

**MINISTRY OF EDUCATION
AND TRAINING**

**MINISTRY OF AGRICULTURE
AND RURAL DEVELOPMENT**

VIETNAM NATIONAL UNIVERSITY OF FORESTRY

NGUYEN DINH HAI

**STUDY ON ECOLOGY AND CONSERVATION OF GREY
LANGUR (*TRACHYPITHECUS CREPUSCULUS*) IN XUAN LIEN
NATURE RESERVE, THANH HOA PROVINCE**

SUMMARY OF DOCTORAL THESIS IN FORESTRY

HANOI – 2018

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Hanoi, 16 July 2018

Dissertation Author

Nguyen Dinh Hai

INTRODUCTION

1. Necessity of the thesis theme

Grey langur *Trachypithecus (phayrei) crepusculus* is a globally endangered primate species, enlisted in IUCN Red List at Endangered category (EN). Grey Langur occurs only in some Southeast Asian countries (Bangladesh, China, India, Laos, Myanmar, Thailand and Vietnam) with 3 subspecies: *phayrei*, *crepusculus* and *shanicus*. The population of Grey Langur in Vietnam was first recognized as subspecies *crepusculus*, however, it was latter recognized as an independant species *Trachypithecus barbei* or *Trachypithecus crepusculus*. In Vietnam, Grey Langur now exists only in some provinces from Northwest to Nghe An province with a number of small sub-populations. The species is under rapid declining in number due to hunting/snaring and habitat loss. Grey langur is enlisted in 2007 Vietnam Red Data Book at "Vulnerable" category (VU), in the Group IB (forest animal species under strict ban of hunting and use for commercial purposes) of the Governmental Decree No. 32/2006/NĐ-CP and in the List of Endangered, Rare and Precious Species with Conservation Priority" under the Governmental Decree No.160/2013/NĐ-CP (In these documents, Grey Langur is enlisted under different scientific names: *Trachypithecus barbei* (*T. phayrei*) or *Trachypithecus (phayrei) barbei*).

Thus, conservation of Grey langur *Trachypithecus phayrei* in the world as well as *Trachypithecus crepusculus* in Vietnam is under high necessity. In Vietnam, the understanding of biology and ecology of Grey Langur *Trachypithecus crepusculus* is very poor. Sofar, only few preliminary studies on the distribution range, reproduction and behaviour of this species has been conducted.

Xuan Lien NR, having a total of 23,406.6 ha, of which 22,000 ha are natural forest, and neighboring Pu Hoat NR of approximately 90,000 ha in Nghe An Province, together make a vast tract of natural forest wich has high biodiversity and plays important role on conservation of Grey Langur in Vietnam. The presence of Grey langur in Xuan Lien NR was first recorded in 1998 surveys and then continouosly recorded in later biodiversity surveys . In 2014, a total of 5 groups with 95-110 individuals of Grey langur were found in Xuan Lien NR.

With the aim to sustainablly conserve Grey Langur population in Xuan Lien NR, Thanh Hoa Province, I have choosed to implement this Ph.D. thesis theme "Study of ecology and conservation of Grey Langur population *Trachypithecus crepusculus* in Xuan Lien Nature Reserve, Thanh Hoa Province"

2. Objectives and Study content

2.1. Overall objective

To develop a scientific basis for conservation and sustainable development of Grey Langur population in Xuan Lien NR in particular and Vietnam in general.

2.2. Specific objectives

- Determining the current status and distribution range of Grey Langur in Xuan Lien NR
- Determining the habitat features, ecological and behaviour charactristics of the Grey Langur population in Xuan Lien NR
- Identifying threats to Grey langur population, evaluating conservation awareness of

local residents; recommending measures for sustainable conservation of Grey Langur population and its habitat in Xuan Lien NR.

2.3. Study content

2.3.1. Determining the current status and distribution range of Grey Langur in Xuan Lien NR

2.3.2. Determining some characteristics of the Grey Langur forest habitat

2.3.3. Determining some ecological characteristics of the Grey Langur population

2.3.4. Evaluation of current management and conservation situation in Xuan Lien NR

2.3.5. Recommending relevant measures for conservation of Grey Langur in Xuan Lien NR

3. Scientific and practical significance of the Thesis

3.1. Scientific significance

This thesis provides updated information/data on biology, ecology and behaviour of Grey Langur. These data can be used for scientific research, university and post-graduate training in the fields of forestry, ecology and wildlife conservation

3.2. Practical significance

The thesis recommends relevant measures for conservation and sustainable development of Grey langur population and its habitat in Xuan Lien NR, Thanh Hoa Province

4. Object and scope of study

4.1. Object of study

Population of Grey Langur and its habitat in Xuan Lien NR, Thanh Hoa Province

4.2. Scope of study

The thesis study is conducted within Xuan Lien NR which is situated in administrative territory of 5 communes (Bat Mot, Yen Nhan, Luong Son, Xuan Cam and Van Xuan) of Thuong Xuan District, Thanh Hoa Province. The thesis study is focused on population status, habitat and some ecological characteristics of Grey Langur, threats to the Grey Langur population and its habitat in Xuan Lien NR.

5. New contributions of the thesis

- Providing updated information/data on population size, group structure and distribution range of Grey Langur in Xuan Lien NR.

- Estimated home range of Grey Langur in Xuan Lien NR as 294 ha; the "feeding" behavior accounting for 48.88% and "rest" accounting for 21.89% of the total active time budget of Grey Langur.

- + Describing habitat features and forest structure of Grey Langur habitats in Xuan Lien NR, identifying plant species having the parts eaten by Grey Langur in Xuan Lien NR and describing their phenological features

- Identified and analyzed the threats to population of Grey Langur as the basis for recommending relevant measures for sustainable conservation of Grey Langur population in Xuan Lien NR.

CHAPTER 1

LITERATURE REVIEW OF RESEARCH TOPICS

1.1. In the World

There are many research directions are conducted in the World such as overall primate research: Mittermeier et al. (1999); study of feeding ecology: Bennett et al. (1994), Silver et al. (1998), Fashing (2001), Chapman et al. (1994, 2002, 2004), Ganzhorn (2003); estimating population size and distribution range of Grey Langur in various geographic areas for development of conservation measures: Nowak (1999), Hutchins et al. (2004), Wilson et al. (2005), Bleisch et al. (2008), Corbett et al. (1992), Mittermeier et al. (2013), Timmins et al. (2013), Schwitzer et al. (2014); study of taxonomy and molecular genetics of Grey Langur: Brandon-Jones (1984), Brandon-Jones et al. (2004), Kay et al. (1994), Wang et al. (1998), Groves (2001), Roos et al. (2001), Karanth et al. (2008); study of basic biological and ecological characteristics of Grey Langur: He et al. (1982), Mukkerjee et al. (1982), Stanford (1988), Choudhury (1987, 1994a, 1994b), Gupta et al. (1994, 1996, 1997), Lekagul et al. (1988), Lu et al. (2010, 2011), Gibson et al. (2012), Suarez (2013); study of social behaviour: Choudhury (1987, 1994b), Gupta (2000, 2002), Bose et al. (2002), Koenig et al. (2004, 2012), Pages et al. (2005), Lu et al. (2012)...

1.2. In Vietnam

In Vietnam, actual development of primate studies has been only since 1960s of XX Century. Based on Dao Van Tien (1987), Pham Nhat (2002), Dang Huy Huynh et al. (2008), Dang Huy Huynh et al. (2010), the history of primatological studies in Vietnam can be summarized as following:

Period before 1954: primate studies in Vietnam were conducted mainly by foreign scientists and in combination with mammal surveys or overall faunal surveys. The most notable works in this period are: Milne-Edwards (1867-1874), Morice (1875), Billet (1896 -1898), Bountant (1900-1906), de Poursagues (1904), Trouessart (1911), Dolman (1912), Osgood (1932), Bourret (1942), Delacour (1940).

Period from 1954 to 1975: Primate studies conducted mainly by Vietnamese scientists and the first vietnamese publications on primates are Dao Van Tien (1960, 1970), Le Hien Hao (1960), Dang Huy Huynh and Do Ngoc Quang (1962), Cao Van Sung et al. (1964).

Period after 1975 to present: Strong development of overall biodiversity studies in Vietnam including primate studies. There are large number of publications on primates in this period such as Dao Van Tien (1983, 1985, 1989), Le Xuan Canh et al. (1992, 1994, 1997, 1998, 2000, 2008), Pham Nhat (1993, 1994, 1995, 2002), Nguyen Xuan Dang et al. (2011), etc.

Results of these studies help to increase understanding on primate biology and ecology, that provides important scientific background for management, conservation and sustainable development of primates in Vietnam, especially in relation to endangered and precious primate species. Results of primatological studies including studies on Grey Langur both in Vietnam and in the World provides important direction for research content of this thesis. This literature review again indicate necessity of the thesis theme "Study of ecology and conservation of Grey Langur *Trachypithecus crepusculus* in Xuan Lien Nature Reserve, Thanh Hoa Province".

CHAPTER 2

TIMELINE, LOCATION AND METHODS OF STUDY

2.1. Timeline of study

This study was conducted from June 2014 to March 2017 with about 600 days of fieldwork.

2.2. Location of study

Study of Grey Langur in the wild was conducted in Xuan Lien NR (Thuong Xuan District, Thanh Hoa province). Study of feeding and behavior of Grey Langur in captivity was conducted in Hanoi Zoo and Endangered Primate Rescue Center (Cuc Phuong EPRC) in Cuc Phuong National Park (NP). Data analysis and development of dissertation was conducted in Vietnam National University of Forestry (VNUF), Institute of Ecology and Biological Resources of Vietnam Academy of Science and Technology and headquarter of Xuan Lien NR.

2.3. Methods of study

2.3.1. Interview survey

Sem-structured interview technique was applied to interview residents living in buffer zone of Xuan Lien NR as well as rangers of Xuan Lien NR. The results of the interview survey were used for designing field studies in Xuan Lien NR. The interview surveys were further conducted in combination with field surveys when the surveyors met local residents or rangers in forest. During interview surveys, color pictures of adult Grey Langur was used to get correct species identification.

Surveys for socio-economic status, knowledge and awareness of local communities on Grey Langur conservation were conducted using Participatory Rural Appraisal method (PRA) of Narayanasamy (2009), Launiala (2009) and Oepen (2013).

2.3.2. Transect survey on population of Grey Langur

- Technique of acquaintance with Grey Langur follows Williamson & Feistner (2011).
- Assessment of population size by transect survey techniques described in Brockelman & Ali, 1987; Ross & Reeve (2011) and Buckland et al., 2015 with some modifications to fit actual situation in Xuan Lien NR. Transects run through various habitat types in Xuan Lien NR. Totally, nine (9) main transects with many side transects were used, the main transect length is from 3 to 7 km each (Figure 2.1). Total length of all transects is about 100 km. The transects with high possible detection of Grey Langur were surveyed several times. The langur surveys were conducted in morning (from 6/7 a.m to 11/11:30 a.m) and in afternoon (from 13 p.m to 17 p.m). The survey team comprised 3-4 persons (myself, 2 assistants, and 1 ranger or local guide). Field equipment used are binoculars, photocameras, videocamera and GPS.



Figure 2.1. Main transects used for Grey Langur survey in Xuan Lien NR

2.3.3. Method of behaviour study

Study area has a complicated terrain with steep slopes and deep narrow valleys and the Grey Langurs in the area are very scared of human presence. These make behavior study of Grey Langur in Xuan Lien NR very difficult. In order to overcome these difficulties, digital Video Camera Sony HDR-24 was used to record activities of Grey Langur in the wild, then in laboratory, software VLC (<http://www.videolan.org/vlc/>) was used to rewind the film for data analysis. The taking video film also allows to record rapid behavior acts that are impossible to be observed by naked eyes (Rowe & Myers, 2011; Le Khắc Quyet, 2014).

Because, it was impossible to recognize sex and age of Grey Langur in the wild, this study only collect behavior data by 3 age classes including adult, juvenile and newborns/infant. The collected information include time and time duration of each behavior act, age class of focal animal. Menu of behavior acts follows Boonratana and Le (1993) and Dong Thanh Hai (2011), including

- Feeding (F): looking for food, use of the food, digestion of the food and selection of the food
- Travel (T): whole animal body moves excluding feeding and forage
- Resting (R): Animal is resting and sleeping without any active activity
- Social communication (S): including allogrooming, play, care of babies
- Self-grooming (G): Animal groom his/herself.
- Observing (O): Animal displays act of observation around
- Unknown behaviors (U): Behavior acts that are impossible to determine
- Out of Sight (OS): Animal disappears from view, can not be observed

Each behavior type of Grey Langur is assessed by percentage (%) of time the langur spent for per total time of all behavior types. Due to low amount of collected data, statistical analysis was not applied in these data analysis.

2.3.4. Description of age classes and sex of Grey Langur

Applying methodology of National Research Council (1981), age class and sex of Grey Langur can be identified as following:

- *Adult male*: Fur is grey to dark grey; there is a fur crest on the back, skin around eyes is blue and white; fur in back is darker than in belly; tail is longer than head&body length; average weight is 6.9kg; scrotum is white, penis is black (Figure 2.3).



Figure 2.3. Adult male

- *Adult female*: Fur is brown grey; there is a fur crest on the back, skin around eyes is white; tail is longer than head&body length; nipple tip is black, average weight is 6.4 kg; often embracing infant or newborn when moving and feeding (Figure 2.4)



Figure 2.4 Adult female

- *Juvenile*: Fur is grey; there is a crest on back; skin around eyes is blue and white; tail is longer than head&body length; feeding independantly; feeding and moving along with adult males or adult females; body size is smaller than those of adults (Figure 2.5)



Figure 2.5 Juvenile

- *Infant*: Fur is light grey; not yet fully stoping nipple feeding and begins learn to eat together with mother; can move around mother; when moving, embraced on mother belly and moved together with mother (Figure 2.6)



Figure 2.6 Newborn

- *Newborn*: Fur is yellow; fully nipple feeding; always embraced on mother belly when moving and resting (Figure 6)

2.3.5. Determining home range

Along survey transects, following the Grey Langur groups from early morning to late afternoon or until the group disappears from the view. Using GPS to record coordinates of the group centre (location with the largest number of the group members) after each 15 minutes or when the group moved on distance ≥ 50 m. Except for this, the location of the group centre is also noted when the group first appeared or disappeared. Then display recorded localities of group centre on the topographic map of scale 1:10.000 and 1:25.000. The home range size is determined following Liu et al. (2004) and estimated by following formula:

$$HR = (\text{Number of grid quadrats with Grey Langur appearing}) \times (0.01 \text{ km}^2)$$

The size of home range by month is determined by sum of grid quadrats with langur appearing in days of the month multiplying by size of the grid quadrats.

2.3.6. Creating the habitat map and identifying habitat of Grey Langur

Map of forest habitats of Xuan Lien NR is developed based on available data and Map of forest types and subtypes in Xuan Lien NR. The latter was developed on VN2000 coordinates system and scale of 1/10.000 by Northwest Forest Investigation and Planning Sub-institute in 2012. There are many forest types and subtypes with small area and they scatteredly distributed throughout the territory of Xuan Lien NR and intersected between other large forest types. These forest types/subtypes can not served as independent habitat type of Grey Langur. Therefore, these small and scattered forest patches are combined with neighboring large forest types with more or less similar characteristics in one forest habitat type of Grey Langur. As the results, 7 key forest habitat types were identified in Xuan Lien NR (table 2.2)

Table 2.1. Key forest habitat types in Xuan Lien NR

Habitat type	Forest type/subtype	Total area (ha)	Percentage (%)
Habitat 1	Subtropical limestone evergreen forest	767	3.4
Habitat 2	Subtropical little-affected evergreen forest	2.259	10.1
Habitat 3	Tropical little-affected evergreen forest	2.801	12.5
Habitat 4	Tropical evergreen forest after commercial logging	1.372	6.2
Habitat 5	Tropical restoration evergreen forest	5.293	23.6
Habitat 6	Mixed wood-bamboo forest	6.617	29.6
Habitat 7	Bamboo forest	3.276	14.6
	Total	22.385	100%

The habitat type used by Grey Langur (Grey Langur habitat) in Xuan Lien NR is identified based on overlapping map layer of Grey Langur distribution on map layer of key forest habitat types

2.3.7. Study of forest structure using standard quadrat method

Applying methods in Ganzhorn và cs (2011) for investigating forest structure in each Grey Langur habitat type. Totally, 45 quadrats of 20x50m (100m²) were surveyed, in each quadrat there were 5 smaller subquadrats of 5x5m (25m²) (Table 2.3)

Table 2.3 System of quadrats surveyed in Xuan Lien NR

No	Habitat type	Total area (ha)	Number of quadrats
1	SC1- Limestone evergreen forest	767	5
2	SC2 - Subtropical evergreen forest	2,259	20
3	SC3 - Tropical little-affected evergreen forest	2,801	10
4	SC6 - Mixed wood-bamboo forest	6,617	10
	Total	12,444	45

- Quadrats are randomly distributed within each Grey Langur habitat type with more concentration in areas where the Grey Langur groups werw often seen.

- In each quadrat, following data were collected:

+ General information: quadrat locality, area, GPS coordinates, altitude, steepness, direction of moutain/hill slope, soil, rocks, humidity, number of forest layers, etc.

+ Vietnamese name/local name and scientific name of all trees with DBH ≥ 10 cm. In case, scientific name can not be identified in the wild, vouchers (leave, flowers, fruits or

bark) were collected for species identification in laboratory. The species identification was made by Dr. Pham Van The - a bontanist from Institute of Ecology and Biological Resources and MSc. Nguyen Anh Duc - a botanist from Hanoi National University.

+ Measuring DBH of all trees of $DBH \geq 10$ cm by specific ruler with ecuracy of milimetre (mm).

+Measuring total tree height (Hvn) and under-branch tree height (Hdc) by ruler with ecuracy of metre (m).

+ Measuring forest coverage by percentage of ground coverage by vertical direction

+ Inventory all out-layer plant species

+ Recording the phenological status of trees (presence or absence of fruits, flowers, etc.)

- In each sub-quadrat (5x5m): inventory of young trees with $DBH < 10$ cm, identifying tree data (species name, number of trees by each height classes cao $H < 50$ cm; 50-150 cm; > 150 cm, regeneration origin, quality of trees). All information/data were noted on the pre-prepared Investigation datasheet

2.3.8. Phenological study

Phenological study of plant parts (leaf, flower, fruit) of potential food plants of Grey Langur follows Silver et al. (1998) and Ganzhorn et al. (2011) .

In each key habitat type within distribution range of Grey Langur, a number of phenological transects were established using abandoned trails for the transect. Each transect is 4 m wide and 1 km long. All trees with $DBH \geq 10$ cm within each transect were identified scientific name and marked with metal sign (Figure 2.6, Figure 2.7)



Figure 2.6. A tree with metal sign on a phenological transect

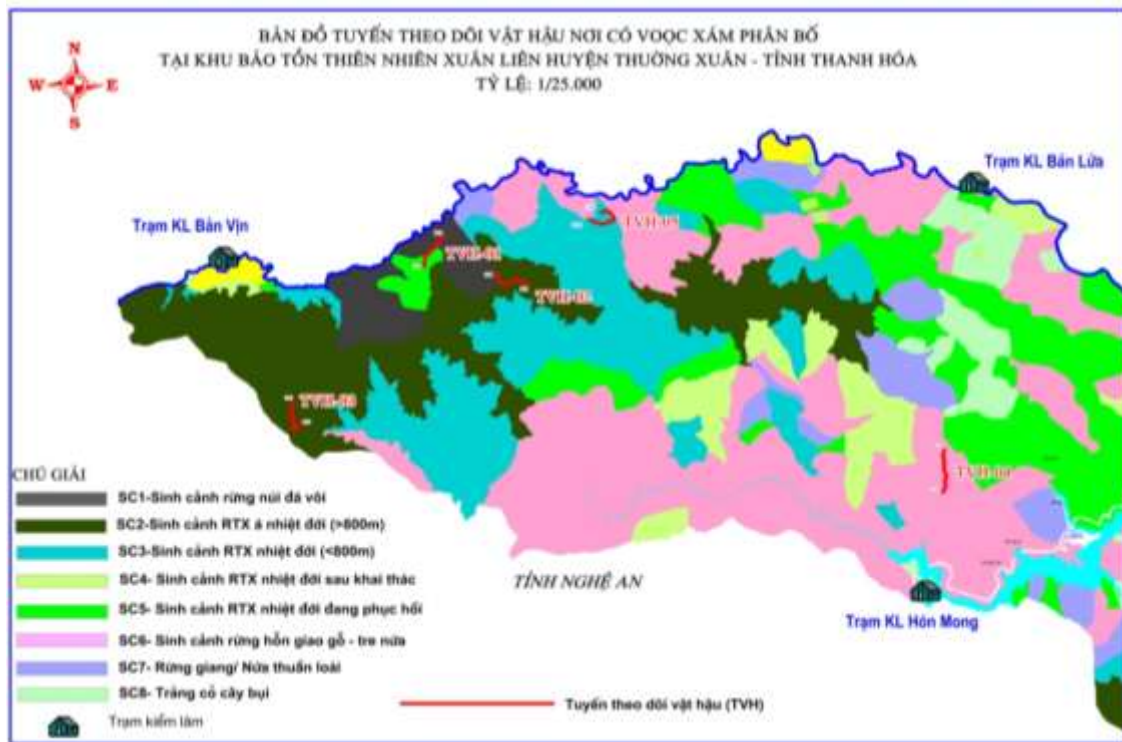


Figure 2.8. Location of phenological transects in Xuan Lien NR

Plant parts of phenological trees are determined as described in Table 2.4.

Table 2.4. Description of plant parts of phenological trees

Part	Description
Bud	Leaf bud not yet turning into leaves
Young leaf	Leaf stage from appearing from bud to the time reaching size and color similar to mature leaf.
Mature leaf	Leaf fully developed in size and color but not yet changing to old stage
Flower	Flower from its appearing to shaking down
Green fruit	Fruit from its appearing (often with green color) to beging of ripening
Ripe fruit	Fruit from changing into yellow color or other specific color

Once month, surveyors walked along transects, observing each marked trees on the transects by naked eyes or binoculars to assess abundance of each plant parts by scale from 0 to 2 (0 means absence, 1 means presence scattered in some branches and 2 means presence abundantly in many branches) and noted into pre-prepared Phenological Observation Sheet. The survey is carried out continuously all 12 months of the year.

2.3.9. Study of Grey Langur food

* Study in the wild

While observing Grey langurs by transect survey, if any plant is found eaten by Grey Langur, folloving data were collected: scientific name of the plant and eaten parts. The voucher of eaten plant was collected, preliminarily proccessed by 70° Ethanol, pressed and dried up in the field. Latter, in laboratory, the vouchers were further proccessed and stored at Botanical Collection room in headquarter of Xuan Lien NR. Scientific name of the vouchers were identified by Dr. Pham Van The - a botanist from Institute of Ecology and Biological Resources and MSc. Nguyen Anh Duc - a botanist from Hanoi National University.

* *Study in captivity*

In order to get more data on food and feeding behaviour of Grey Langur which were very difficult to obtain in the wild, similar study was conducted in captive Grey langurs kept in Hanoi Zoo and Cuc Phuong EPRC in July to August 2015 and May to July 2016.

In Hanoi Zoo, study was conducted on 2 Grey langurs: an adult female (body weight of about 10 kg) transported from Lai Chau Province in July 1993 and a juvenile male (body weight of about 3 kg) transported from Dien Bien Province in September 2014. Both animals were kept in one mesh cage.

In Cuc Phuong EPRC, the study was conducted on 4 adult females of Grey langur (body weight of each animals ranges from 9 to 11 kg). All 4 animals were kept in one mesh enclosure without roof. The enclosure was constructed under tree canopy. Furniture inside the enclosure includes food containing tray, drinking water container and 3 matt layers made of bamboo stems. Short information of the 4 animals are as following: NOISY arrived at 22 January 1997, capture locality was un-known, body weight at arriving day was 2.2 kg; HEICHI arrived at 14 April 2000 from Pu Mat National Park, body weight at arriving day was 1.6 kg; HUE was born in Cuc Phuong EPRC in 24 January 2002. His mother is NOISY and his father is ID 4 - 06 (dead of old age); and OMA arrived in 20 March 2012, capture location was un-known, body weight at arriving day was 7.8 kg.

2.3.10. *Study of threats to Grey Langur and its habitat*

Recording evidences of threats caused by local residents and local agencies/organizations with description of each threat type and its severity. Collecting statistical data on forest protection violation cases of Xuan Lien NR within recent 11 years (from 2006 to 2016) stored in Forest Protection Section of Xuan Lien NR. Conducting the data analysis, and then ranking threats by severity from lowest (score 1) to highest (score n) following Margoluis and Salafsky (1998). Each threat was evaluated by 3 categories: 1) scope of threat effect, 2) severity of the threat, and 3) urgency of the threat mitigation

2.4. Methods of data analysis

The collected data were stored in computer and analyzed by common softwares such as Word, Excel, SPSS 24.0, MapInfo 15.0, etc. GIS technique was used for creating distribution map of Grey Langur in Xuan Lien NR.

* **Calculating the forest structure criteria/indexes of Grey Langur habitat**

- *Average forest coverage (C_{tb})*

$$C_{tb} = \frac{\text{Total forest coverage of all standard quadrats}}{\text{Total area of all standard quadrats}}$$

- *Average density of trees in habitat (N_{tb})*

$$N_{tb} \text{ (tree/ha)} = \frac{\text{Total trees in all standard quadrats}}{\text{Total area of all standard quadrats}} \quad (2.2)$$

- *Frequency of mature trees by height classes*

Frequency distribution of mature trees by height classes is a specific characteristics of spatial structure of forest layers (canopy and under canopy layers) of forest habitat. First, establish the table of the frequency distribution of mature trees by height classes, then draw a diagram

of the frequency distribution.

- *Frequency of mature trees by DBH classes*

Frequency distribution of mature trees by DBH classes is a specific characteristics of age structure of tree community in the forest ecosystems. First, establish the table of the frequency distribution of mature trees by DBH classes, then draw a diagram of the frequency distribution.

- *Density of bamboo in habitat*

Density of bamboo in Mixed wood-bamboo forest habitat is assessed by density of bamboo stems per hectare (stem/ha) or bamboo clumps per hectare (clump/ha).

- *Calculating Important Value Index (IVI)*

Important Value Index (IVI) indicates structure, relationship and dominance between species in a plant community (Mishra, 1968). IVI reach maximum of 300 when the plant community comprising trees of only single species. IVI can be calculated by 2 following formulas:

$$IVI = RD + RF + RC \text{ (Sharma, 2003)} \quad (2.3)$$

$$IVI = RD + RF + RBA \text{ (Mishra, 1968)} \quad (2.4)$$

While, RD is relative dominance, RF is relative frequency, RC is relative forest coverage, and RBA is relative total basal area of each species, Rastogi (1999), Sharma (2003), Pandey et al (2002).

In this study, we used formula (2.4) to calculate IVI (Mishra 1968) based on percentage (%) of number of trees of concern species in the standard quadrat and percentage (%) of total basal area of concern species in the habitat.

- *Relative density RD (%)*: Relative density of a tree species is calculated by following formulas:

$$\text{Density (tree/ha)} = \frac{\text{Total number of trees of concern species appeared in all quadrats}}{\text{Total area of all quadrats}} \quad (2.5)$$

$$RD (\%) = \frac{\text{Density of concern species}}{\text{Total density of all tree species}} \times 100 \quad (2.6)$$

- *Relative frequency RF (%)*: Relative frequency indicates a number of quadrats containing concern species expressing at percentage (%). High level of concern species appeared when $RF > 50\%$; medium level when $RF = 25\% - 50\%$; low level when $RF < 25\%$. Formulas for calculating relative frequency are:

$$\text{Frequency (F\%)} = \frac{\text{Number of quadrats containing concern species}}{\text{Total number of quadrats}} \times 100 \quad (2.7)$$

$$RF(\%) = \frac{\text{Frequency of concern species}}{\text{Total frequency of all species}} \times 100 \quad (2.8)$$

- *Relative basal area of species RBA(%)*: Basal area is an important criterion of species dominance. Basal area indicates actual area of land surface which is occupied by the species for its development in specific environment.

$$\text{Basal area of a tree (BA) (cm}^2\text{)} = \pi \times (\text{DBH})^2/4$$

$$\text{RBA (\%)} = \frac{\text{Basal area of concern species}}{\text{Total basal area of all species}} \times 100 \quad (2.9)$$

- *Density of basal area G (m²/ha)*: Density of basal area G is calculated by basal area of a quadrat (Go), that comprises basal area of all trees (g) in the quadrat.

$$G = \frac{G_o}{S_o} \times 10,000 \quad (2.10)$$

Where, S_o is area of quadrat, $G_o = \sum_{i=1}^n g_i$, $g_i = 3.1416 \times (\text{DBH})^2/40,000$

- *Species diversity index H' (Shannon and Weiner's Index)*: following Shannon and Weiner, 1963 [153]:

$$H' = - \sum_{i=1}^n \{N_i/N\} \ln\{N_i/N\} \quad (2.11)$$

Where, H' is diversity index or Shannon- Wiener index; N_i is number of trees of species i, N is total number of trees of all species in the habitat.

- *Index of Concentration of Dominance (Cd)*: This index is calculated following Simpson (1949):

$$Cd = \sum_{i=1}^n \{N_i/N\}^2 \quad (2.12)$$

Where, Cd - Index of Concentration of Dominance or Simpson Index; N_i is number of trees of species i, N is total number of trees of all species in the habitat.

* *Determining characteristics of regenerating trees in habitat*

Estimating some criteria of regenerating trees (DBH < 10cm) in Grey Langur habitat

- Calculating species composition formula: $N\% = \frac{N_i}{\sum_{i=1}^m N_i} \times 100 \quad (2.13)$

(Only species with N_i ≥ 5% are enlisted into Species composition formula)

- Calculating composition coefficient: $K_i = \frac{N_i}{m} \times 10 \quad (2.14)$

(K_i: composition coefficient of species i; N_i: number of trees of species i; m: total number of trees investigated).

- Density of regenerating trees: $N/ha = \frac{10,000 \times n}{S} \quad (2.15)$

(S is total area of subquadrats in which regenerating trees are inventoried (m²), n is number of regenerating trees inventoried).

$$\text{- Calculating ratio of regenerating tree quality: } n\% = \frac{n}{N} \times 100 \quad (2.16)$$

(n%: percentage of good/bad trees; n: total number of good/ bad trees, xấu; N: total number of regenerating trees inventoried).

- Frequency distribution of regenerating trees by 3 height: I (H<50 cm); II (51cm < H ≤ 150cm); III (H > 151cm).

2.5. Material for Thesis development

This thesis was constructed based on analysis of following set of scientific materials:

- A total of 140 hours observing Grey Langurs in Cuc Phuong EPRC and 56 hours observing Grey Langurs in Hanoi Zoo

- A total of 2,400 hours observing Grey Langurs in Xuan Lien NR from June 2014 to March 2017. The fieldworks were for determining population status and distribution range of Grey Langurs, study of some behaviour and feeding of the Grey Langur and survey on threats to Grey Langur in Xuan Lien NR.

- A total of 708 videoclip files equal to 72 hours with 5,663 records of Grey Langur behaviour activities in Xuan Lien NR.

- A total of 525 pictures of Grey Langur and habitat

- 2,124 Interview survey datasheets

- Other notes in study notebooks

CHAPTER 3 RESULTS AND DISCUSSION

3.1. Current status of Grey Langur population in Xuan Lien NR

3.1.1. Population size

Field surveys could observe 5 groups of Grey Langur in Xuan Lien NR. Except for this, there is another group observed previously by Nguyen Truong Son and Le Anh Dung (2012). Detail information of all observations, duration of each observation and number of individuals of each group are shown in Annex 3. Locality of the Grey Langur groups are shown in Table 3.1 and Table 3.2

Table 3.1. Groups of Grey Langur recorded in Xuan Lien NR

Group name	Locality of records		Observation		Nq	Nu
	Compartment	Administrative name	Number of times	Min-Max		
Group 1	489	Phong Village, Bat Mot commune	4	7-15	15	30
Group 2	485, 495	Phong Village, Bat Mot commune	15	4-22	22	30
Group 3	485, 495	Phong Village, Bat Mot commune	36	1-35	35	35

Group 4	497	Vin Village, Bat Mot Commune	6	10-19	19	30
Group 5	499	Lua Village, Yen Nhan Commune	7	25-30	30	35
Group 7*	497, 505	Vin Village, Bat Mot Commune	1	1-8	8	20
Tổng số			69	-	129	180

Note: Nq - maximum number of observed individuals of the group, Nu - estimated number of individuals, (*) follow Nguyen Truong Son and Le Van Dung (2012)

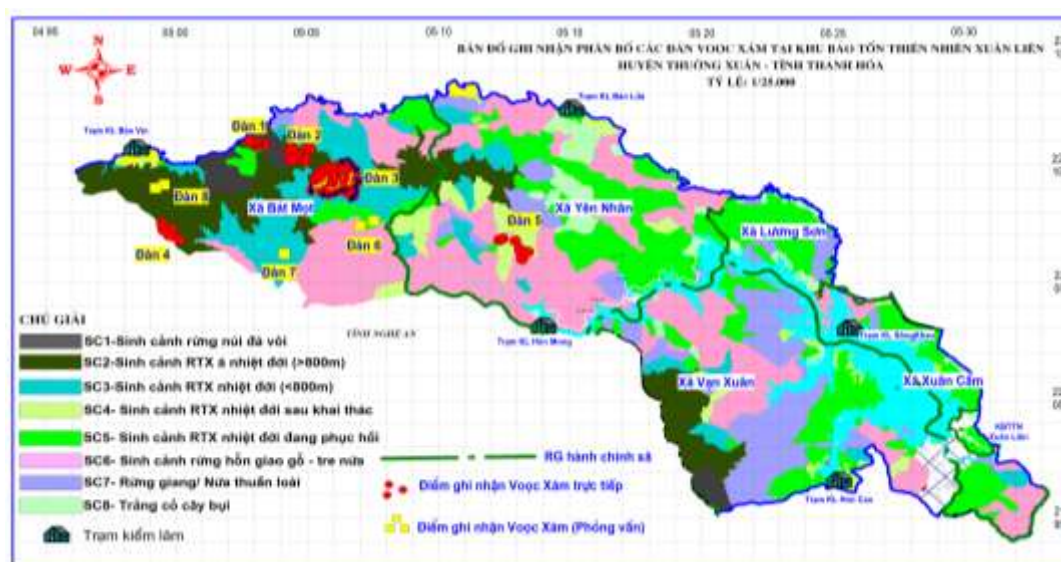


Figure 3.1. Localities of Grey Langur groups in Xuan Lien NR

Thus, in Xuan Lien NR, total of 5 - 6 Grey Langur Groups were recorded, out of them, 5 groups were confirmed by this study and another group was recorded by previous study. Total number of Grey Langur individuals directly sighted is 129 and total estimated number is 180. If 2 other groups temporarily recorded by interview survey are taken into account, total number of sighted animals is 156 individuals and total estimated number is 224 individuals.

3.1.2. Size and structure of Grey Langur group

Results of field studies in Xuan Lien NR show that, within 5 directly observed groups, the largest group has 35 individuals (Group 3) and smallest group has 15-30 individuals (Group 1). Average size of Grey Langur group is 24.2 individuals by sighted data and 32 individuals by estimated data.

Regarding group structure, due to impossible observation of all individuals within a group and impossible identification of age and sex of all observed individuals, this study could not give exact age and sex structure of Grey Langur groups in Xuan Lien NR. However, obtained data indicate that Grey langur group consists of adult males, adult females, juveniles, infants and/or newborns. Each component has at least one individual, and number of adult females is larger than number of adult male (Table3.5)

Table 3.5. Age and sex structure of 5 Grey langur groups

Group name	Number of observations which recognize group structure	Number of observed individuals (individual)					
		Adult male	Adult female	Juveniles	Infant	Newborn	Un-identifiable
Group 1	1	1	1	-	1	1	3
Group 2	5	1 -3	2	1-4	-	1	3-22
Group 3	14	1 -5	1- 8	1 -7	4	1- 3	5-20
Group 4	6	1	1 – 5	1 – 3	-	1- 2	4-10
Group 5	5	1 – 2	3 – 4	3- 20	3	1- 3	3-17

3.1.3. Group organization

In Xuan Lien NR, two types of group organization were observed: Group of 1 male and many females, and Group of many males and many females. Each group has a strong male as a group head. During this study, there are 24 times observing group sex structure, within it there are 13 times (54.2%) observing group of 1 male and many female, and 11 times (45.8%) observing groups of many males and many females

3.2. Distribution of Grey langur in Xuan Lien NR

3.2.1. Distribution by habitat types

In Xuan Lien NR, Grey Langur distributes/lives in 4 forest habitat types: 1) Limestone evergreen forest, 2) Subtropical little-affected evergreen forest, 3) Tropical little-affected evergreen forest, and 4) Mixed wood-bamboo forest (Figure 3.2). Within them, Grey langur was found most in 3 first habitat types while for Mixed wood-bamboo forest, Grey Langur was found only in Pu Co mountain summit and Pu Khoe Mountain summit (Yen Nhan Commune) belonging to forest compartment 499.

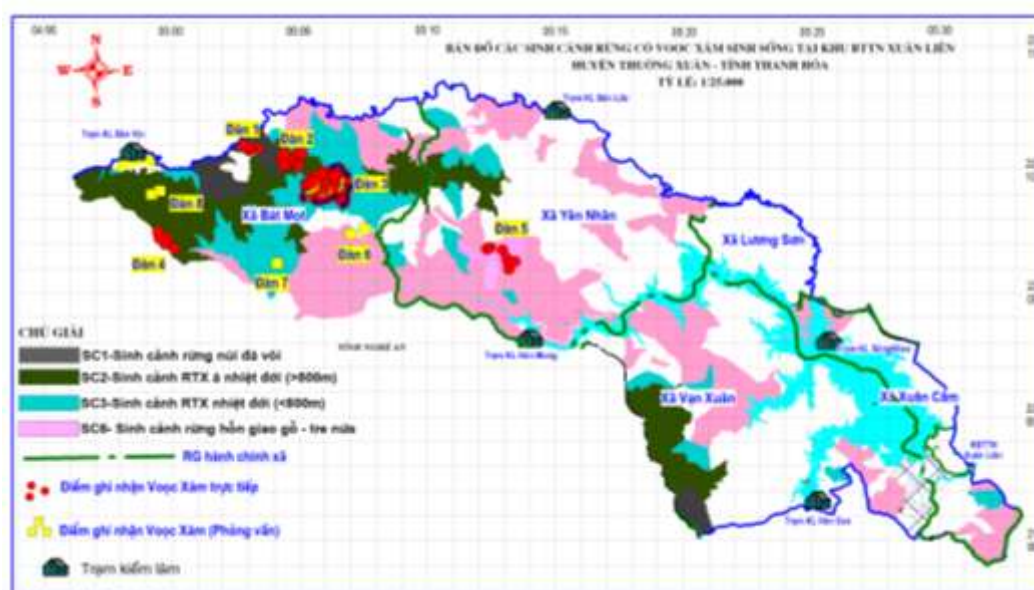


Figure 3.2. Distribution by habitats of Grey Langur in Xuan Lien NR

3.2.2. Distribution by geographic areas and altitude

In Xuan Lien NR, Grey Langur lives in 4 forest habitat types with total area of about 12,444 ha, accounting for 53.5% of the total area of Xuan Lien NR. Regarding altitude, the Grey Langurs were found at altitudes ranging of 490 to 1,217 m asl. (Table 3.9)

Table 3.9. Altitude of Grey Langur group records

Group name	Compartment	Altitude (m)
Group 1	489	660-720
Group 2	495	820- 1.090
Group 3	485, 495	590-1029
Group 4	497	1.100-1.217
Group 5	499	490-765

Thus, the results of this study indicate that in Xuan Lien NR, Grey Langur live at altitude range from 490 to 1.217 m asl.

3.3. Some ecological features of Grey Langur

3.3.1. Food of Grey Langur

* Food items

Results of studies on Xuan Lien NR, Cuc Phuong EPRC and Hanoi Zoo recorded 58 plant species from 28 families are food plants of Grey Langur.

* Feature of Grey Langur food

Within recorded 58 species of Grey Langur food plants, 44 species are wood species accounting for 74.6% of the total recorded food plant species. Height percentage of wood trees indicates that forest habitat with high abundance of trees would more favorable for Grey Langur. Except for these key food items from plant parts, Grey Langur also need natural mineral source for their body development

3.3.2. Home range size

This study has found Grey Langur appearing in 294 grid quadrats of 0.01 km² each, of which, 44 quadrats were found in 2015 and 250 quadrats were found in 2016 (Figure 3.2). Based on these data, home range size of Grey Langur in Xuan Lien NR was calculated at 294 ha ($HRs_{(100 \times 100 \text{ m})} = 294 \times 0,01 = 2,94 \text{ km}^2$).



Figure 3.3. Map of localities of recording Grey Langur Group 3 in Xuan Lien NR

3.3.3. Behavior

The data on behavior of Grey Langur was collected within 4 months (October to November 2016, January 2017 and March 2018) in natural forest habitats in Xuan Lien NR. Totally, 72 hours observing and 5,663 records of behavior were obtained, including Feeding (Fe), Grooming (Gr), Observing (Ob), Resting (Re), Social communication (S), Travel (Tr) and Un-identifiable (Un).

** Distribution of time budget between behavior types*

The study results show that, in Xuan Lien NR, Grey Langur spent more time for Feeding (48.88%) and Resting (21.89%), other behavior types have little time budget: Social communication (15.03%), Travel (6.20%), Observing (5.75%), Grooming (1.64%) and Un-identifiable (0.61%)

**Change of behavior time budget by months*

Comparison of behavior time budget between different months (October - November 2016, January 2017 and March 2018) shows that in Xuan Lien NR, Grey Langur has a change of behavior time budget by months. The langurs spent more time for Feeding in October 2016 (63.24%) and in March 2017 (58.06%), less time budget for Feeding in November 2016 (44.28%) and January 2018 (33.64%). Grey langur also spent more time for Resting in January 2017 (38.37%) and October 2016 (25.05%) and less time spent for Resting in March 2017 (15.89%) and November 2016 (14.28%). Regarding Travel, Grey langur spent more time for in November 2016 (7.98%), October 2016 (6.74%), March 2017 (5.88%) and less time in January 2017 (3.72%). Social communication has more time budget in January 2017 (19.21%), November 2016 (17.19%), March 2017 (16.21%) and less time budget in October 2016 (2.19%).

** Change of behavior time budget by age classes*

There is difference in behavior time budget between age classes of Grey Langur. Adults spent more time for Feeding(51.79%) than sub-adults (37.70%) and infants (4.08%) did. Adults also spent more time for Resting (23.29%) than infant (21.16%) and sub-adults (4.02%) did. However, these are only preliminary data because of poor data about sub-adults and infants. Infants spent more time for social communication (69.12%) than sub-

adults (33.42%) and adults (11.05%) did. Oppositely, sub-adults spent more time for Travel and Grooming(14.14% and 2.49% respectively) than adults (5.86% and 1.65%) and infants (0.78% and 0.05%) did.

3.4. Characteristics of Grey Langur Habitat

3.4.1. Area, distribution and forest status

** Limestone evergreen forest (Habitat 1)*

This habitat has small area of about 767.15 ha, accounting for 3.28% of the total area of Xuan Lien NR. This habitat is distributed on limestone mountains which is concentrated mostly in Pu Nam Mua area in Northwest of Xuan Lien NR and a small patch in Pu Gio Mountain in Southwest of Xuan Lien NR. The terrain is deeply dissected, average steepness of 25-45°, some area, up to 60-70°. Karst terrain is complicated, difficultly accessible, altitude can reach more than 800 m asl in some areas.



Figure 3.7. Limestone evergreen forest habitat

** Subtropical evergreen forest (Habitat 2)*

Habitat Subtropical evergreen forest comprises subtropical dense evergreen broadleaved forest. This habitat has an area of about 2,337.20ha, accounting for 9.96% of the total area of Xuan Lien NR. Habitat 2 is distributed at altitude of 800 - 1,600 m asl, concentrated mostly in areas of Trai Keo, Vung Bo, Pu Nam Mua in Northwest of Xuan Lien NR and partly in Pu Gio mountain in Southwest of the Nature Reserve. Terrain is granite-mountainous, deeply dissected, average steepness of 25 - 40°

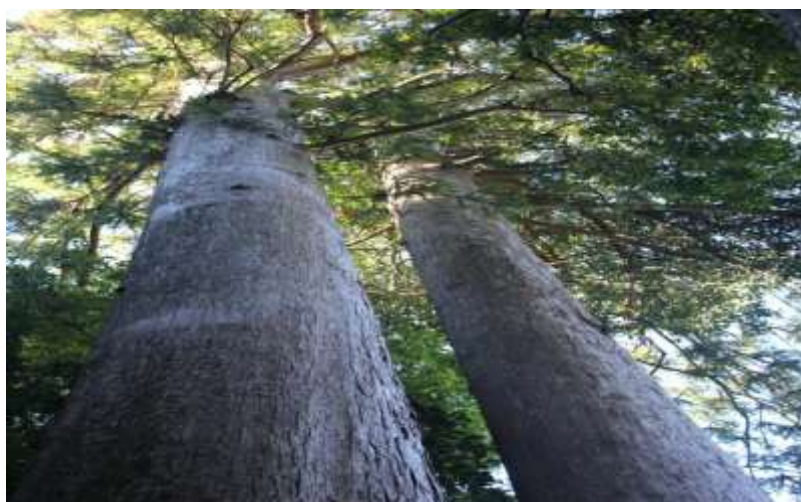


Figure 3.8. Subtropical evergreen forest habitat

** Tropical evergreen forest habitat (Habitat 3)*

This habitat type has an area of 2,801.33 ha, accounting for 11.97% of the total area of Xuan Lien NR. The habitat is distributed in elevations under 800 m asl, concentrated mostly in Pu Nam Mua and Hon Hich mountains of the Nature Reserve. This habitat has mountainous, deeply dissected terrain, average steepness is 25 - 40°. In this habitat, there are many streams with water running round year; humidity is high.



Figure 3.9. Tropical evergreen forest habitat

** Mixed wood-bamboo forest habitat (Habitat 6)*

Mixed wood-bamboo habitat has an area of 6,617.3 ha, accounting for 26.65% of the total area of Xuan Lien NR. This habitat is distributed scattered from Xuan Cam Commune to Bat Mot Commune. This habitat was originated from Tropical evergreen as the consequence of forest clearing for agricultural fields or selected timber logging. Main vegetation component of this habitat are bamboo species intergrown by several dominant tree species such as *Ormosia balansae*, *Neolitsea oblongifolia*, *Clethra delavayi*.



Figure 3.7. Mixed wood-bamboo forest habitat

3.4.2. Specific structure features of Grey Langur forest habitats

** Species composition of trees in high forest layers and groups of dominant species*

Results of tree inventory recorded 3,129 trees in 45 standard quadrats and 1,406 trees in 5 phenological transects. These trees belong to 290 species, 139 genera and 56 families.

** Basic structure criteria of high forest layers*

In 45 surveyed standard quadrats, 205 tree species were identified including 71 species in Habitat 1 (34.6%), 82 species in Habitat 2 (40.0%), 101 species in Habitat 3 (49.3%), and

110 species in Habitat 6 (53.7%). Average tree density in these habitats varies from 521 trees/ha in Habitat 6 to 789 trees/ha in Habitat 3.

Average total habitat basal area (G , m^2/ha) of trees varies from 22.50 m^2/ha in Habitat 6 to 196.14 m^2/ha in Habitat 2. Actually, the Habitat 2 has a forest of very good quality, just similar to pristine forest. Habitat 6 has a forest of lowest quality due to low number of trees. In this habitat, dominant are light-tolerant, fast-growing species which form the high layer of the forest.

Biodiversity index Shanon - Wiener (H') is 3.41 - 3.64 without significant difference between 4 habitats. Habitat 6 - Mixed wood-bamboo forest habitat has highest species diversity index ($H'=3.64$) with 110 plant species recorded. Many light-tollerant, fast-growing species found in standard quadrats has $DBH \geq 10cm$ (such as *Clethra delavayi*, *ormosia balansae*, etc.) entered in the species composition formula. Lowest H' is in Habitat 3 ($H'=3.41$).

Simpson index (Cd) of 4 Grey langur habitats varies from 0.04 to 0.10, approximating limit 0 ($0 \leq Cd \leq 1$). This indicates low dominance of species in this habitat, there is no absolute dominance species in 4 forest habitats. Relationship with Simpson indexes (Cd) always has value and significance opposited index H' , this indicates that the less Cd is the more H' and vice versa.

Average forest coverage varies by 4 habitats from 0.6 to 0.78. The largest change in forest coverage occurred in Habitat 6, ranging from 0.3 to 0.8, followed by Habitat 1 (0.55-0.80) and Habitat 3 (0.55-0.9). The most stable forest coverage was found in Habitat 2 (0.7- 0.85).

Average DBH varies by 4 habitats, ranging from 20.0 to 39.6 cm. Average DBH is highest in Habitat 2 ($39.0 \pm 41.9cm$) and lowest in Habitat 6 ($20.0 \pm 12.3 cm$). This habitat is characterized by presence of many light-tollerant, fast-growing tree species which can grow under shade of bamboos in their first stage.

Under-branch height (Hdc) is correlated with total tree height (Hvn). Habitat 1 has the largest average Hvn ($18.4 \pm 5.8cm$) and average Hdc ($10.7 \pm 4.5 cm$). These measurements are lower in Habitat 2, Habitat 3 and Habitat 6. Variation between Hvn and Hdc is not large, average Hvn varies from 15.4 - 18.4 indicating the stability of the Habitats.

* Important Value Index of high forest layers

Habitat 1: It was inventoried in standard quadrats 71 tree species of 50 genera and 31 families. There are 3 dominant species with $IVI \geq 10\%$ including *Hopea mollissima* ($IVI = 63.4\%$), *Aglaia odorata* ($IVI = 18.9\%$) and *Gironniera subaequalis* ($IVI = 11.4\%$). Two species entered into composition formula by IVI include *Hopea mollissima* and *Aglaia odorata*, and 01 species (*Hopea mollissima*) is a food plant species of Grey Langur.

Habitat 2: It was inventoried in standard quadrats 82 tree species of 60 genera and 35 families. There are 9 dominant species with $IVI \geq 10\%$ including *Fokienia hodginsii* with highest IVI ($IVI = 32.2\%$), then *Hopea mollissima* ($IVI = 24.4\%$) and *Cunninghamia konishii* with lowest IVI . Three species entered into composition formula by IVI including *Fokienia hodginsii*, *Hopea mollissima* and *Castanopsis chinensis*, and 01 species (*Hopea mollissima*) is a food plant species of Grey Langur.

Habitat 3: It was inventoried in standard quadrats 101 tree species of 69 genera and 40 families. There are 3 dominant species with $IVI \geq 10\%$ including *Clethra delavayi* ($IVI = 43.9\%$), *Hopea mollissima* ($IVI = 26.1\%$) and *Vatica chevalieri* ($IVI = 12.6\%$). Two species entered into composition formula by IVI including *Clethra delavayi* and *Hopea mollissima*

and 01 species (*Hopea mollissima*) is a food plant species of Grey Langur.

Habitat 6: It was inventoried in standard quadrats 110 tree species of 71 genera and 37 families. There are 7 dominant species with $IVI \geq 10\%$ including *Ormosia balansae* with highest IVI ($IVI = 34.9\%$), followed by *Huodendron biaristatum* ($IVI = 21.4\%$), and *Vernicia montanau* has lowest IVI ($IVI = 10.7\%$); Three species entered into composition formula by IVI including *Ormosia balansae*, *Huodendron biaristatum*, *Clethra delavayi*. No food plant species of Grey Langur was found in quadrats in this Habitat.

** Tree frequency by DBH and total height classes*

Majority of trees in all 4 habitat has DBH ranging within 10-58 cm, namely, these trees account for 95.8% of the total number of trees found in the Habitat 1; 81.74% in Habitat 2, 96.99% in Habitat 3; 97.7% in Habitat 6 (Figure 3.11 and Figure 3.12). They are trees of forest layer A2 and A3 where Grey Langur spent most of its feeding times. Trees with $DBH > 102\text{cm}$ were found mostly in Habitat 2 and account for 6.13%; there are some trees of *Cunninghamia konishii* have DBH of 380 cm.

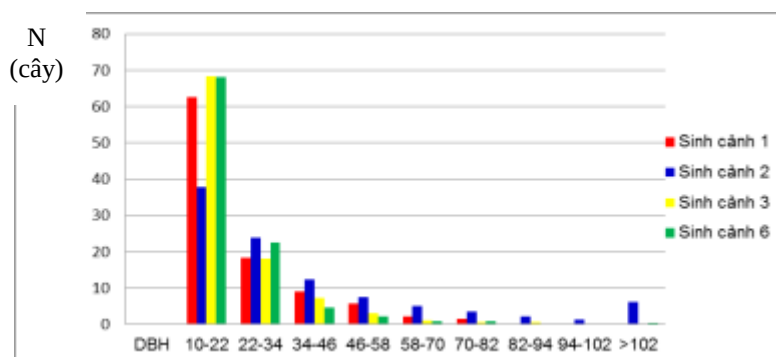
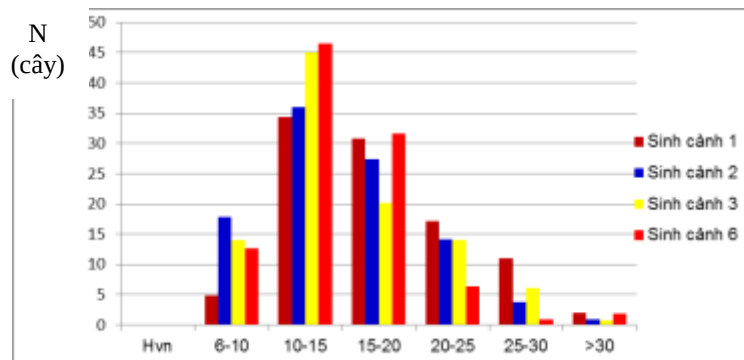


Figure 3.11. Diagram of tree DBH distribution



Hình 3.12. Diagram of tree Hvn distribution

** Out-layer plant species*

This study has found 46 out-layer plant species, within them, 36 species are lianas, 10 species are parasite. Some of common out-layer plant species are *Drynaria fortunei*, *Asplenium nidus*, *Piper saxicola*, *Rhaphidophora decuasiva*, *Pothos grandis*, etc. Two species are food plants of Grey Langur including *Sarcostigma paniculata* and *Schefflera brevipedicellata*.

** Features of regenerating trees in Grey Langur habitats*

- Species composition of regenerating trees

In Habitat 1, it was recorded 60 species of regenerating trees, of which 2 species were entered into composition formula: *Hopea mollissima* (28.3%), *Archidendron chevalieri*

(15.5%) and 58 other species (56%).

In Habitat 2, it was recorded 86 species of regenerating trees, of which 4 species were entered into compistion formula: *Hopea mollissima* (20.5%), *Cinnamomum parthenoxylon* (7.4%), *Cryptocarya annamensis* (6.2%), *Engelhardtia roxburghiana* (5.3%) and 82 other species (61%).

In Habitat 3, it was recorded 85 species of regenerating trees, of which 4 species were entered into compistion formula: *Hopea mollissima* (25.15%), *Archidendron clypearia* (8.3%), *Clethra delavayi* (7.1%), *Cinnamomum parthenoxylon* (5.0%) and 81 other species (54.6%).

In Habitat 6, it was recorded 82 species of regenerating trees, of which 5 species were entered into compistion formula: *Archidendron clypearia* (27.1%), *Ormosia balansae* (13.8%), *Clethra delavayi* (7.0%), *Camellia sinensis* (6.7%), *Co khet* (5.2%) and 77 other species (40%).

- Percentage of regenerating plants as food plants of Grey Langur

Habitat 1: Five (5) of 31 families of regenerating plants contains Grey Langur food plant species, accounting for 16.13%. They are Euphorbiaceae, Clusiaceae, Dipterocarpaceae, Phyllanthaceae, Sapindaceae. Five (5) of 60 species of regenerating plants are Grey Langur food plant species, accounting for 8.3%. They are *Macaranga denticulata*, *Garcinia oblongifolia*, *Hopea mollissima*, *Baccaurea ramiflora*, *Nephelium cuspidatum* Blume var. *bassacense*.

Habitat 2: Three (3) of 37 families of regenerating plants contains Grey Langur food plant species, accounting for 10.81%. They are Clusiaceae, Dipterocarpaceae, Sapindaceae. Three (3) of 61 species of regenerating plants are Grey Langur food plant species, accounting for 3.49%. They are *Garcinia oblongifolia*, *Hopea mollissima*, *Nephelium cuspidatum* Blume var. *bassacense*.

Habitat 3: Four (4) of 45 families of regenerating plants contains Grey Langur food plant species, accounting for 8.89%. They are Dipterocarpaceae, Clusiaceae, Alangiaceae, Sapindaceae. Four (4) of 85 species of regenerating plants are Grey Langur food plant species, accounting for 8.89%. They are *Hopea mollissima*, *parthenoxylon*, *Garcinia oblongifolia*, *Alangium kurzii*, *Nephelium cuspidatum* Blume var. *bassacense*.

Habitat 6: Two (2) of 36 families of regenerating plants contains Grey Langur food plant species, accounting for 5.56%. They are Clusiaceae, Dipterocarpaceae. Two (2) of 82 species of regenerating plants are Grey Langur food plant species, accounting for 2.44%. They are *Garcinia oblongifolia*, *Hopea mollissima*.

- Density and quality of regenerating plants in Grey Langur Habitats

The density of regenerating plants is highest in Habitat 6 (7,864 trees/ha) and lowest in Habitat 2 (6,412 trees/ha)

The origin of the regenerating trees is mainly seeds, ratio of seed-regenerating is highest in Habitat 1 (96.81%) and lowest in Habitat 2 (50.9%)

3.4.3. *Some phenological features of Grey Langur habitats*

Monthly variation in availability of potential food of Grey Langur in each habitats was studied on 1,402 mature trees of 158 species occurring in 5 phenological transects set up in 4 forest habitats (Habitat 1, Habitat 2, Habitat 3 and Habitat 6).

** Phenology of buds in forest high layers in phenological transects*

Buds occurred all round year, the bud abundance was highest in May (92%), lowest in cold months from October (35%) to December (44%), and medium from April (82%) to August (77%). Regarding 5 food plant species of Grey Langur, bud abundance was relatively stable between months, highest is from April (12.6%) to August (11.6%)

** Phenology of young leaves in forest high layers in phenological transects*

Young leaves occurred all round year, their abundance was highest in May (90.5%), lowest in cold months from November (45.9%) to December (47.4%), and medium from April (87.1%) to August (89.0%). Regarding 5 food plant species of Grey Langur, leaf abundance was relatively stable between months, highest is from April (12.9%) to August (11.0%)

** Phenology of mature leaves in forest high layers in phenological transects*

Mature leaves occurred all round year without significant variation between months, their abundance was highest in January (96.7%) and medium from February (77.2%) to December (96.2%). Regarding 5 food plant species of Grey Langur, adult leaf abundance was relatively stable between months, relatively higher from January (7.2%) to December (9.5%)

** Phenology of flowers in phenological transects*

Availability ratio of flowers was low and equally changed between months, their abundance was highest in May (7.8%), lowest in February (1.3%) and medium from March (3.1%) to July (5.3%).

** Phenology of fruits in phenological transects*

Green fruits: Availability ratio of green fruits was low and regularly changed between months, their abundance was highest in September (8.1%), lowest in February (1.0%) and medium from June (6.5%) to October (8.0%).

Ripe fruits: Availability ratio of ripe fruits was low and regularly changed between months, their abundance was highest in December (6.1%), lowest in May (0.1%) and medium from January (4.2%) to February (1.1%) and from August (3.6%) to December (6.1%)

** Phenology of known Grey Langur Food plants in the phenological transects*

Within 98 tree species occurred in 4 phenological transects, five (5) are food plant species of Grey Langur (Table 3.20 in Dissertation). Phenological ratios of these tree parts are stable within 12 months. Tree parts which Grey langur uses as food including buds, young leaves, mature leaves have high phenological ratio in period from April to August. This phenological cycle is similar to those in other tree species in the phenological transects

3.5. Current status of management and conservation of Grey Langur in Xuan Lien NR

3.5.1. Threats to Grey Langur population and its habitat

* Direct threats

Wildlife hunting/snaring; selected timber removal, harvesting of Non-timber forest products, free raising of cattles inside forest, fuelwood collecting and others

* Indirect threats

High povety ratio, low efficiency of agricultural land use, low cultural standard, high rate of people increase, low efficiency of management of wildlife hunting and trade, infrastructure development in buffer zone

3.5.2. Conservation awareness of local communities

Evaluation of knowledge, attitude and awareness of local communities on Grey Langur conservation and biodiversity conservation was based on analysis of interview information for 549 persons (499 males and 50 females). Majority of interviewees perceives importance of forest as water source maintaining (87.43%), providing medicinal plants and other forest products (80.69%), providing timber (19.49%) and as habitats for forest animals and plants (22.4%).

General knowledge on importance of Xuan Lien NR of local communities living around the Reserve core zone is relatively good in relation to providing and maintaining water sources, fuel materials and part of medicinal material and other food stuff. Knowledge on governmental laws on forest protection and conservation is medium, knowledge on endangered animal species is limited.

Attitude of households participating in forest management /protection and development, protection of plant and animal species is limited. Attitude on utilization of forest products from Xuan Lien NR is relatively good. Attitude on importance of Xuan Lien NR is good. Attitude on the forest management organization is that Government should maintain a special organization responsible for the forest management.

Awareness of communities in buffer zone of Xuan Lien NR on forbidden activities in Nature Reserve is under medium. Awareness of trend of forest products is relatively good. Awareness on importance of Reserve establishment is relatively good. Awareness on factors causing decline of forest resources in the Reserve is suitable to current situation. Awareness on measures for sustainable protection of forest resources is confined on poverty-reducing policies and strong will of timber use and wildlife hunting.

3.5.3. Conservation of Grey Langur in Xuan Lien NR

- *Awareness education for communities:* Raising awareness of villagers on Grey Langur conservation is the top priority.

- *Forest patrolling for forest protection law enforcement:* Eleven (11) villages in buffer zone belonging to 5 communes in the boundary of Xuan Lien NR is given priority on offering the contracts on allocation of core zone forests for protection. Each village organized a Forest Protection Team of 25-50 people depending number of households in the village. The members of Forest Protection Team were voted by villagers and final list of the Team members was appoved by Communal People Committee.

- *Scientific research:* In Xuan Lien NR there are many scientific research projects conducted by Vietnamese and foreign scientists. Majority of the projects is concentrated on biodiversity assessment, study of population status of various species including Grey

Langur.

- *Supporting livelihood of communities living in buffer zone* : Community-based forest protection activities. Integrating scientific research with conservation of endangered species. Transferring technological advances for local communities is combined with development of high efficient economic models, etc. All these activities contribute to increasing efficiency of biodiversity conservation in Xuan Lien NR.

3.6. Recommending measures for conservation of Grey Langur in Xuan Lien NR

3.6.1. Intensification of awareness raising education and enforcement

Activity 1: To increase awareness on conservation of Grey Langur conservation and protection of its habitats in Xuan Lien NR.

Activity 2: Integrating Grey Langur conservation and protection of its habitat into Village Agreement on forest protection and sustainable utilization and development of forest resources of Villages situated in buffer zone of Xuan Lien NR.

Activity 3: Conducting regular forest patrols, periodic monitoring of precious, rare and endangered plant and animal species of conservation priority including Grey Langur. This activity should involve active participation of Forest Protection Teams in villages situated around Xuan Lien NR.

Activity 4: Control over hunting guns, snares/traps that use for forest animal hunting

3.6.2. Improvement of livelihood of communities living the Reserve buffer zone

Activity 5: Conducting participatory landuse planning in buffer zone, especially the areas surrounding the Xuan Lien NR.

Activity 6: Transferring new technological advances for production in the Reserve buffer zone.

3.6.3. Research, survey, monitoring of Grey Langur population and protection/restoration of Grey Langur habitats

Activity 7: Regularly monitoring Grey Langur population based on study of its biology, ecology and status; timely catching the change on population size, activity areas of the population, factors causing the changes for development of relevant conservation measures.

Activity 8: Protection and restoration of Grey Langur habitats

Activity 9: Developing the Programme "Sustainable use of forest resources in Xuan Lien NR"

CONCLUSION, WEAKNESS, RECOMMENDATION

1. Conclusion

1.1. Current population status and distribution of Grey Langur in Xuan Lien NR

- In Xuan Lien NR, it was recorded 5-6 groups of Grey Langur, of which 5 groups were recorded by directly observation and one group was recorded by other study in 2012. Total number of Grey langur by direct sighting is 129 individuals and estimated number is 180 individuals. If 2 groups temporarily recorded by interview data is taken into account, total

number of Grey langur by direct sighting is 151 individuals and estimated number is 224 individuals. Each group contains at least on adult male, many adult females, juveniles and infants/newborns. Head of the group is a strong adult male. Xuan Lien NR is recognized to harbor one of the a largest populations of Grey Langur in Vietnam and thus the Reserve is very important for conservation of this primate species in Vietnam.

- It was calculated home range of Grey Langur in Xuan Lien NR as about 219 ha.

- Grey Langur distributes in 4 forest habitats including Limestone evergreen forest, Subtropical evergreen forest, Tropical evergreen forest and Mixed wood - bamboo forest. Total area of these 4 habitats is 12,523 ha, accounting for 53% of the total area of Xuan Lien NR. These forests have good quality, abundance of food sources and high security for sustainable development of Grey Langur population in Xuan Lien NR

- Grey langur lives at altitude ranging from 490 - 1,217 m asl, belonging to 7 forest compartments 484, 485, 489, 495, 497, 499 and 505. Together with forest quality, security of habitat plays important role in selecting distribution area of Grey Langur in Xuan Lien NR

1.2. Food of Grey Langur

- It was identified 58 plant species of 28 families as food plants of Grey Langur, of which, 18 species were directly recorded in Xuan Lien NR including 15 tree species, 2 liana species and 1 bamboo species belonging 16 genera, 12 families. In each food plant species, Grey Langur only choose to eat one or some parts including buds, young leaves, mature leaves, young branches, leaf petioles, young stems, bark, flower, green fruits, ripe fruits and seeds.

- Low phenological variation of plant parts (leaves, flowers, fruits, seeds) of high forest layers by annual cycle indicates stable abundance of food source for Grey Langur within all months. Phenological ratios of 5 known food plant species of Grey Langur found in phenological transects are stable in all 12 months. Plant parts eaten by Grey Langur (buds, young leaves, mature leaves) all have high availability in period from April to August.

1.3. Behavior of Grey Langur

Grey Langur spent much of time for Feeding (48.88%) and Resting (21.89%), while spent much less time for other behaviors including Social communication (15.03%), Travel (6.20%), Observing (5.75%), Grooming (1.64%) and un-identifiable (0.61%). Time budget of Grey Langur behaviors varies between months and age classes.

1.4. Features and structure of Grey Langur habitats

- All habitats of Grey Langur contains natural forest of good quality: forest has many layers, canopy height is from 15.4 ± 5.0 to 18.4 ± 5.8 m, average tree density is from 521 trees/ha to 798 trees/ha; diverse tree composition (290 species of 139 genera, 56 families), less than 10 tree species in forest high layers having IVI ≥ 40 % of the total IVI in the habitat.

- In all Grey Langur habitats it was inventoried 33 dominant tree species including *Hopea mollissima*, *Aglaia odorata*, *Madhuca pasquieri*, *Fokienia hodginsii*, *Cunninghamia konishii*, *Elaeocarpus balansae*, *Vatica chevalieri*, *Cinnamomum parthenoxylon*, *Xerospermum noronhianum*, *Castanopsis chinensis*, etc.

- All Grey Langur habitats have a good tree regeneration capacity, which help to maintain the current forest structure and food source for Grey Langur. It was inventoried 169 regenerating tree species of 118 genera and 57 families; density of regenerating trees is from

6,412 to 7,864 trees/ha, ratio of high potential regenerating trees (having height of over 1.5m) reaches 13.9% in Habitat 2, 39.8% in Habitat 1. Ratio of regenerating trees of good quality is from 71% in Habitat 2 to 100% in Habitat 1; ratio of regenerating food plants is from 2.4% in Habitat 6 to 8.3% in Habitat 1.

1.5. Threats and recommended measures for Grey Langur conservation

- Direct threats to Grey Langur population and its habitat in Xuan Lien NR include: illegal timber removal, illegal wildlife hunting, harvesting non-timber forest products, cattle raising in forest, fuel wood collecting and other disturbances by local residents. Indirect threats are high poverty percentage, low land use efficiency, limited cultural standard, high population increase ratio, un-controlled wildlife hunting and trade and increasing of infrastructure construction

- Local communities living in buffer zone of Xuan Lien NR has relatively good knowledge, attitude and awareness on importance of Xuan Lien NR for overall biodiversity conservation and Grey Langur conservation in particular

- In order to conserve and sustainably develop the Grey Langur population in Xuan Lien NR, 3 groups of measures and 9 activities were recommended. They are 1) Intensifying conservation awareness raising education and enforcement; 2) Improving livelihood of buffer zone communities; and 3) Research, survey, monitoring of population of Grey Langur and protection, restoration of Grey langur habitats

2. Weakness

The data of this thesis were collected during long period from June 2014 to June 2017. However, due to many constraints such as complicated terrain in study area (highly steep, deeply dissected), unfavorable weather conditions, study object (Grey Langur) with low density, distributed in remote areas and very scared of human presence, and limited material and human sources for the study, etc. the data on feeding, foods and behavior could not obtained as much as required.

3. Recommendation

- Data collected for this thesis is an important scientific background for development of measures for conservation and sustainable development of Grey Langur population in Xuan Lien NR in particular and in Vietnam in general. The management measures recommended in this thesis are important hints, which the conservation organizations should apply to improve efficiency of Grey Langur conservation in Xuan Lien NR as well as in Vietnam.

- More surveys, research on ecology and behaviour of Grey Langur population in Xuan Lien NR is necessary to add more scientific data for conservation and sustainable development of this endangered species.

LIST OF PUBLICATIONS RELATED TO THE THESIS

1. Nguyen Dinh Hai, Nguyen Xuan Dang, Dang Huy Phuong, Nguyen Mau Toan, Nguyen Xuan Nghia (2016). Current status of Grey Langur *Trachypithcus crepusculus* in Xuan Lien Nature Reserve, Thanh Hoa Province. Journal of Biology (38): 162 - 170 (in Vietnamese with English summary). [Nguyễn Đình Hải, Nguyễn Xuân Đăng, Đặng Huy Phương, Nguyễn Mậu Toàn, Nguyễn Xuân Nghĩa (2016), "Hiện trạng quần thể Voọc xám (*Trachypithcus crepusculus*) ở Khu bảo tồn thiên nhiên Xuân Liên, tỉnh Thanh Hóa", Tạp chí Sinh học, (38), trang 162-170.]

2. Nguyen Dinh Hai, Nguyen Xuan Dang, Nguyen Mau Toan (2017). Some data on foods of Grey Langur *Trachypithcus crepusculus* in Vietnam. Journal Agriculture and Rural Development (7): 112-119. (in Vietnamese with English summary).[Nguyễn Đình Hải, Nguyễn Xuân Đăng, Nguyễn Mậu Toàn (2017), "Một số dẫn liệu mới về thức ăn của Voọc xám (*Trachypithcus crepusculus*) ở Việt Nam", Tạp chí Nông nghiệp và Phát triển nông thôn, (7), trang 112-119.]

3. Nguyen Dinh Hai, Nguyen Xuan Dang, Nguyen Mau Toan (2017). Study of some features of forest structure and floral species diversity in habitat of Grey Langur *Trachypithecuscrepusculus* in Xuan Lien Nature Reserve. Journal Agriculture and Rural Development, pp. 172-178. (in Vietnamese with English summary).[Nguyễn Đình Hải, Nguyễn Xuân Đăng, Nguyễn Mậu Toàn (2017), "Nghiên cứu một số đặc điểm cấu trúc rừng và tính đa dạng thành phần loài thực vật trong các sinh cảnh của Voọc xám (*Trachypithecuscrepusculus*) ở Khu bảo tồn thiên nhiên Xuân Liên", Tạp chí Nông nghiệp và Phát triển nông thôn, trang 172 – 178].