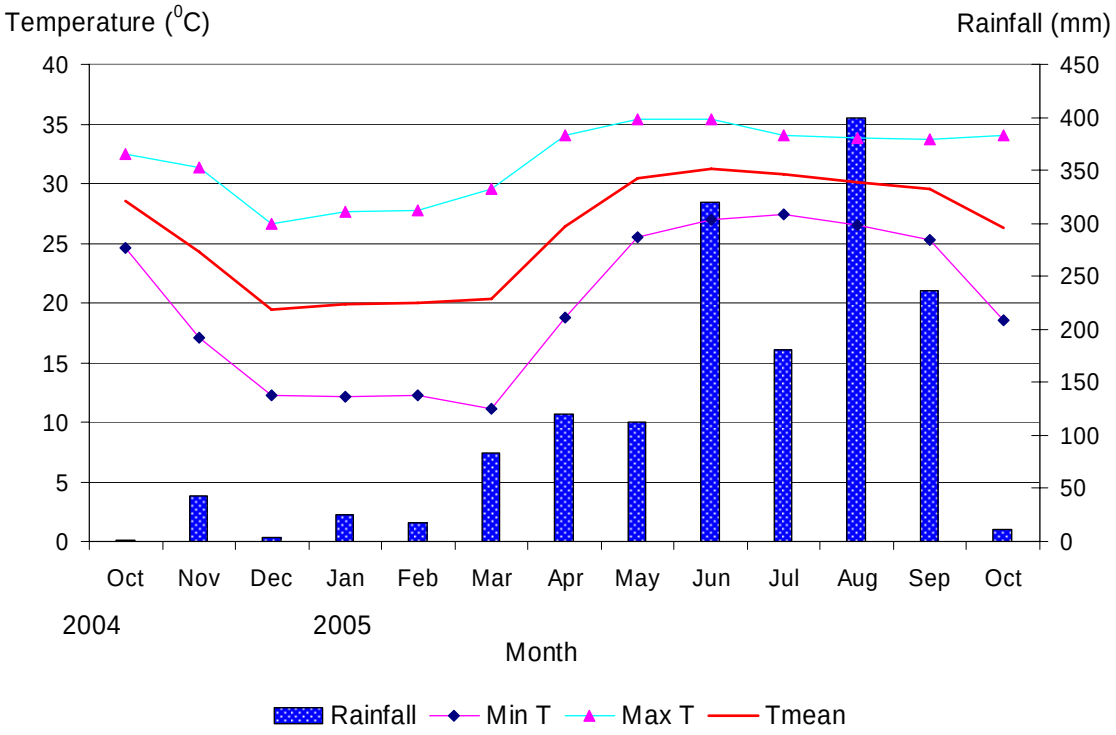



Figure 6.2. Phenological patterns at Tat Ke, Na Hang Nature Reserve (n= 333)

6.2. Khau Ca Forest

*6.2.1. 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 6.3). 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.

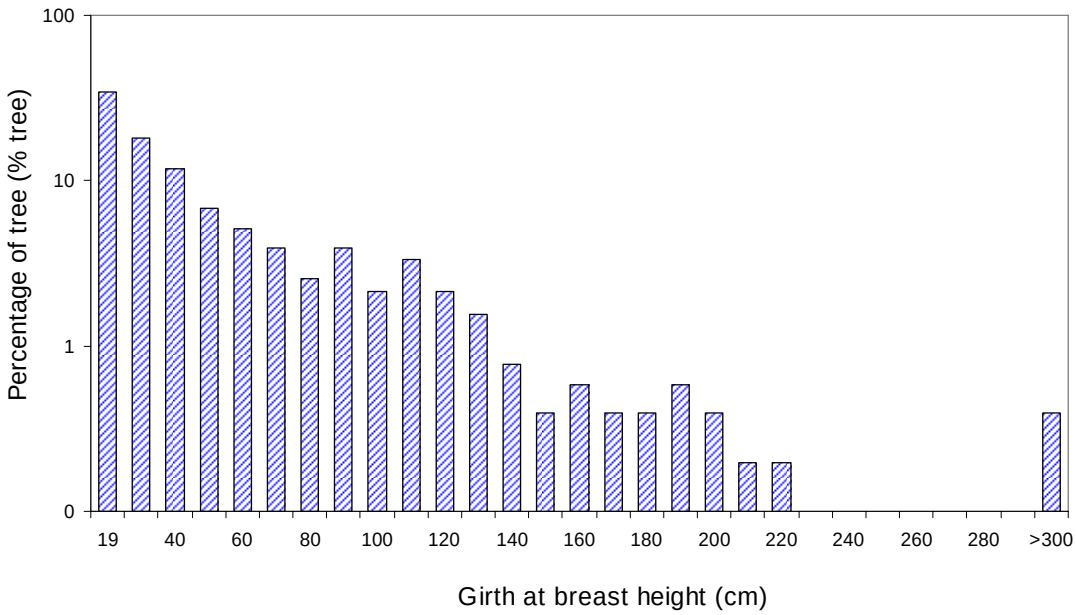



Figure 6.3. Frequency distribution of girths at breast height of plots at Khau Ca Forest (n=512)

*6.2.2. 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 $m^2$.

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 6.4).

Table 6.5 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 3.6). *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.

### *6.2.3. 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 3.8).

The production of young leaves and leaf buds was high throughout the course of the study (more than 90% of trees produced leaves, figure 1.). 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).

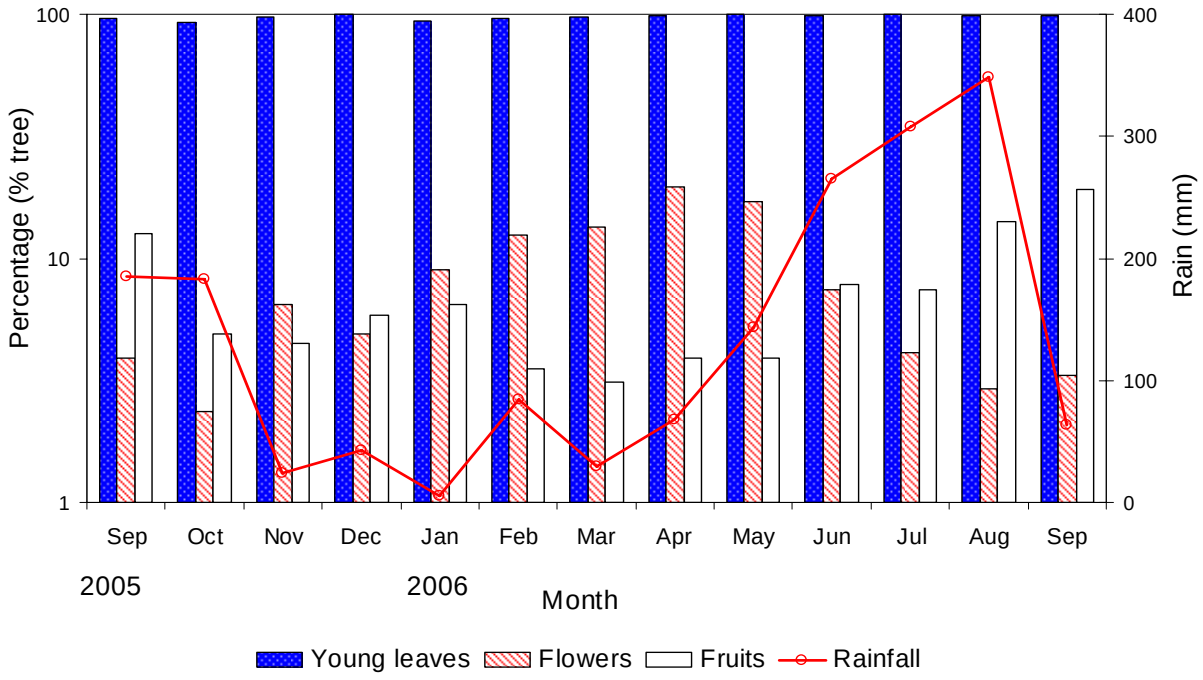



Figure 6.4. Phenological patterns at Khau Ca Forest (n=512)

Table 6.4. 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 6.4. 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 6.5. Abundance and basal area of tree families in botanical plots at Khau Ca Forest

| 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 6.5. Abundance and basal area of tree families in botanical plots at Khau Ca Forest (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 6.6. Twenty nine commonest tree species in 58 plots at Khau Ca Forest

| **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 6.6. 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 |

## 6.3. Comparison between Tat Ke Sector and Khau Ca Forest

### *6.3.1. 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.

### *6.3.2. 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%).

### *6.3.3. 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 ($U=64$, $n_1=11$, $n_2=13$, $p>0.05$).

## 7. Conservation of Rhinopithecus avunculus

### 7.1. Threats

#### *7.1.1. 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).

### *7.1.2. Habitat destruction*

Human activities such as past legal and illegal logging, swidden and 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).

Swidden burn and shifting cultivation are 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.

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).

## 7.2. Training and educational accomplishments

### *7.2.1. Students and local assistants*

2 students from Forestry University, 1 student from Institute of Ecology and Biological Resources, 1 student from Hanoi 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.

Table 7.1. 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 | Local assistant | Assistant |
| 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 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.

Teammember of the project.

### *7.2.2. 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.

### *7.2.3. 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.

### *7.2.4. 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.

### *7.2.5. 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.

### *7.2.6. 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, such as 21$^{st}$ International Primatological Society at Uganda 2006 and workshop on the most twenty five critically endangered primates at Cambodia 2006.

## 8. Wildlife survey

The presence of fauna, other than *R. avunculus*, was recorded opportunistically during the surveys. 18 mammals and 34 birds were recorded during study period at Tat Ke Sector and Khau Ca Forest. The list of birds and other mammals recorded is given below (table 8.1 and 8.2).

Francois' leaf monkey Trachypithecus francoisi francoisi

Another endangered primate, Francois's leaf monkey (*Trachypithecus francoisi francoisi*) has been reported to be in Tat Ke Sector (Boonratana & Le, 1994), but there is no sighting of *T. f. francoisi* in the areas surveyed.

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 8.1 for more details). This is due to past and current hunting pressure in the forests surveyed.

Table 8.1. 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** | **Site/Evidence** |
|---|---|---|---|
| 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. | Wild pig | *Sus scrofa* | A, B(1,2) |
| 14. | Barking deer | *Muntiacus muntjak* | A, B(1,2,3) |
| 15. | Serow | *Capricornis sumatraensis* | A, B(1) |
| 16. | Rhesus Macaque | *Macaca mulata* | A(9, 1), B(1) |
| 17. | Stump-tailed Macaque | *Macaca arctoides* | A(9), B(1) |
| 18. | Assamese Macaque | *Macaca assamensis* | A(9, 1), B (1) |

A: Tat Ke Sector
B: Khau Ca Forest

Table 8.2. 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. | Red-headed Drongo | *Harpactes erythrocephalus* | A, B (1) |
| 11. | Greater Yellownape | *Picus flavinucha* | A, B(1) |
| 12. | Bay Wood pecker | *Blythipicus pyrrhotis* | A, B(1) |
| 13. | Long-tailed Broadbill | *Psarisomus dalhousiae* | A(1) |
| 14. | Yellow Wagtail | *Motacilla flava* | A(1) |
| 15. | Scarlet Minivet | *Pericrocotus flameus* | A(1) |
| 16. | Red-wiskered Bulbul | *Pycnonotus jocosus* | A(1) |
| 17. | Chestnut Bulbul | *Hamixos castanonotus* | A(1) |
| 18. | Sooty-headed Bulbul | *Pycnonotus aurigaster* | A(1) |
| 19. | Greater Racket-tailed Drongo | *Dicrurus paradiseus* | A(1) |
| 20. | Black Drongo | *Dicrurus macrocercus* | A(1) |
| 21. | Sultan Tit | *Melanochlora sultanea* | A, B(1) |
| 22. | Limestone Wren-Babbler | *Napothera crispifrons* | A(1) |
| 23. | Black-throated Laughingthrush | *Garrulax merulus* | A(1) |
| 24. | Oriental Magpie Robin | *Copsychus saularis* | A(1) |
| 25. | White-tailed Robin | *Cinclidium leucurum* | A(1) |
| 26. | Blue Whistling Thrush | *Myiophoneus caeruleus* | A(1) |
| 27. | Long-tailed Shrike | *Lanius schach* | A(1) |
| 28. | Fork-tailed Sunbird | *Aethopyga christinae* | A(1) |
| 29. | Mr. Gould's Sunbird | *Aethopyga gouldiae* | A(1) |
| 30. | Common Stonechat | *Saxicola torquata* | A, B(1) |
| 31. | Blue Whistling Thrush | *Myophonus caeusleus* | A(1) |
| 32. | White-throated Fantail | *Rhipidura albicollis* | A(1) |
| 33. | Grey-checked Fulvetta | *Alcippe mourinsonia* | 1 |
| 34. | Yellow-checked Tit | *Paurus spilonotus* | A, B(1) |

1: Tat Ke Sector
2: Khau Ca Forest

## 9. Reccomendations

### 9.1. General reccommedations

Na Hang and Ha Giang Forest Protection Departments should work with police and other related sectors to control illegal gun use and to prevent trade of *R. avunculus* and its parts as well as other forest products. Law enforcement should be carried out continuously in the range of *R. avunculus*

Conservation awareness raising programmes should be conducted in the two areas. This will be an important tool to give the local people living in and around the reserve, especially targeting hunters, the feeling and pride that they are owner of a "very rare species" of the world.

An annual population monitoring progamme should be carried out by researchers at the two areas. Surveys should be conducted in provisional areas where *R. avunculus* has been reported.

### 9.2. Specific recommendations

#### *9.2.1. Tat Ke Sector*

The population size of *R. avunculus* at Tat Ke Sector is very small and they are under high hunting pressure from local people living in and around the reserve. More importantly, the basic social structure of *R. avunculus* is one-male unit, so the chance of survival of the population in the future is unlikely if local authorities do not take action immediately.

Na Hang Nature Reserve Management Board should reorganize the patrol groups. Firstly, patrol groups should be recruited equally from villages living in and around the reserve. Secondly, each patrol at every the ranger station group should be pointed to patrol a specific area. Lastly, Na Hang Nature Reserve Management Board must make sure that

patrollers must know very well about the area that they manage and do patrol regularly in the forest.

Na Hang Nature Reserve Management Board's staff should make regular and random trips to ranger stations and villages living in and around the reserve. This will help to monitor the patrol groups and get more information about current status of *R. avunculus* from villagers.

Na Hang Forest Protection Departments and Na Hang Nature Reserve Management Board should work with police and other related sectors to control illegal gun use.

Na Hang authorities should be aware of the current population status and threats to the *R. avunculus* and its habitats. This requires not only effort from local authorities but good advice from experts.

*9.2.2. Khau Ca Forest*

Khau Ca Forest holds the largest population of *R. avunculus* among four known sites and the population there appeared to be growing and under a good management. To make sure the long term survival of the population, some of the following recommendations should be taken into account.

At present, Khau Ca Forest does not have any legal status, so it is necessary to plan a feasible project as soon as possible in order to establish Khau Ca Tonkin snub-nosed monkey Area.

Compared to other colobines, the current population of *R. avunculus* at Khau Ca Forest is still low (9 individuals/$km^2$), but they are competing for food with other primates such as *Macaca mulata, Macaca assamensis,* and *Macaca artoides*. If the populations of all the species are growing in the future, Khau Ca Forest (10 $km^2$) will not be capable of carrying those populations. Therefore, Ha Giang Forest Protection Department should prepare a Khau Ca extension plan in the future. Du Gia Nature Reserve (ca. 120 $km^2$) is located nearby; it is possible to make a corridor between Khau Ca Forest and Du Gia Nature

Reserve. However, a research at Du Gia Nature Reserve is needed to make sure that ecology between sites is accorded.

Long-term researches should be conducted at Khau Ca Forest to better understand the ecological requirements, ranging behavour of *R. avunculus*. Trained local people who have wildlife techniques and conservation skills should be recruited to participate the following research.

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