GROUP COMPOSITION AND BEHAVIOR PRELIMINARY STUDY OF LAOTIAN BLACK CRESTED GIBBON (*NOMASCUS CONCOLOR LU*) AROUND BAN TOUP, NAM KAN NATIONAL PROTECTED AREA, LAO PDR

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การศึกษาโครงสร้างกลุ่มและพฤติกรรมเบื้องต้นของชะนีแก้มดำบริเวณบ้านตูบ ป่าสงวนแห่งชาติน้ำก่าน สาธารณรัฐประชาธิปไตยประชาชนลาว

นายสิงพร หลวงลือไช

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาชีววิทยาสิ่งแวดล้อม
มหาวิทยาลัยเทคโนโลยีสุรนารี
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สิงพร หลวงลือไช : การศึกษาโครงสร้างกลุ่มและพฤติกรรมเบื้องต้นของชะนีแก้มดำ *NOMASCUS CONCOLOR LU* บริเวณบ้านตูบ ป่าสงวนแห่งชาติน้ำก่าน สาธารณรัฐประชาธิปไตยประชาชนลาว (GROUP COMPOSITION AND BEHAVIOR PRELIMINARY STUDY OF LAOTIAN BLACK CRESTED GIBBON (*NOMASCUS CONCOLOR LU*) NEAR BAN TOUP, NAM KAN NATIONAL PROTECTED AREA, LAO PDR). อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร.พงศ์เทพ สุวรรณวารี, 96 หน้า.

ชะนีแก้มดำลาวเป็นสิ่งมีชีวิตที่ถูกคุกคาม และพบอาศัยในภาคเหนือของสาธารณรัฐประชาธิปไตยประชาชนลาวเท่านั้น การศึกษาสมาชิกในฝูงและพฤติกรรม กระทำโดยการติดตามชะนีจำนวน 4 ฝูง เป็นเวลา 4-7 วัน จากเดือนสิงหาคมถึงพฤศจิกายน พ.ศ. 2556 บริเวณบ้านตูบ ในป่าสงวนแห่งชาติน้ำก่าน การศึกษาพบชะนีทั้งสิ้น 20 ตัว เฉลี่ย 5 ตัวต่อฝูง มี 2 ฝูงที่พบตัวผู้ตัวเดียวแต่มีตัวเมียสองตัว ในขณะที่อีก 1 ฝูง ไม่มีลูกอ่อน หรือวัยเด็กเลย

จากการเฝ้ามองเป็นช่วง ๆ ชะนีเต็มวัยตัวผู้และตัวเมียใช้เวลาในการเดินทางมากที่สุด ร้อยละ 25 รองลงมาคือ การกินอาหารและการเฝ้าระวัง แต่ชะนีวัยหนุ่มสาว วัยเด็ก และวัยทารกกลับใช้เวลาส่วนใหญ่ในการเล่น รองลงมาคือ การเดินทางและการเฝ้าระวัง การที่ชะนีใช้เวลาจำนวนมากในการเดินทางหาอาหารและการกินอาหาร อาจเนื่องมาจากมีแหล่งอาหารไม่เพียงพอ และมีการรบกวนจากมนุษย์มากในพื้นที่ศึกษา

มีเพียงชะนีตัวโตเต็มวัยและวัยหนุ่มสาวเท่านั้นที่ร้อง ชะนีชนิดนี้ส่งเสียงร้องในตอนเช้าตั้งแต่ 06:04 ถึง 07:36 โดยร้องเป็นเวลานาน 28 ± 5 นาที จากต้นไม้ที่ชะนีใช้ร้องจำนวน 35 ต้น พบว่าเป็นพืช 9 ชนิด ชนิดที่มีจำนวนมากที่สุดคือ *Spondias lakhonensis* Pierre ร้อยละ 22.9 ตามด้วย *Ficus benjamina* ร้อยละ 20.0 และ *Spondias axillaris* Roxb ร้อยละ 17.1 ตามลำดับ ชะนีกินพืช 15 ชนิด จากพืชที่พบ 131 ต้น พืชที่ชะนีชอบที่สุดคือ *Spondias lakhonensis* Pierre ร้อยละ 27.9 รองลงมาคือ *Ficus hispida* L. ร้อยละ 15.1 *Ficus benjamina* ร้อยละ 11.6 และ *Choerospondias axillaris* ร้อยละ 10.5 ตามลำดับ โดยชะนีทั้งตัวผู้และตัวเมียเลือกที่จะกินผลมากที่สุด ร้อยละ 72.9 รองลงมาคือ ใบอ่อน ร้อยละ 14.7 ดอก ร้อยละ 6.9 และใบแก่ ร้อยละ 5.4 ตามลำดับ

ชะนีเดินทาง 1.4-3.0 กิโลเมตรต่อวัน เฉลี่ย 2.3±0.6 กิโลเมตรต่อวัน พวกมันออกหาอาหารคิดเป็นพื้นที่ 9.0-37.4 เฮกแตร์ต่อวัน เฉลี่ย 19.1±7.9 เฮกแตร์ต่อวัน พื้นที่หากินต่อวันนี้มีความแตกต่างอย่างมีนัยสำคัญในชะนีแต่ละฝูง

SINGPHONE LUANGLEUXAY : GROUP COMPOSITION AND BEHAVIOR PRELIMINARY STUDY OF LAOTIAN BLACK CRESTED GIBBON (*NOMASCUS CONCOLOR LU*) AROUND BAN TOUP, NAM KAN NATIONAL PROTECTED AREA, LAO PDR**.** THESIS ADVISOR : ASST. PROF. PONGTHEP SUWANWAREE, Ph.D. 96 PP.

GIBBON/ *NOMASCUS CONCOLOR LU*/ BEHAVIOR/ NAM KAN

Laotian black crested gibbon (*Nomascus concolor lu*) is a globally threatened species and only lives in northern Lao PDR. Group compositions and behavior of this gibbon was investigated by following 4 gibbon groups for 4-7 days from August to November 2013 at Ban Toup, Nam Kan National Protected Area. A total of 20 individuals were found with mean group size of 5.0 individuals. Interestingly, two groups had one adult male and two adult females while one group had no juvenile or infant.

From scan sampling technique, adult males and adult females spent most time on travelling (25%), followed by feeding and watching but sub adults, juveniles and infants spent most time on playing, followed by traveling and feeding. Gibbon spent most time on feeding and traveling more than other behaviors, due to not enough food patches and high human disturbance.

Only adults and sub adults call. They sang early morning calls after dawn between 06:04 to 07:36. The calls lasted 28 ± 5 minutes. From 35 singing trees found, nine plant species were identified. The highest number was *Spondias lakhonensis*

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CHARPTER I

INTRODUCTION

1.1 Backgrounds and Problem

Laotian black crested gibbon (*Nomascus concolor Lu*) is listed as critically endangered species (Bleisch *et al.*, 2008) and there are only a few populations in the northern Laos that remain entirely unstudied. In 1939, this gibbon was discovered at Ban Nam-Khueng in Bokeo province, northwestern Lao. A dozen individuals were collected, which were subsequently described as a new subspecies (Delacour, 1951). The Laotian black crested gibbon only occurs in small populations in Nam Kan National Protected Area (NPA), Bokeo province. An additional small population in Nam Ha NPA, Luang Namtha province, Lao PDR.

In 1999, 13 gibbon groups were found in Ban Toup and Ban Lor Xor in the southern half of Nam Kan NPA (Geissmann, 2007). Later Robichaud *et al.* (2010) surveyed and interviewed villagers in and around Nam Kan NPA and they reported 9 to 14 groups of Laotian black crested gibbon in the southern part and later reported 10 to 14 groups were found at Ban Chomsy forest area and in the north central of the NPA mostly in the catchments of the upper Nam Touey and Nam Hmongnoy (Timmins and Duckworth, 2013). In addition, five gibbon groups were found in Nam Ha NPA in 2003 (Johnson *et al.*, 2005) which is only adjacent national protected area located on the north

next to this study site. However, only one group was found three years later at the same location (Brown, 2009). This group still remains in that area as confirmed recently by Luangluexay and Suwanwaree (2012). Therefore, Nam Kan NPA is very important for conservation of this gibbon population as the only site that can support viable population of this gibbon.

The population of Laotian black crested gibbons has declined due to habitat loss and hunting, habitat degradation and deforestation. These activities also inhibit sustainable economic development, particularly for rural communities who are often entirely dependent upon local natural resources. Hunting by both local villagers and outsiders appears to be the most important issue directly affecting the recovery of the gibbon. Nam Kan NPA is easily accessible to markets in China via transportation along the Mekong River and the R3 road which runs through the protected area (Robichaud *et al*., 2010). Therefore, this study is the first effort to understand the activity and feeding proportion and home range of Laotian black crested gibbon in Nam Kan NPA. Results of this study would be useful for conservation planning and management of the species in the future.

The Gibbon Experience ecotourism is the best way to protect forest and wildlife habitat of this area. The team has long been looking for innovative methods to change the villagers' idea that they can make a non-destructive living from their unique environment, by protecting the forest and farming at the lower altitude flat lands. Gibbon Experience supports the monitoring and protecting the forest from external

logging and poaching local people. Now the Gibbon Experience has proved that taking care of the forest can be a profitable activity for all.

1.2 Research Objectives

The objectives of the study are: To identify group composition of Laotian Black crested gibbon at the Gibbon Experience ecotourism near Ban Toup, Nam Kan National Protected Area, Bokeo province, Lao PDR.

1) To observe behaviors of adult male, adult female, sub adult, juvenile and infant of this gibbon.

2) To characterize singing trees, feeding trees, feeding proportion, movement and foraging area of this gibbon.

1.3 Scope and Limitations of the Study

The study site was located at Gibbon Experience around 1 km in the West of Ban Toup in Nam Kan NPA. Four gibbon groups were selected and followed for 4-7 day each group per month from August to November 2013. Group composition, behaviors, singing trees, feeding trees, feeding proportion, movement and foraging area were observed. We could not follow the gibbons for the whole day and the same length of time for each group due to bad weather in the field. We could follow each gibbon group only one time due to funding limit

CHAPTER II

LITERATURE REVIEW

2.1 Gibbons

Gibbon constitutes the small ape among the order primates of the class Mammalia. There are 17 gibbon species (Table 2.1) in four genera (*Hylobates, Hoolock, Nomascus and Symphalangus*) living in tropical and subtropical rainforests of south Asia, China and south east Asia (Figure 2.1), from northeast India to Indonesia and southern China, including the islands of Sumatra, Borneo, and Java (Van Ngoc Thinh *et al*., 2010).

Lao PDR has a high diversity of gibbons, as second to only Indonesia in the world (Duckworth, 2008). Seven species occur in Lao PDR of which Black crested gibbon (*Nomascus concolor lu*) and Northern white-cheeked gibbon (*Nomascus leucogenys*), are globally list as critically endanger and all others such as Northern buffed-cheeked gibbon (*Nomascus annamensis*), Red-cheeked gibbon (*Nomascus gabriellae*), Lar gibbon (*Hylobates lar*), Pileated gibbon (*Hylobates pileatus*) and Southern white-cheeked gibbon (*Nomascus siki*) are endangered. Gibbons are distributed throughout Lao PDR; the two species of Hylobates are found west of the Mekong River and the five species of *Nomascus* are found east of the Mekong River (Bleisch *et al*., 2008).

Table 2.1 Gibbon species, distribution and conservation status (Bleisch *et al*., 2008).

No	Scientific name	Common name	IUCN Red List Status	Distribution
1	*Hylobates agilis*	Agile gibbon	Endangered	Indonesia, Malaysia and Thailand
2	*Hylobates albibarbis*	Bornean white-bearded gibbon	Endangered	Indonesia
3	*Hylobates klossii*	Kloss's gibbon	Endangered	Indonesia
4	*Hylobates lar*	Lar gibbon	Endangered	Indonesia, Lao PDR, Malaysia, Myanmar and Thailand
5	*Hylobates moloch*	Silvery Javan gibbon	Endangered	Indonesia
6	*Hylobates muelleri*	Müller's Bornean gibbon	Endangered	Indonesia and Malaysia
7	*Hylobates pileatus*	Pileated gibbon	Endangered	Thailand, Lao PDR and Cambodia
8	*Hoolock hoolock*	Western hoolock gibbon	Endangered	India, Myanmar and Bangladesh
9	*Hoolock leuconedys*	Eastern hoolock gibbon	Vulnerable	China and Myanmar
10	*Nomascus annamensis*	Northern buffed-cheeked gibbon	Not assess	Vietnam, Cambodia and Lao PDR
11	*Nomascus concolor*	Black crested gibbon	Critically endangered	China, Lao PDR and Viet Nam
12	*Nomascus gabriellae*	Red-cheeked gibbon	Endangered	Cambodia, Viet Nam and Lao PDR
13	*Nomascus hainanus*	Hainan gibbon	Critically endangered	Hainan Island, China
14	*Nomascus leucogenys*	Northern white-cheeked gibbon	Critically endangered	Viet Nam, Lao PDR and Yunnan, China
15	*Nomascus nasutus*	Cao-vit crested gibbon	Critically endangered	Viet Nam and China
16	*Nomascus siki*	Southern white-cheeked gibbon	Endangered	Lao PDR and Viet Nam
17	*Symphalangus syndactylus*	Siamang	Endangered	Indonesia, Malaysia and Thailand

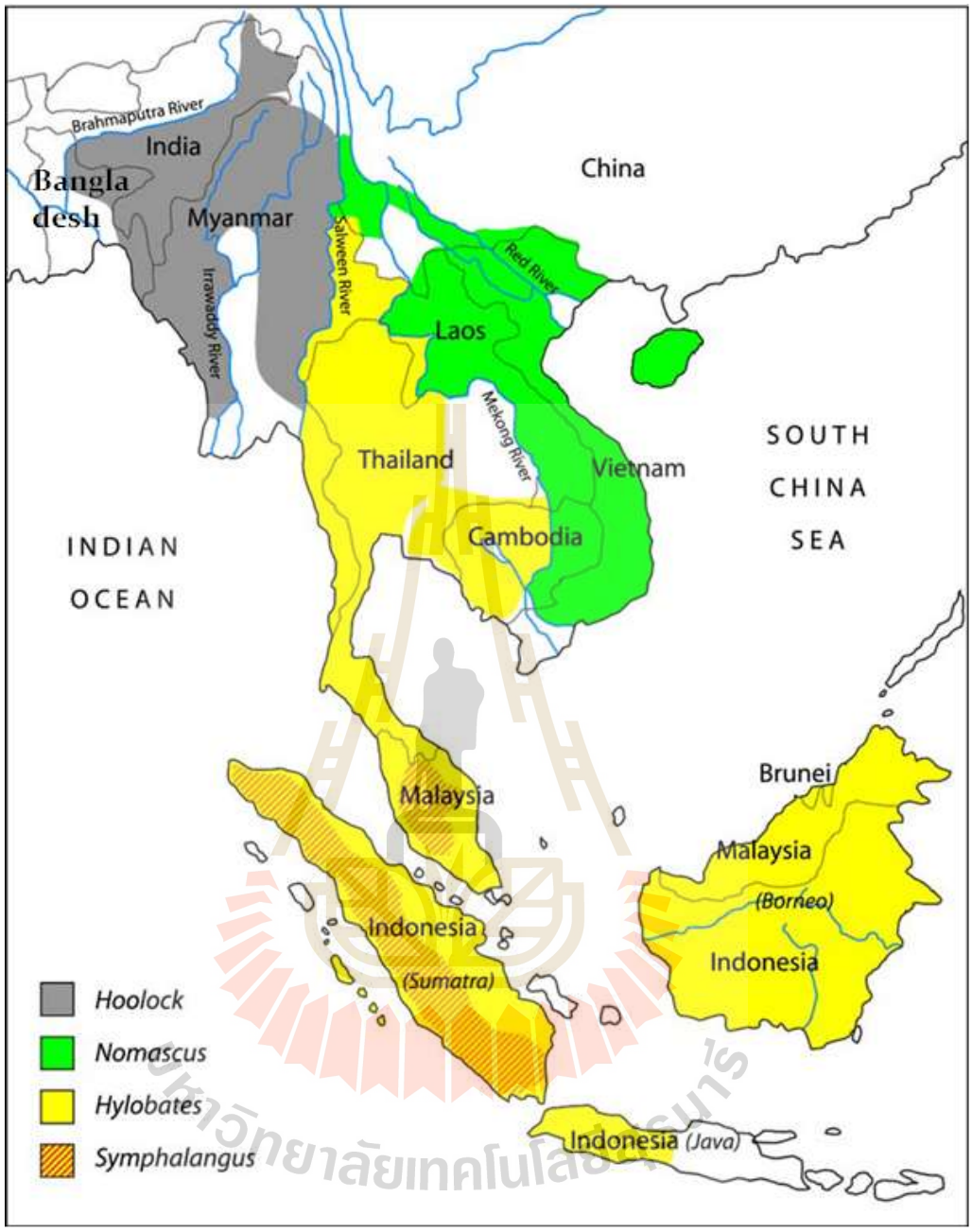

Figure 2.1 Geographical distributions of four gibbon genera (Mootnick and Fan, 2011).

2.2 Black crested gibbon (*Nomascus concolor*) [Harlan, 1826]

2.2.1 Taxonomy

Domain Eukarya

Kingdom Animalia

Phylum Chordata

Class Mammalia

Order Primates

Family Hylobatidae

Genus *Nomascus*

Species *Nomascus concolor*

The black crested gibbon has been divided in to four subspecies: particularly the Tonkin black crested gibbon (*N. c. concolor*), the West Yunnan black crested gibbon (*N. c. furvogaster*), the Central Yunnan black crested gibbon (*N. c. jingdongensis*) and the Laotian black crested gibbon (*N. c. lu*). Each subspecies has only minimal molecular differences among *N. c. concolor*, *N. c. furvogaster* and *N. c. jingdongensis* (Mootnick and Fan, 2011).

2.2.2 Description

Adult males are completely black. A few single white hairs may occur in the corner of the mouth. Adult females are pale yellow, yellow, orange or beige brown. Adult females have a black cap and a large, often rhomboid area with black hairs on the ventral area (Figure 2.2). The amount of ventral black varies. In some females, the whole ventral fur maybe black, strongly contrasting with the light back, at the other end of the range, the ventral fur may be merely interspersed with some black hairs

(Geissmann *et al*., 2000). Black Crested Gibbons are not monkeys but apes. Males are all black with black hairless faces while females are yellowish-beige with black hairless faces and black patches on the top of their head, chest and abdomen. Females and males generally weigh from 6.9 to 10 kg (average 8 kg) and measure between 43 and 54 cm (average 50 cm). Gibbons have the longest arm length relative to body size of all primates. Gibbons' arms are about twice the length of their body and one and a half times the length of their legs. This sexual dichromatic develops with age, the female changes from black to buff or tawny coloration in early adulthood (Mootnick and Fan, 2011).

Male Female with infant

Figure 2.2 Adult male and adult female with infant of *Nomascus concolor* (Rawson *et al*., 2011).

Darker fur coloration, which was originally considered to be distinctive for females of Laotian black crested gibbon, turned out to be based on inclusion of sub adult females which have not completely finished their colour change from juvenile black to adult yellow. Fully adult females do not exhibit these characteristics. Males of Laotian black crested gibbon have also been reported to exhibit a silvery-black line between eye and ear (Geissmann *et al*., 2000).

Black crested gibbons communicate through vocalizations, including calls and songs, by most between 6:00 am to 7:00 am in the morning but possibly start from 5:00 am to10:00 am. While singing the animal has physical interactions and facial expressions. The song of black crested gibbon maybe used for variety of purpose, including defense of resources and establishment of territories, as well as attracting mates and strengthening pairs bonds (Geissmann, 2007).

2.2.3 Population and Distribution

Black crested gibbon global population is estimated at 1,300-2,000 individuals and occurs discontinuously in southwestern China, northwestern Lao PDR and northern Viet Nam (Geissmann *et al*., 2000; Figure 2.3). *N. c. concolor* estimated at 40 to 300 individuals lived in southwestern Yunnan, China (Jiang *et al*., 2006) and 59 individuals were found at Lao Cai, Yen Bai, Son La, and Lai Chau Provinces in northern Viet Nam (Le Trong Dat and Le Ming Phong, 2001). It is found between the Song Da (Black) and Song Hong (Red) rivers, north to 23°45'N and south to about 20°N (Groves, 2001).

N. c. furvogaster, estimated at 50 to 100 individuals, occurs in southwestern Yunnan, southern China (Jiang *et al*., 2006). It is found only in a small region near the

Myanmar border, west of the Mekong river from 23°15’ to 23°40’N and 99°05’ to 99°29’E (Groves, 2001). *N. c. jingdongensis*, estimated at 195 to 450 individuals, occurs in west-central Yunnan, southern China (Jiang *et al*., 2006). It is found only in a small region around Wuliang Mountain, between the Mekong and Chuanhe River about 24 to 25°N (Groves, 2001). *N. c. lu*, expected up to 200 individuals, occurs in northwestern Lao PDR. An isolated population, it is known for certain only in a tiny area on the east bank of the Mekong river at about 20°17’ to 20°25’N. It has been confirmed in Nam Ha NPA, Luang Namtha province, and Nam Kan NPA, Bokeo province (Johnson *et al.*, 2005; Brown, 2007; Geissmann, 2007).

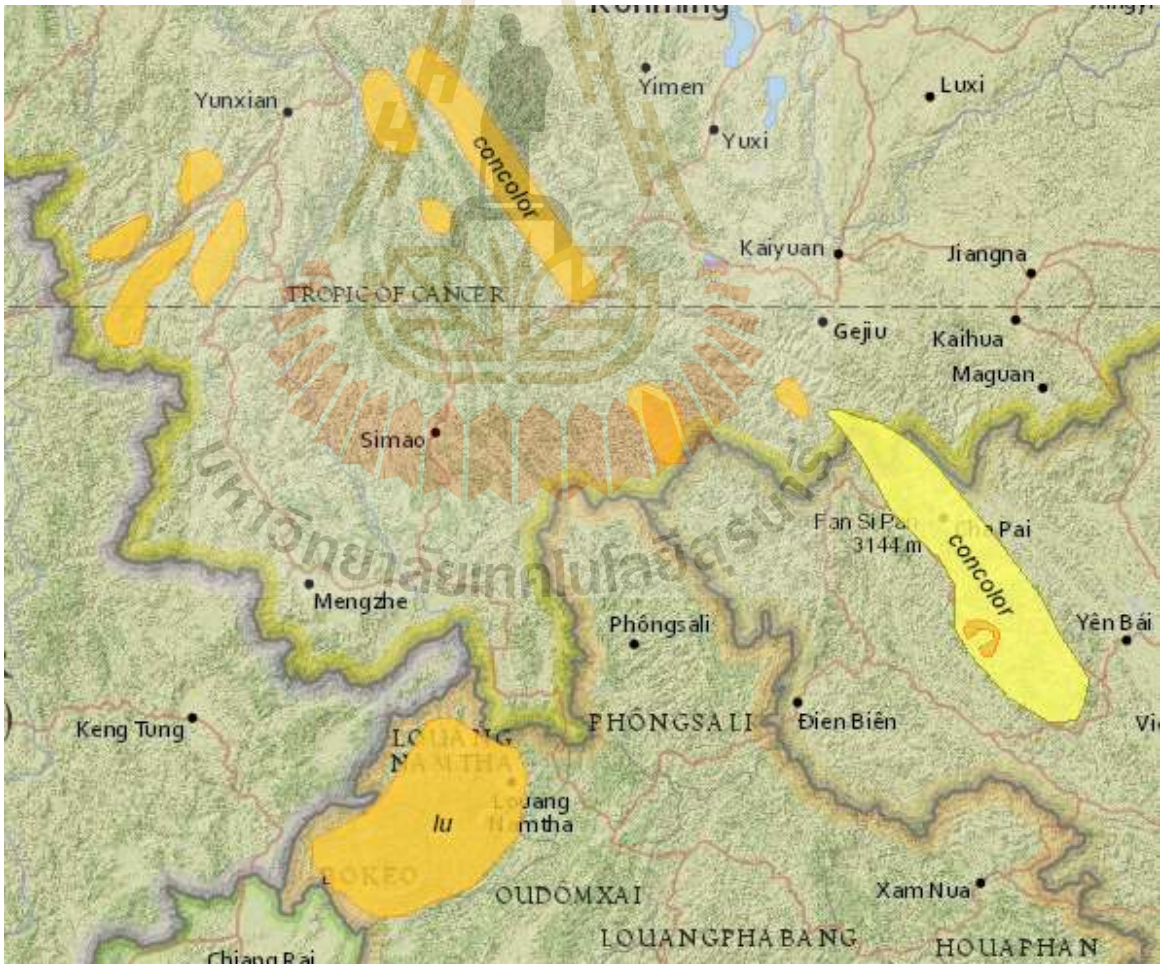

Figure 2.3 Distribution of *Nomascus concolor* (Bleisch *et al*., 2008).

2.2.4 Habitats

The black crested gibbon occurs in subtropical and montane evergreen, semi-evergreen and deciduous forest (Bleisch *et al*., 2008). In China it is likely restricted to broadleaved evergreen forests. In Yunnan province, it occurs at altitude ranging from 1,900 to 2,790 m, but at other sites in Yunnan the species may also occur at elevation as low as 500 m. In northern Viet Nam, the species was reported at elevation of 1,600 to 2,000 m and in Nam Kan NPA Lao PDR, it was found at 450 to 900 m, but mainly above 550 m. The main forest type since which they are species found in Nam Kan NPA is dry evergreen and mixed deciduous forest (Timmins and Duckworth, 2013).

2.2.5 Group Structure

Black crested gibbons live in typically small monogamous groups of family units, most of which consist of a pair of adults, one male and one female, and their offspring. It has been observed that some groups consist of one adult male living with two to four females and their offspring. The groups can potentially include one infant, one juvenile and one sub adult (Jiang *et al*., 1999). Other gibbons have group size average from 3 to 6 (Table 2.2).

A gibbon family is territorial and defends its territory with regular morning songs performed by the breeding male and female (Leighton, 1987). Groups have, on average, four to eight individuals and usually include an adult male and female, one juvenile and one infant, although the group may also include one adolescent and one subadult (Leighton, 1987). There is a high degree of social and behavioral equality between adult males and females and codominance is exhibited (Leighton, 1987;

Geissmann *et al.*, 2000). Because of this egalitarian social atmosphere and no competition between males for access to females, white-cheeked gibbons are not sexually dimorphic

Table 2.2 Group size average of other gibbon species.

Species	Location	Group size	References
Hoolock hoolock	Jorhat, Assam, India	3.2	Tilson (1979)
	Tripura, India	3	Kakati *et al.* (2009)
Hylobates agilis	W. Malaysia	4.4	Gittins and Raemaekers (1980); Mitani (1987)
	W. Kalimantan, Indonesia	4.1	Mitani (1987, 1990)
Hylobates klossi	Siberut, Indonesia	3.4	Tenaza (1975)
	Siberut, Indonesia	3.7	Whitten (1980)
	Siberut, Indonesia	4.1	Tilson (1981)
Hylobates lar	Khao Yai, Thailand	4.3	Brockelman *et al*. (1998); Bartlett (1999) and Reichard (1995)
	Kuala Lompat, Malaysia	3.3	Gittins and Raemakers (1980) Barelli *et al*.(2006)
	Tanjong Triang	3.3	Ellefson (1974)
	Ketambe, Sumatra, Indonesia	4.1	Palombit (1992)
Hylobates moloch	Ujung-Kulon, West Java, Indonesia	4	Kim *et al*. (2011)
	Leuweung Sancang, West	3.3	Malone and Oktavinalis (2006)
Hylobates muelleri	Kutai, Kalimantan, Boneo, Indonesia	3.4	Leighton (1987), McConkey *et al.* (2002)
Hylobates pileatus	Khao Soi Dao, Thailand	6	Srikosamatara (1984)
Nomascus nasutus	Bangliang, Jingxi, Chi	6	Fan *et al*. (2010)
Symphalangus	Ulu Sempan, Malaysia	4	Chivers (1974), Lanpan (2007)
syndactylus	Kuala Lompat, Malaysia	5	Chivers (1974)
	Kuala Lompat, Malaysia	3	Gittins and Raemaekers (1980)
	Ketambe, Sumatra, Indonesia	3.8	Palombit (1992 and 1994)
	Way Canguk, Sumatra, Indonesia	4	Lappan (2005) and O'Brien *et al*. (2003)

2.2.6 Foraging area

Gibbons are territorial animals with a restricted home range and foraging area. The sizes of foraging area vary considerably depending upon the habitat and quality of the forest (Fan *et al*., 2008). Black crested gibbon has a home range size of 100-500 ha (Table 2.3). However, there is no study on the home-range of this gibbon species that has been undertaken in Lao PDR.

2.2.7 Reproduction

Black crested gibbons reproduce once every 2 to 3 years, usually producing one offspring in each interval. The gestation period lasts about 7 to 8 months, and newborns weigh about 510 g at birth (Geissmann and Orgeldinger, 1995). Offspring are weaned at around two years of age, and they reach sexual maturity at about eight years of age. Males and older offspring also provide care to young (Geissmann and Orgeldinger, 1995).

2.2.8 Food and Feeding Behaviors

Black crested gibbons feed preferentially on ripe, sugar-rich fruit, such as figs, but occasionally consume vitamin-rich leaf buds as well as flowers and rarely eat animals (Fan *et al.*, 2009). Gibbons are typically frugivorous gibbons consumed 77 different plant species and two insect-species (Table 2.4). Buds and leaves constituted 46.5% of the diet (21.0% vine leaves and buds, 19.2% tree leaves and buds, and 6.3% epiphyte leaves). Fruits, figs and flowers accounted for 25.5, 18.6 and 9.1% of the diet, respectively (Fan *et al.*, 2009). The proportion of their food varies by season (Figure 2.4).

Table 2.3 Home range and mean group size of *Nomascus concolor* in different locations.

Scientifics name	Location	Country	Group size	Home range (ha)	References
Nomascus concolor	Xiobahe, Yunnan	China	5.25		Sheeran (1993); Lan and Sheeran (1995)
	Yunnan	China		100-200	Jiang *et al*. (1994)
	Hainan	China	5.25	200-500	Zhenhe *et al*. (1989)
	Hainan	China		300- 500	Lid *et al*. (1989)
	Che Tao/Ho Nam Mu	Vietnam	6.0		Zhenhe *et al*. (1989)
	Mt. Wuliang, Yunnan	China		150	Fan *et al*. (2009)
N. c. lu	Nam Kan NPA	Lao	3.6-3.8		Geissmann (2007)
N. c. furvogaster	Yunnan	China			Groves (2001)
N. c. jingdongensis	Central Yunnan, China	China	2.9- 6.6	151	Fan *et al*. (2008)

Table 2.4 List of plant species fed on by black crested gibbons at Mt. Wuliang, central Yunnan, China (Fan *et al*., 2009).

Family	Species	Life form	Parts eaten	Total (%)	Month(s) consumed
Araliaceae	*Pentapanax leschenaultia*	T	Fr, L, S	3.9	October–June
Betulaceae	*Betula alnoides*	T	L,B	13.1	March–April
Celastraceae	*Celastrus gemmatus*	V	Fr, L	1.2	June–August; December–January
Ericaceae	*Rhododendron siderophyllum*	T	FI	1.8	April
Gnetaceae	*Gnetum montanum*	V	Fr	1.8	October–April
Labiatae	*Leucosceptrum canum*	T	FI	4.5	January–March
Moraceae	*Ficus neriifolia*	T	Fr, L	21.6	Whole year
Moraceae	*Ficus sarmentosa*	E	Fr	2.3	April–May–July–August–October
Myrsinaceae	*Embelia ribes*	V	Fr	1.1	December–May
Orchidaceae	*Pholidota articulate*	E	L	7.8	July–March
Rosaceae	*Photinia serrulata*	V	Fr	2.3	February–March
Sabiaceae	*Sabia dielsii*	V	Fr,L	2.2	June–November; April
Saurauiaceae	*Saurauia napaulensis*	T	Fr, L	5.9	October–March
Schisandraceae	*Kadsura interior*	V	Fr, Fl	7.1	April–June (Fl); September–November (Fr)
Symplocaceae	*Symplocos ramosissima*	T	Fr	1.3	November–December
Vitaceae	*Tetrastigma delavagi*	V	Fr, L	8.1	September–May

Plant type: T tree, V vine, E epiphyte

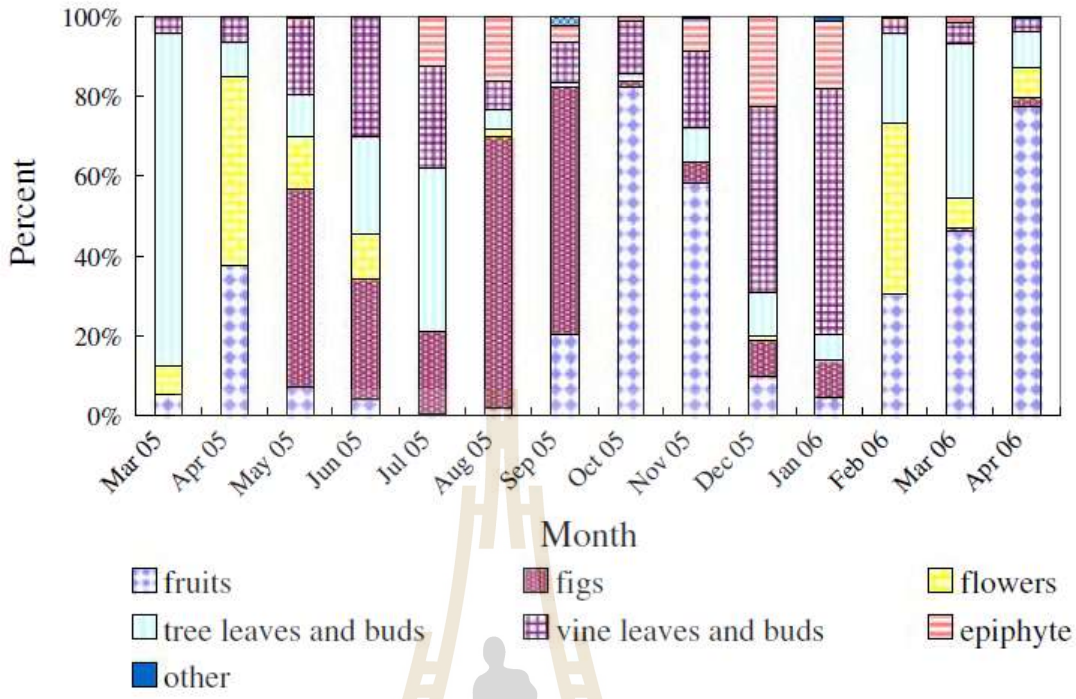

Figure 2.4 Annual change in the proportion of time spent in feeding on different foods at Wuliang Mountain (Fan *et al*., 2008).

2.2.9 Sleeping Trees

Black crested gibbons at Wuliang usually selected the highest trees (45%) as sleeping trees in the plot and also tend to sleep on the trees with the tallest and thickest canopy with large crowns on steep slopes and near important food patches. Sleeping trees were situated within 30 m of the hill ridge of the valley (Fan and Jiang, 2008). Sleeping trees may be chosen to make approach and attack difficult for predators and to provide an easy escape route in the dark (Fan and Jiang, 2008).

The members of the group typically formed four sleeping units (adult male and juvenile, adult female with one semi-dependent black infant, adult female with one dependent yellow infant, and sub adult male) spread over different sleeping tree

branches. Individuals or units preferred specific areas to sleep (Fan and Jiang, 2008). The adult male and juvenile often huddled and shared the same sleeping place, but the other gibbons slept in different trees (except for females with their dependent infants). Individuals or units tended to sit at the crotch of a large branch to sleep, and sleeping spaces were usually well covered by the crown (Fan and Jiang, 2008).

The gibbons at Wuliang usually entered the sleeping trees on average at 17:02 h (range: 15:10-18:25 h) before sunset and they left the sleeping trees on average at 7:59 h (range: 6:45-8:45) after sunrise. There were no signs of searching for sleeping trees. Individuals always moved rapidly in a straight line to the sleeping trees and their sleeping places and became silent once settled (Fan and Jiang, 2008).

2.2.10 Singing

All gibbon species are known to produce loud and long song bouts, lasting for 10-30 minutes. The black-crested gibbon sings in the morning, sometimes in duets initiated by the male. The males choose the highest tree branches, often near ridges (Fan *et al.*, 2009). The songs are thought to be used for resource defense, mate defense, pair bonding, and group cohesion and mate attraction (Geissmann, 2007). The songs are innately altruistic, as each group calls separately. The adult male and two females in the study group always sang interactively to produce duet bouts. Males, and in some also females sing solos to attract mates, as well as advertise their territories. There are three main songs referred as Great call, Duet song and solo. The solo can be made by either male or female (Table 2.5).

Table 2.5 Occurrence of Black crested gibbon song types.

No	Song types	Description	References
1	Great call	A duet bout usually consists of male loud calls repeated phrases increasing in loudness and complexity and somewhat more modulated and complex, stereotyped phrases of females called ‘‘great calls’’.	Fan *et al*. (2009)
2	Duet song	The vocalizations of gibbon male and female together. Duet song bouts, like female song bouts, usually have duration of less than 30 minutes.	Geissmann (2002)
3	Male solo song	The vocalizations of gibbon male only, the mated males of most gibbon species may engage in uninterrupted solo song bouts of considerable length, sometimes lasting more than 2 h.	Geissmann (2002)
4	Female solo song	Female solo song bouts are of shorter duration than male solo song bouts (usually less than 30 minutes). Most gibbon species do not normally produce solo song bouts.	Geissmann (2002)

CHAPTER III

MATERIALS AND METHODS

3.1 Study Area

This study was carried out at Gibbon Experience around 1 km West from Ban Toup in Nam Kan NPA, 14 km from the main road of Luangnamtha to Bokeo provinces in the South (Figure 3.1). This village belongs to Hmong ethnic group. Nam Kan NPA is situated at latitude 20°21′ to 20°23′ N and longitude 100°51′ to 100°59′ E in the northwest of Lao PDR about 60 km from Bokeo province. It covers an area of 136,000 ha, of which about 66,000 ha is in Bokeo province and 70,000 ha is in Luang Namtha province (Robichaud *et al.*, 2010). The current gibbons recorded were mainly around treehouse areas of the Gibbon Experience.

3.1.1 Climate

There are two distinct seasons at Ban Toup, Laos is a monsoon country, with a rainy season from May to September and a dry one from October to April. In 2013, the maximum temperature average was 28.0 °C and the minimum temperature average was 16.7 °C (Figure 3.2), while the rainfall average was 8.7 mm per year (Figure 3.3). Since the study site has no climatic data logger, the climatic data were collected from meteorological station at Bokeo province (Meteorology Department Bokeo province, 2013).

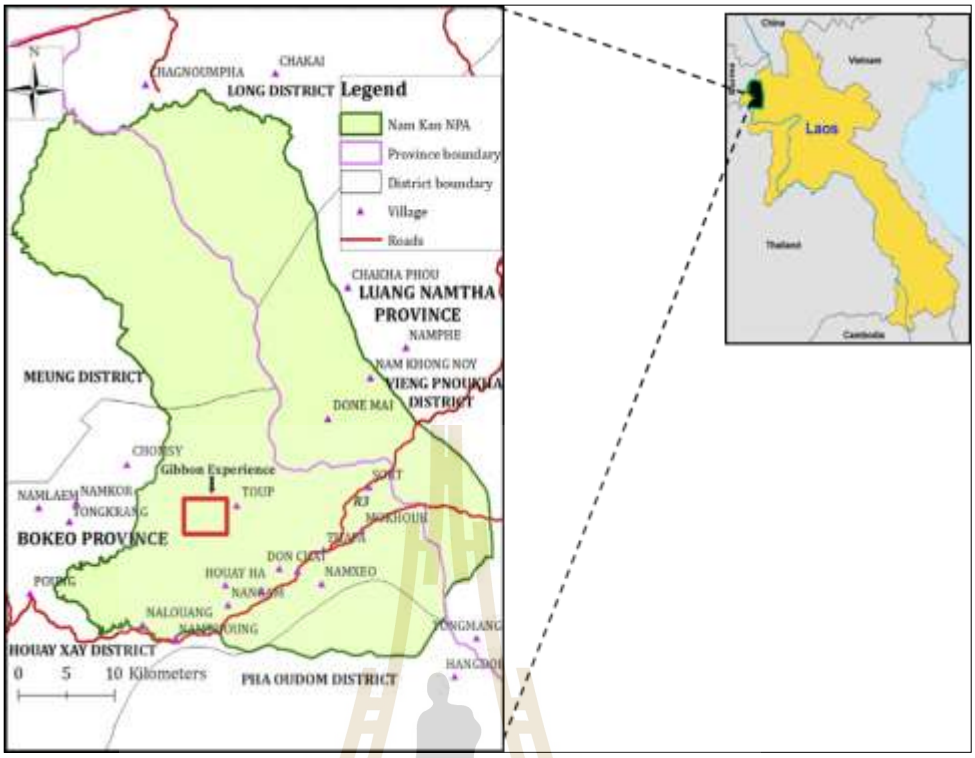

Figure 3.1 Study sites at Ban Toup in Nam Kan National Protected Area, Lao PDR.

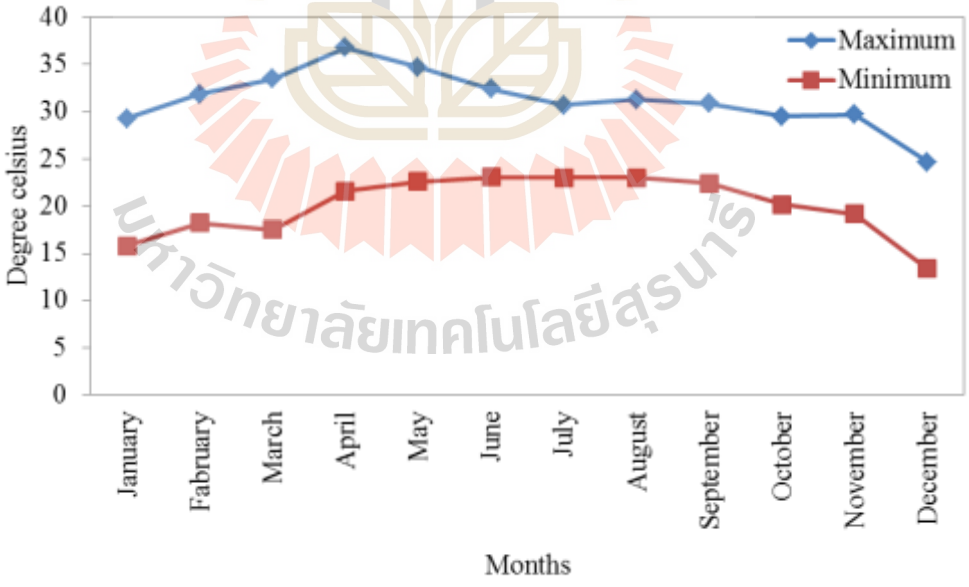

Figure 3.2 Mean monthly temperature in 2013 (Meteorology Department of Bokeo province, 2013.

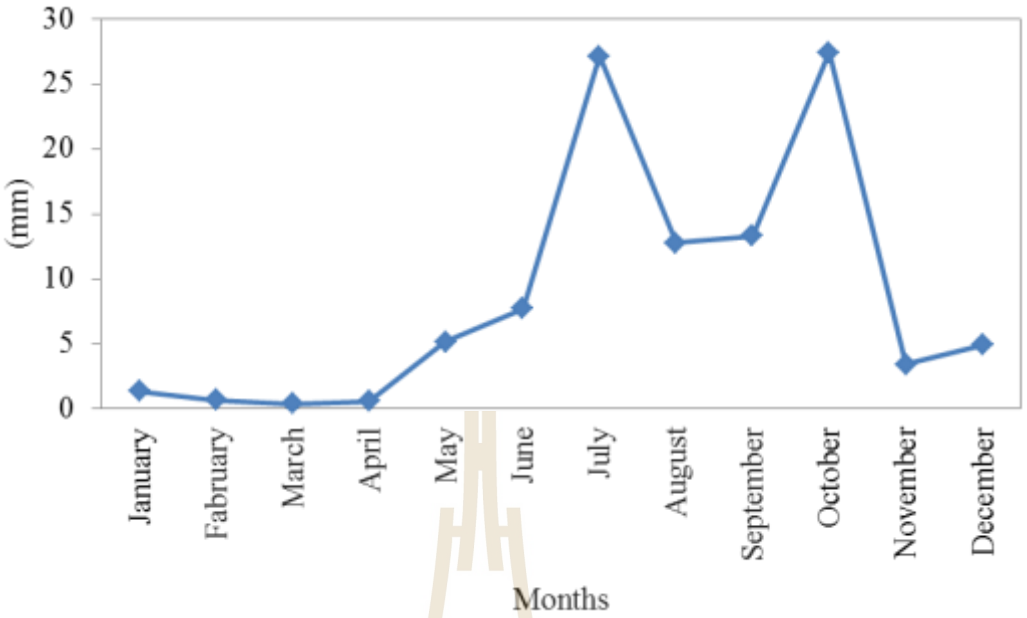

Figure 3.3 Mean monthly rainfall in 2013 (Meteorology Department of Bokeo province, 2013).

3.1.2 Topography

Nam Kan NPA has altitude ranging from 440 to 1,468 m above sea level (Figure 3.4). The Nam Kan NPA is mainly dominated with steep slope mountains and evergreen forest, tropical rain forest with outstanding scenic values. There are six main rivers such as Nam Pha Noy and Nam Touy are lying at the northern part and Nam Pea, Nam Kan, Nam Nga and Nam Ngao they lying at the central and southern parts of Nam Kan NPA (Robichaud *et al.*, 2010).

The study sites connect with Nam Nga in the North, Nam Kan and Ban Toup in the East, Nam Kok in the South and Nam Ngao in the West of Nam Kan valleys (Figure 3.5).

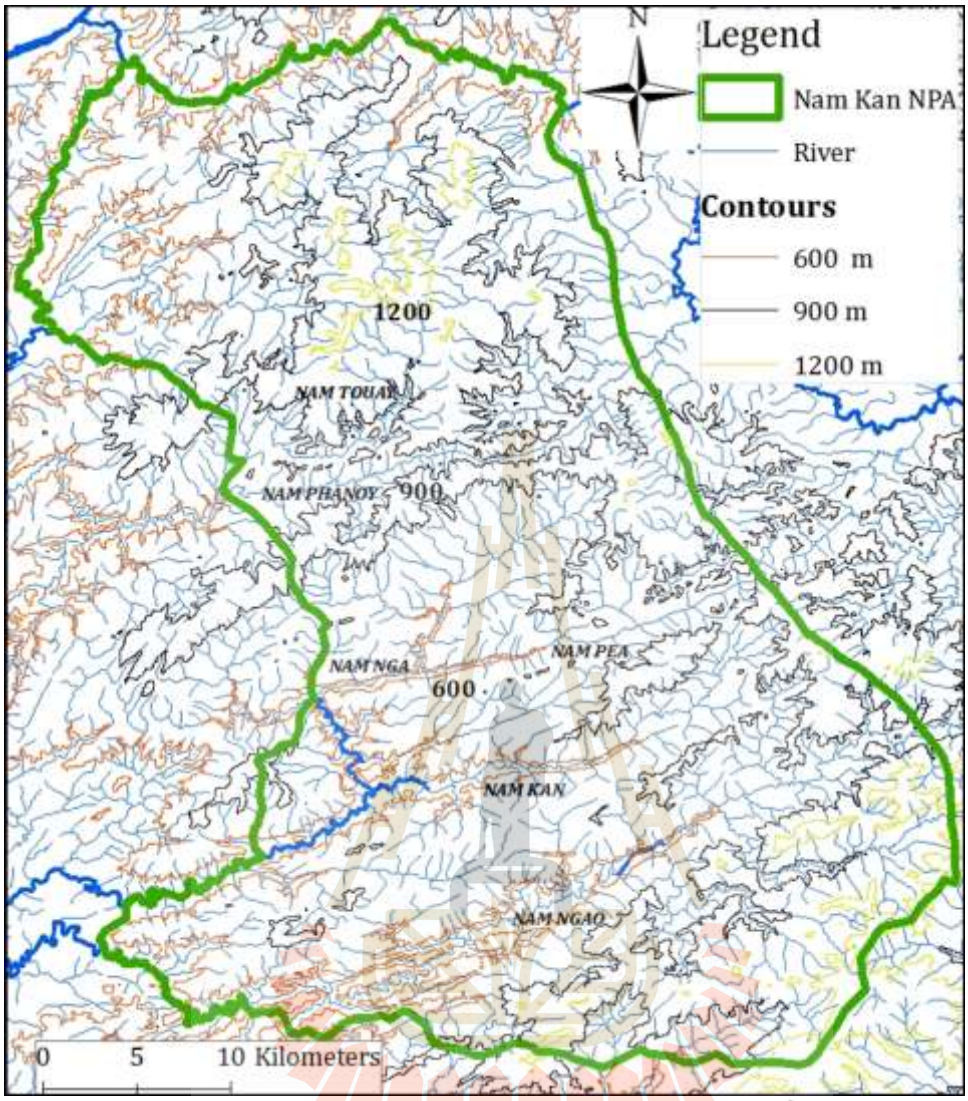

Figure 3.4 Topography of Nam Kan NPA.

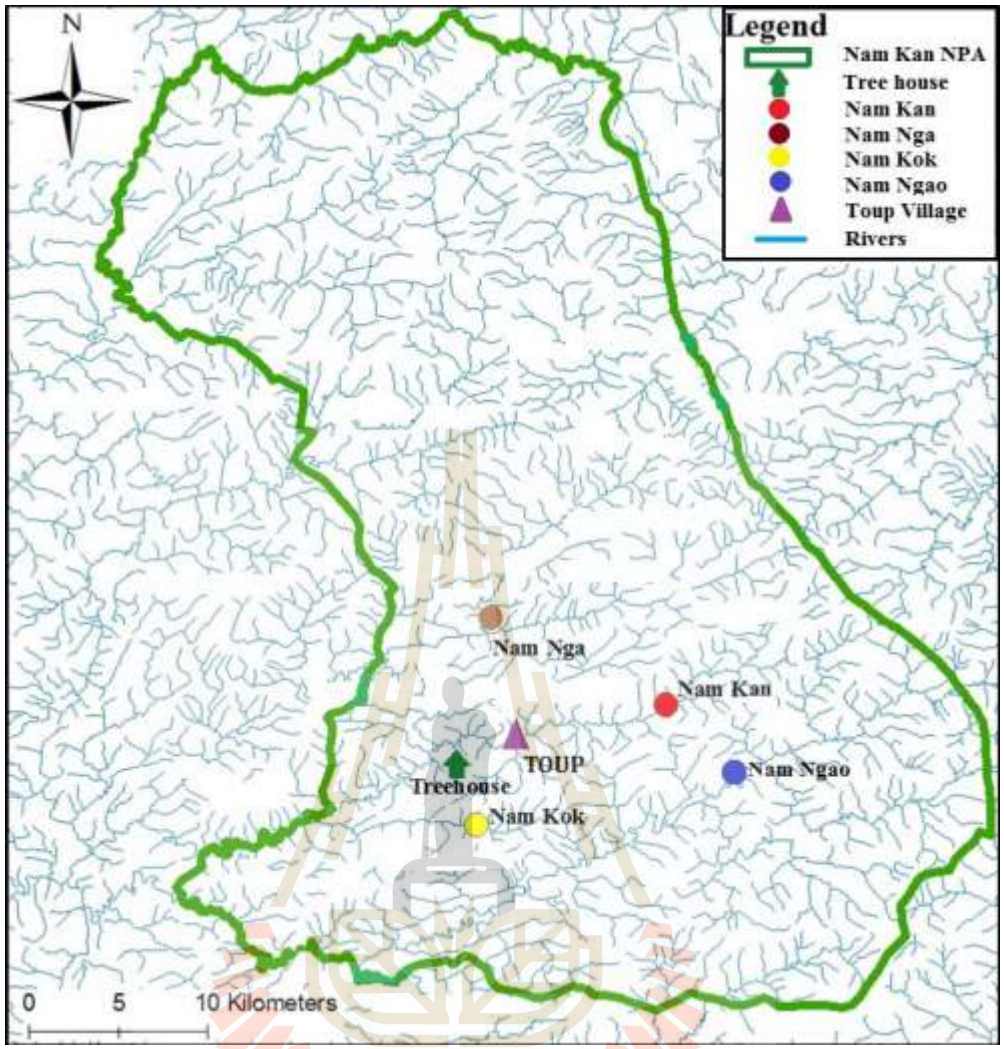

Figure 3.5 Study sites and 4 main rivers in Nam Kan NPA.

3.1.3 Land Cover

The Nam Kan National Protected Area has different forest types (Figure 3.6). Mixed deciduous forest area is 65,500 ha (48.2%) in the north and south, dry evergreen forest area is 40,200 ha (29.6%) at the central, secondary forest area is 22,000 ha (16.2%), agriculture land is 8,000 ha (5.9%) distributed around NPA and some grassland is 300 ha (0.2%) (Department of Forestry, 2005).

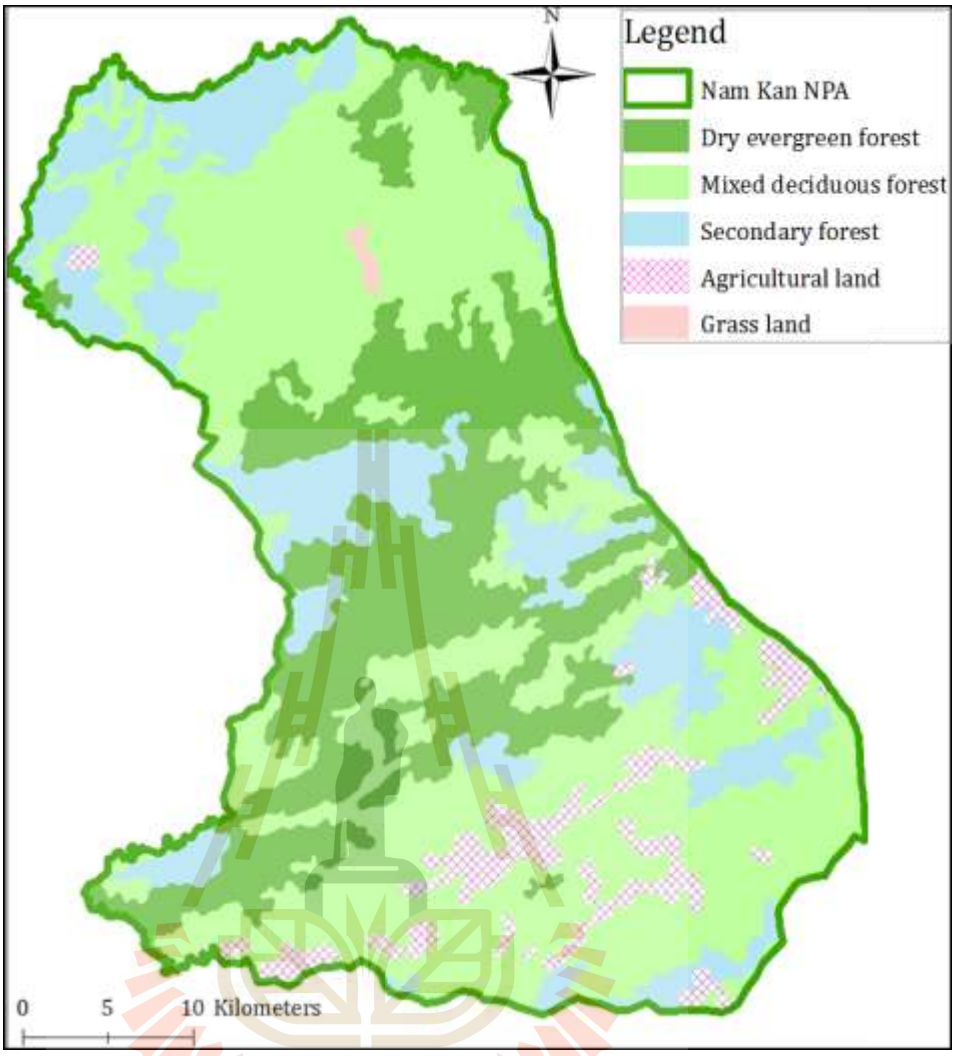

Figure 3.6 Land cover of Nam Kan NPA.

3.1.4 Flora and Fauna

Little is known about flora in Nam Kan NPA, but common species are recorded in the area including *Afzelia xylocarpa*, *Pterocarpus*, *Azadirachta*, *Phyllantus emblica*, *Spondias pinnata*, *Dipterocarpus intricstus*, *Baccaurea ramiflora*, *Ficus neriifolia*, *Amomum villosum*, rattan, broom grass and bamboo (Timmins and Duckworth, 2013).

Nam Kan NPA is also important for wildlife conservation in Laos with high diversity of wildlife. There is a number of current wildlife identified especially for bird species. The bird species recorded includes Great salty woodpecker *Mulleripicus pulverulentus*, Woodpeckers (Picidae), Oriental pied hornbill *Anthracoceros albirostris*, Brown hornbill *Anorrhinus tickelli*, Blyth's kingfisher *Alcedo Hercules*, Stork-billed kingfisher *Halcyon capensis*, Crested kingfisher *Megaceryle lugubris*, Barred cuckoo dove *Macropygia unchall*, Little cuckoo dove *Macropygia ruficeps*, Green pigeons *Treron*, Green imperial pigeon *Ducula aenea*, Blue naped / Blue rumped *Pitta Pitta nipalensis / P. soror* and Large billed Crow *Corvus macrorhynchos* (Timmins and Duckworth, 2013).

The mammals include Pig tailed macaque *Macaca nemestrina*, Assamese macaque *Macaca assamensis*, Bear macaque *Macaca arctoides*, Phayre's leaf monkey *Semnopithecus phayrei*, Dhole *Cuon alpinus*, Otters (Lutrinae), Chevrotain *Tragulus*, Sambar *Cervus unicolor*, Muntjacs *Muntiacus* and Black giant squirrel *Ratufa bicolor* (Timmins and Duckworth, 2013).

3.2 Methods

Four groups of gibbon were selected for this study. They were located near tree house number 1, 2, 3, 5 and 7 (Figure 3.7). Group 1 (G1) lived near the tree house 3 and 7, group 2 (G2) near the tree house 2, group 3 (G3) near the tree house 1 and kitchen 1 and group 4 (G4) near the tree house 5 to the west of Nam Kan valley. The distances between group 1, 2 and 3 are 1 km apart from each other.

Gibbon groups were located by listening to the loud calls in the morning. After the groups were found. All group members were counted and classified into 5 age-sex classes, including infant, juvenile, sub-adult, adult female and adult male. The infant is less than 1.5 years old. The average distance from observing team to gibbon groups were from 80 to 250 m.

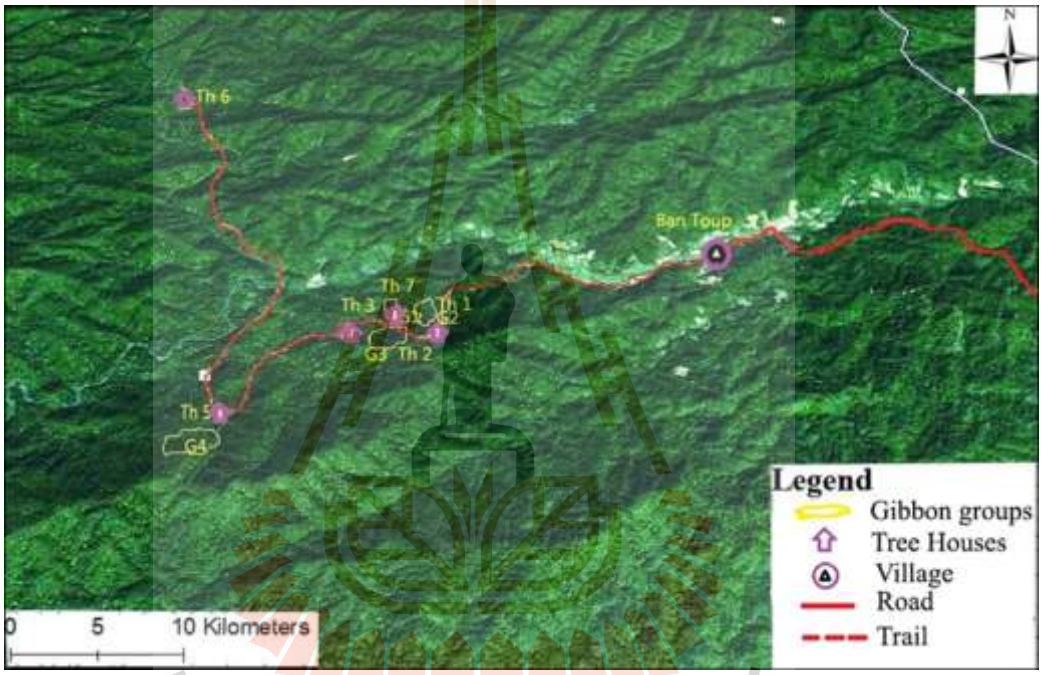

Figure 3.7 Location of study sites and tree houses (Th).

Behavior of one adult male, adult female, sub-adult, juvenile and infant of each group were observed by 1-minute scan sampling every 15 minutes interval (Altmann, 1974). Behaviors were classified in 8 types; singing, travelling, feeding watching, grooming, playing, resting and sleeping (Nguyen Xuan Nghia *et al.*, 2010). Due to poor weather condition, gibbon groups were followed for 4-7 days per group, one group per month, for totally 22 days from August to November 2013.

Because we cannot follow gibbon until they go to sleep in the evening, we cannot call the trees they sing in the morning as sleeping trees. We call them singing trees instead. Singing trees and food plants GPS locations were recorded. Plant local names and specific part eaten (e.g., fruit, leave and flower) were also noted and photographed. Later, the height and diameter at breast height (DBH) at 1.3 m from the ground were measured. Height was measured using a direct-reading optical Bushnell Bow hunter range finder. Plant specimens were collected and identified by Dr. Khamseang Shihalath at Faculty of Agriculture and Forestry, National University of Lao. Wild animals encountered during this study were also listed.

The activity budgets of adult male, adult female, sub-adult, juvenile and infant were calculated and compared. DBH and height of singing trees and feeding trees of each group were compared by the analysis of variance (ANOVA) using SPSS version 15.0. All gibbon movement GPS positions were gathered. Daily travel paths and lengths were mapped and calculated using ArcMap 10.2.2. Since we follow gibbon for only a short period, we cannot calculate home range of this gibbon but can show only the foraging area. The daily and total foraging areas were calculated by minimum convex polygon method (MCP) and using ArcMap 10.2. Group daily travel lengths and foraging areas were compared by ANOVA. Statistical significant difference was determined at $p \leq 0.05$.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Group Composition

Four gibbon groups of total 20 individuals were found ranging from 2 to 8 gibbons per group (Table 4.1). G1, near tree house number 3 and 7 (Figure 4.1), was the biggest group consisting of 8 individuals. G2, near tree house 1 next to the kitchen to the east, had 7 individuals. G3, near Mr. Laoxo farm rice very closed to Nam Kan River, had 3 individuals. G4, the smallest group near tree house 5, had only 2 individuals. This small group probably results from hunting pressure which perhaps adult males or females are shot and cannot have more infants.

Table 4.1 Group composition of Laotian black crested gibbon in Nam Kan NPA.

Group	Adult male	Adult female	Sub adult	Juvenile	Infant	Total
1	1	2	1	3	1	8
2	1	2	1	2	1	7
3	1	1		1		3
4	1	1				2
Total	4	6	2	6	2	20

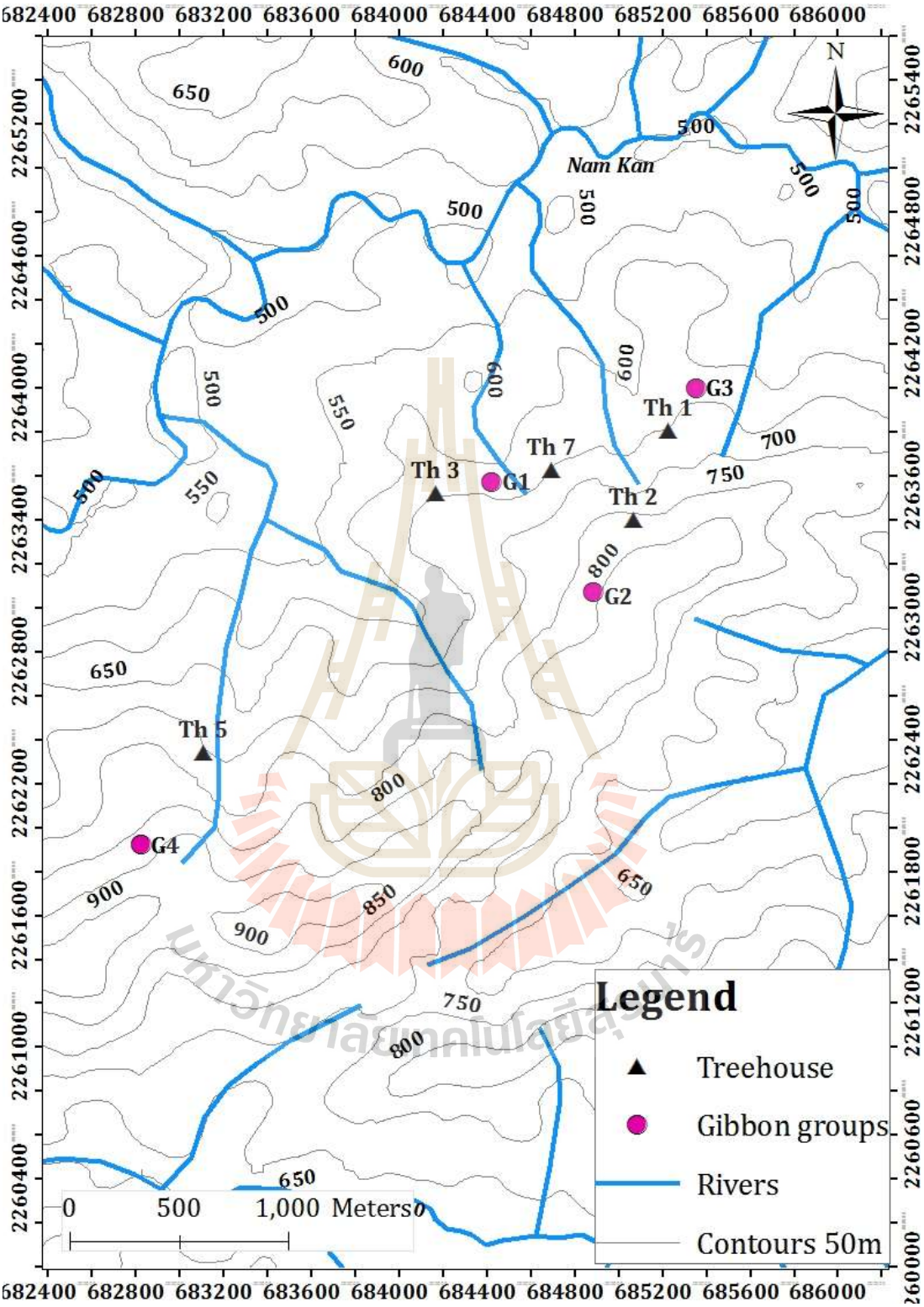

Figure 4.1 Locations of 4 gibbon groups near Gibbon Experience's tree houses in Nam Kan NPA.

In this study, we observed polygyny in 2 gibbon groups (G1 and G2), similar to another subspecies, *Nomascus concolor jingdongensis* at Dazhaizi, Mt. Wuliang, Central Yunnan, China (Fan, 2006), *Nomascus nasutus* at Bangliang Nature Reserve, Jingxi County, Guangxi, China (Fan *et al.*, 2010) and *Nomascus hainanus* at Bawangling National Nature Reserve, Hainan, China (Fellowes *et al.*, 2008).

Group size average of gibbon at this location is 5 individuals, closed to other subspecies in China and Vietnam (Table 4.2) but higher than those of previous studies in the same area (Geissmann, 2007) and other places in Nam Kan NPA (Youanechuexian *et al.*, 2014). The group size is big because Hmong people does not hunt gibbons and Gibbon Experience ecotourism provides more income to local people in this area.

Table 4.2 Group size comparison of Laotian black crested gibbon and other gibbons.

Species	Location	Group size	References
Nomascus concolor lu	Nam Kan, Lao	5.0	Present study
	Nam Kan, Lao	3.6-3.8	Geissmann (2007)
	Nam Kan, Lao	3.9	Youanechuexian *et al.* (2014)
Nomascus concolor	Che Tao/Ho Nam Mu, Vietnam	6.0	Zhenhe *et al.* (1989)
	Hainan, China	5.25	Zhenhe *et al.* (1989)
	Xiobahe, Yunnan, China	5.25	Lan and Sheeran (1995)
N. c. jingdongensis	Central Yunnan, China	2.9- 6.6	Fan *et al.* (2008)
Nomascus nasutus	Bangliang, Jingxi, China	6	Fan *et al.* (2010)
Hoolock hoolock	Tripura, India	3	Kakati *et al.* (2009)
Hylobates agilis	West Kalimantan, Indonesia	4.1	Mitani (1990)
Hylobates klossi	Siberut, Indonesia	3.4	Tenaza (1975)
	Siberut, Indonesia	4.1	Tilson (1981)
Hylobates lar	Khao Yai, Thailand	4.3	Bartlett (1999)
	Kuala Lompat, Malaysia	3.3	Barelli *et al.* (2006)
Hylobates moloch	West Java, Indonesia	4	Kim *et al.* (2011)
Hylobates muelleri	Kutai, Kalimantan, Boneo, Indonesia	3.4	McConkey *et al.* (2002)
Hylobates pileatus	Khao Soi Dao, Thailand	6	Srikosamatara (1984)
Symphalangus syndactylus	Ulu Sempan, Malaysia	4	Lanpan (2007)

4.2 Activity Budget

From total of 670 observations, both adult males and adult females spent most daily time on travelling, followed by feeding and watching respectively but less time on

sleeping (Table 4.3 and 4.4). Adult males spent a bit more time on singing than adult females while adult females spent more time on grooming than singing. In contrast, sub adults, juveniles and infants spent most time on playing, followed by traveling and feeding, respectively (Table 4.5-4.7). Sub adults spent least time on singing and sleeping while juveniles and infants did not sing at all.

Table 4.3 Male activity budget of Laotian black crested gibbon in Nam Kan NPA.

Groups	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	14	21	31	26	18	9	13	5	137
G2	18	37	46	36	14	14	10	5	180
G3	23	38	44	36	19	14	14	6	194
G4	18	30	46	23	15	7	15	5	159
Total	73	126	167	121	66	44	52	21	670
%	10.9	18.8	24.9	18.0	9.8	6.5	7.7	3.1	100

Table 4.4 Female activity budget of Laotian black crested gibbon in Nam Kan NPA.

Groups	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	15	18	38	19	23	13	5	6	137
G2	18	39	40	36	16	10	11	10	180
G3	20	41	37	29	22	18	15	12	194
G4	16	34	45	24	15	5	12	8	159
Total	69	132	160	108	76	46	43	36	670
%	10.3	19.7	23.8	16.1	11.3	6.8	6.4	5.3	100

Table 4.5 Sub-adult activity budget of Laotian black crested gibbon in Nam Kan NPA.

Group	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	4	19	30	22	16	31	11	4	137
G2	6	37	28	21	20	45	17	6	180
Total	10	56	58	43	36	76	28	10	317
%	3.1	17.6	18.3	13.5	11.3	23.9	8.8	3.1	100

Table 4.6 Juvenile activity budget of Laotian black crested gibbon in Nam Kan NPA.

Group	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	0	20	37	14	15	40	9	2	137
G2	0	28	39	18	27	53	12	3	180
G3	0	49	30	16	26	58	11	4	194
Total	0	97	106	48	68	151	32	9	511
%	0.0	18.9	20.7	9.3	13.3	29.5	6.2	1.7	100

Table 4.7 Infant activity budget of Laotian black crested gibbon in Nam Kan NPA.

Group	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	0	14	32	14	14	50	12	1	137
G2	0	31	37	15	16	65	13	3	180
Total	0	45	69	29	30	115	25	4	317
%	0.0	14.2	21.7	9.1	9.4	36.2	7.8	1.2	100

Clearly, sub adult, juvenile and infant spent 4-5 proportion of time on playing more than those of adult male and female but spent 2 times on watching less (Figure 4.2). Sub adults sing and travel but very much less than adult gibbons. Adult male and female have similar proportion of time for each behavior because they live in the same group and do the same thing all the time.

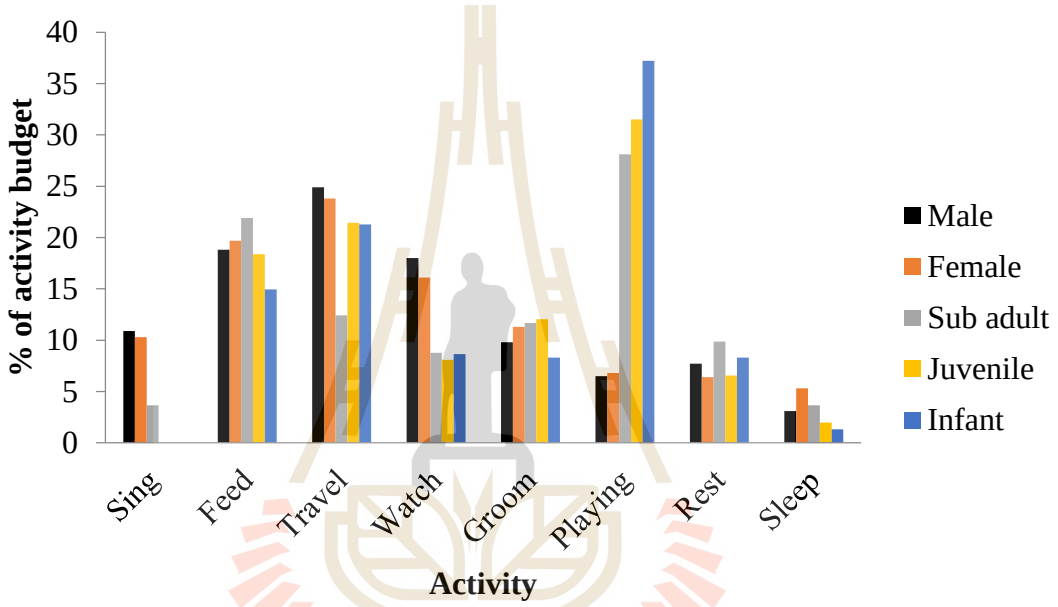

Figure 4.2 Activity budget comparison among adult male (n=4), adult female (n=4), sub adult (n=2), juvenile (n=3) and infant (n=2) of Laotian black crested gibbon.

When we compared adult male data with another subspecies, Laotian black crested gibbons in our study sites spent most time in resting (38.8%) similar to *Nomascus concolor jingdongensis* in Yunnan, China (Lan, 1989; Fan et al., 2008; Table 4.8) and the same as many gibbon species such as *Hylobate albibarbis* in Indonesia (Cheyne, 2004), *H. klossii* in Sumatra (Whitten, 1980), *H. moloch* in Java (Kim, 2011) and *H. pileatus* in Thailand (Srikosamatara, 1984).

However, gibbons of our study spent more time on traveling but less time on feeding than another subspecies in Yunnan, China (Lan, 1989; Fan *et al*., 2008), indicating possible lower food availability or higher human disturbance in this study site.

Table 4.8 Activity budget comparison among gibbon species.

Species	Study area	Activity budget (%)					References
		Feed	Travel	Rest	Sing	Others	
Nomuscus concolor lu	Nam Kan, Lao	18.8	24.9	38.8	10.9	6.6	Present study
N. c. jingdongensis	Yunnan, China	33	14	50	3		Lan (1989)
	Yunnan, China	35.1	19.9	40	2.6	2.5	Fan *et al.* (2008)
	South-west Yunnan	29	37	18	11	4	Sheeran *et al.* (1998)
Hylobate agilis	Malay Peninsula	29	10	29	5		Gittins (1982)
Hylobate albibarbis	Indonesia	32	16	26	8	18	Cheyne (2004)
	Indonesia	37	24	37	2		Cheyne (2004)
	Indonesia	18	20	49	7	8	Cheyne (2004)
Hylobate klossii	Sumatra, Indonesia	34	11	54	2		Whitten (1980)
Hylobate moloch	Java, Indonesia	36	15	41		8	Kim (2011)
Hylobate muelleri	Indonesia	18	20	49	7	8	Cheyne (2004)
	Java, Indonesia	32	23	40	5		Kappeler (1981)
Hylobate pileatus	Thailand	22	24	39	8	7	Srikosamatara (1984)
Hoolock hoolock	Bangladesh	52	8	28	3	4	Ahsan (2000)
Symphalangus syndactylus	central Malaya	31–56	8–20	35–52	1–3	2	Chivers *et al.* (1975)

4.3 Activity Budget by Time

Adult male gibbons spend 70% of time singing from 6:00 to 8:00 then they feed, travel, watch and do other activities from 8:00 to 15:00 (Figure 4.3). Feeding reduces in the afternoon while traveling increases. They also sleep at noon or midday around 11:00-14:00. However, after 15:00 we were unable to follow them because they travel fast and it gets darken very quickly in the field. Adult females used 70% of the first hour, 6:00-7:00 for singing too but they sing less only 30% from 7:00 to 8:00 (Figure 4.4). They even start traveling after 6:00 and start feeding after 7:00. Females also take longer sleep than males until 15:00. Unlike adult gibbons, sub adults play all the time around 20-30% of each hour starting from 6:00 (Figure 4.5). They sing from 6:00 to 8:00. They start feeding and traveling after 7:00 and take a nap like adult males some time from 11:00 to 14:00. Finally, juveniles and infants also spent most their time on playing from 6:00 to 15:00 but more than sub adults (Table 4.9 and 4.10). The rest activities are the same as sub adults.

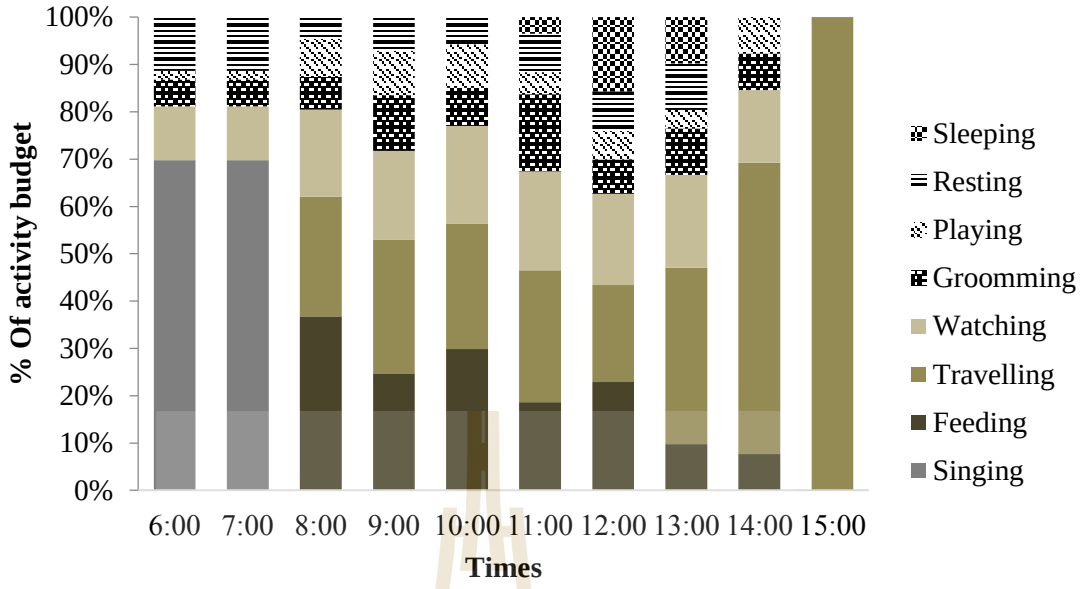

Figure 4.3 Percentage of adult male activity budget by time.

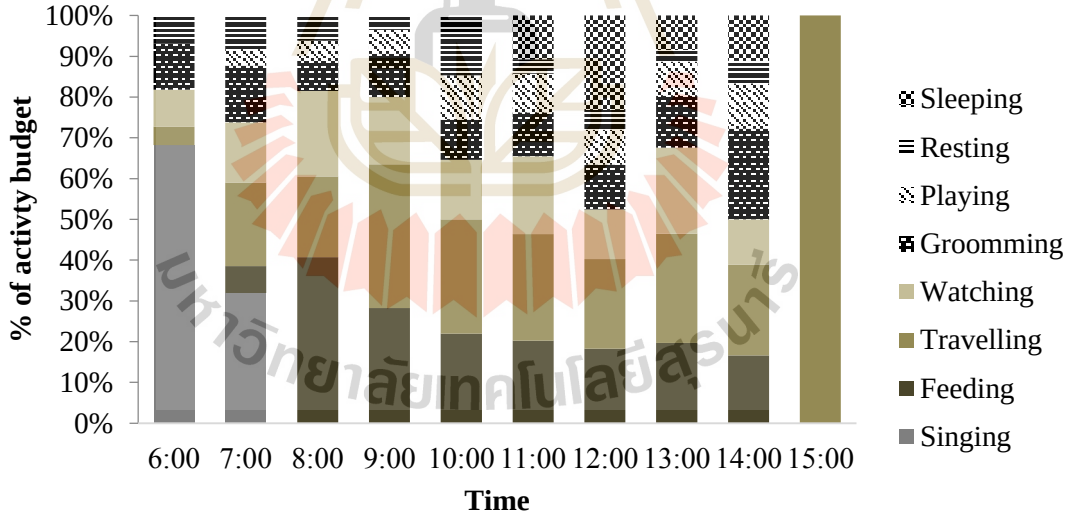

Figure 4.4 Percentage of adult female activity budget by time.

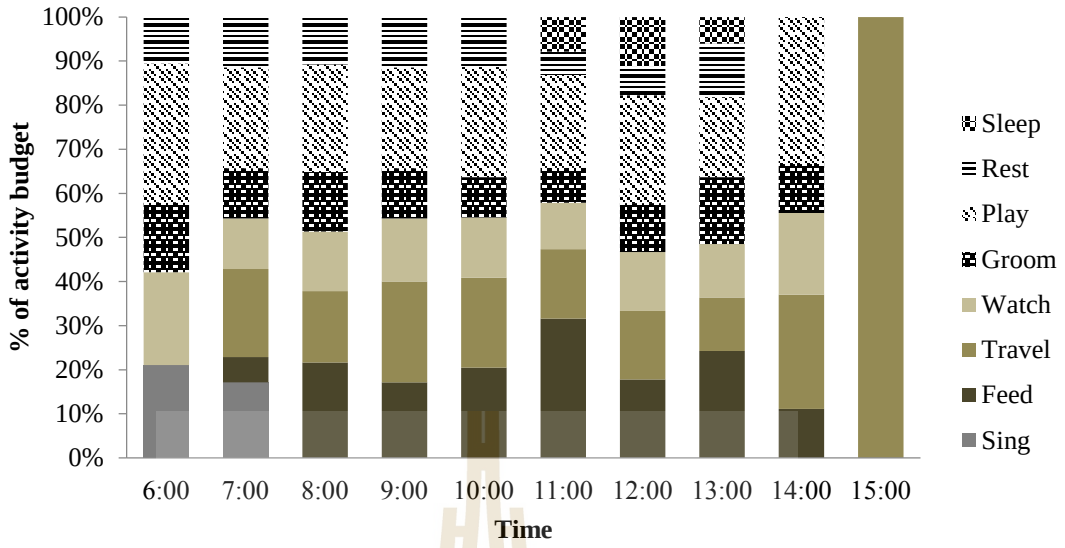

Figure 4.5 Percentage of sub adult activity budget by time.

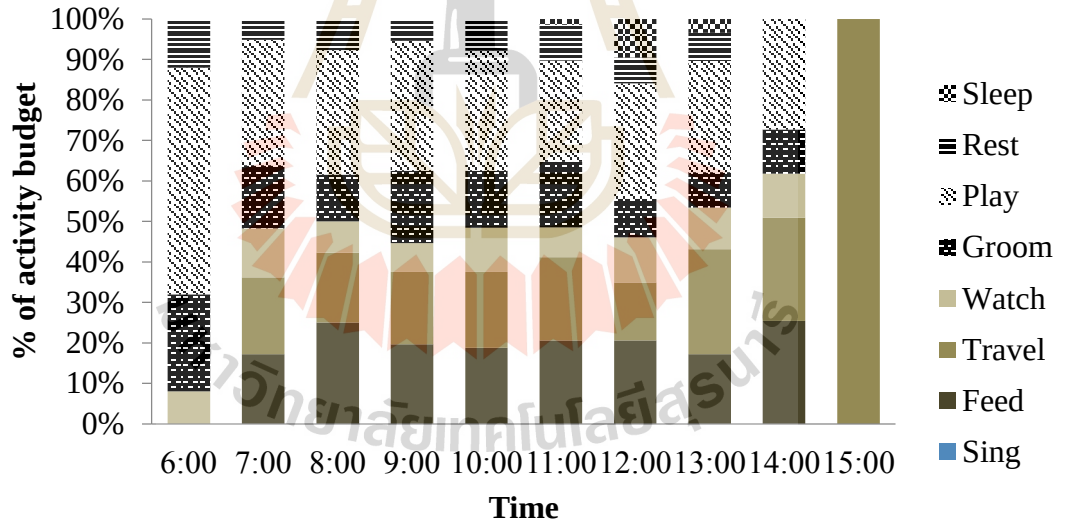

Figure 4.6 Percentage of juvenile activity budget by time.

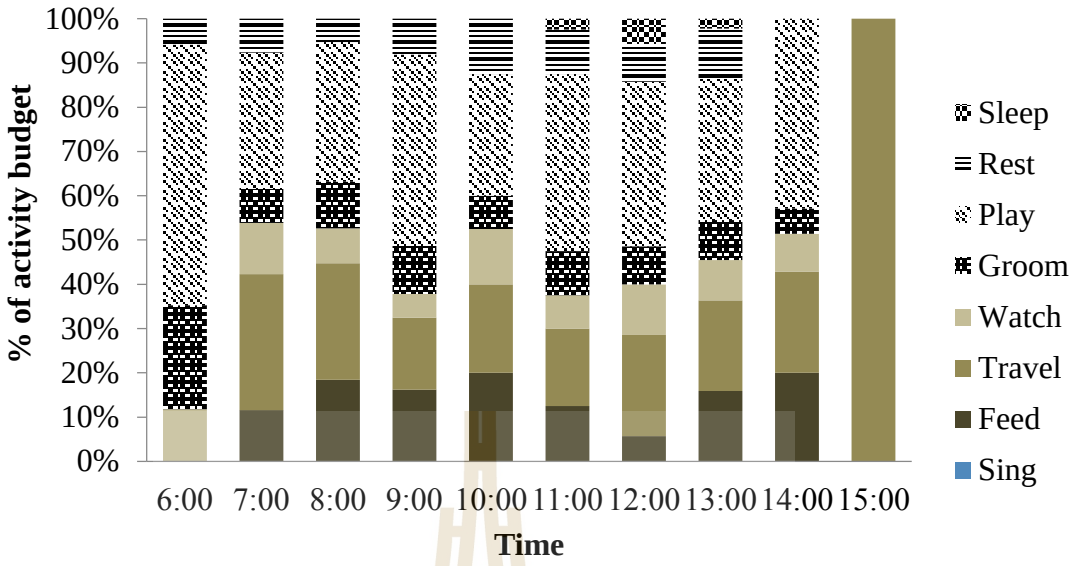

Figure 4.7 Percentage of infant activity budget by time.

4.4 Singing Behavior

The Laotian black crested gibbons generally sing early morning call after dawn and stop before 8: 00 (Table 4. 9) . Adult males and females in the study group always sang interactively to produce duet bouts at a little bit same time. The first of all adult male calling, and then adult females started to duet followed with the sub adult male and other individuals in the group called, after that the song are produced harmonize to together. The singing lasts from 18 to 38 min with the mean of 28.3±5.1 min. The songs are thought to be used for resource defense, mate defense, pair bonding, and group cohesion and mate attraction (Fan *et al*., 2009). The songs are innately altruistic, as each group calls separately.

Table 4.9 Singing time of Laotian black crested gibbon in Nam Kan NPA.

Groups	Date	Time of Call		minute	Altitude	Location
		Start	End			
G1	04-Aug-13	6:20	6:41	21	654	Tree house 7
	05-Aug-13	6:19	6:52	33	620	Tree house 7
	06-Aug-13	6:40	7:14	34	682	Tree house 7
	07-Aug-13	6:55	7:23	28	621	Tree house 3
G2	01-Sep-13	6:20	6:57	37	680	Tree house 2
	02-Sep-13	6:34	7:06	32	767	Tree house 2
	03-Sep-13	6:15	6:38	23	750	Tree house 2
	04-Sep-13	6:08	6:31	23	796	Tree house 2
	05-Sep-13	6:15	6:43	28	683	Tree house 2
	06-Sep-13	6:21	6:59	38	550	Tree house 3
G3	04-Oct-13	6:30	7:01	31	670	Tree house 1
	05-Oct-13	7:05	7:36	31	643	Tree house 1
	06-Oct-13	6:25	6:49	24	785	Tree house 1
	07-Oct-13	7:00	7:24	24	550	Tree house 1
	08-Oct-13	6:44	7:12	28	812	Kitchen 1
	09-Oct-13	6:15	6:47	32	790	Kitchen 1
	10-Oct-13	6:17	6:44	27	778	Tree house 1
G4	02-Nov-13	6:34	7:06	32	864	Tree house 5
	03-Nov-13	6:20	6:38	18	600	Tree house 5
	04-Nov-13	6:04	6:32	28	895	Tree house 5
	05-Nov-13	6:45	7:11	26	760	Tree house 5
	06-Nov-13	6:30	6:55	25	843	Tree house 5

4.5 Singing Trees

From 35 singing trees of this study, we identified 9 different plant species (Table 4.10). The highest number of singing trees used by Laotian black crested gibbon is *Spondias lakhonensis* Pierre (22.9%), followed by *Ficus benjamina* (20.0%) and *Spondias axillaris* Roxb (17.1%), respectively. Each group used different plants ranging 5-8 species and 7-11 trees. Singing tree locations of each group are shown in (Figure 4.8-4.11). Singing trees had 25.0 ± 5.5 m mean height, 84.4 ± 14.8 cm mean DBH and 771 ± 95 m mean elevation (Figure 4.12- 4.14). Gibbon chooses these trees for singing mostly because they can easily find fruit or food resource. They usually selected the highest tree as singing tree to facilitate voice transmission for long distance. Sometime gibbons use the sleeping trees as singing trees as reported in Kloss gibbons (Whitten, 1982) and Moloch gibbons (Kappeler, 1984).

Table 4.10 Singing trees of Laotian black crested gibbons in Nam Kan NPA.

No	Local name	Scientific name	G1	G2	G3	G4	Total	%
1	Khishi	*Dipterocarpus alatus* Roxb.		1	1		2	5.7
2	Deang Nam	*Bauhinia nervosa* (Wall.ex Benth)	1	1	1	1	4	11.4
3	Ngom Hin	*Chukrasia tabularis* A. Juss	1	1			2	5.7
4	Mai Hai	*Ficus benjamina*	2	1	2	2	7	20.0
5	Mark Hor	*Spondias lakhonensis* Pierre	2	1	3	2	8	22.9
6	Mark Kom	*Microcos paniculata*		1	1		2	5.7
7	Mark Mue	*Spondias axillaris* Roxb	2	1	2	1	6	17.1
8	Ton Pao	*Dioscorea bulbifera* Loureiro	1				1	2.9
9	Mark Fan	*Protium serratum* (Wall.) Engl		1	1	1	3	8.6
		Total number	9	8	11	7	35	100
		Total species	6	8	7	5	9	

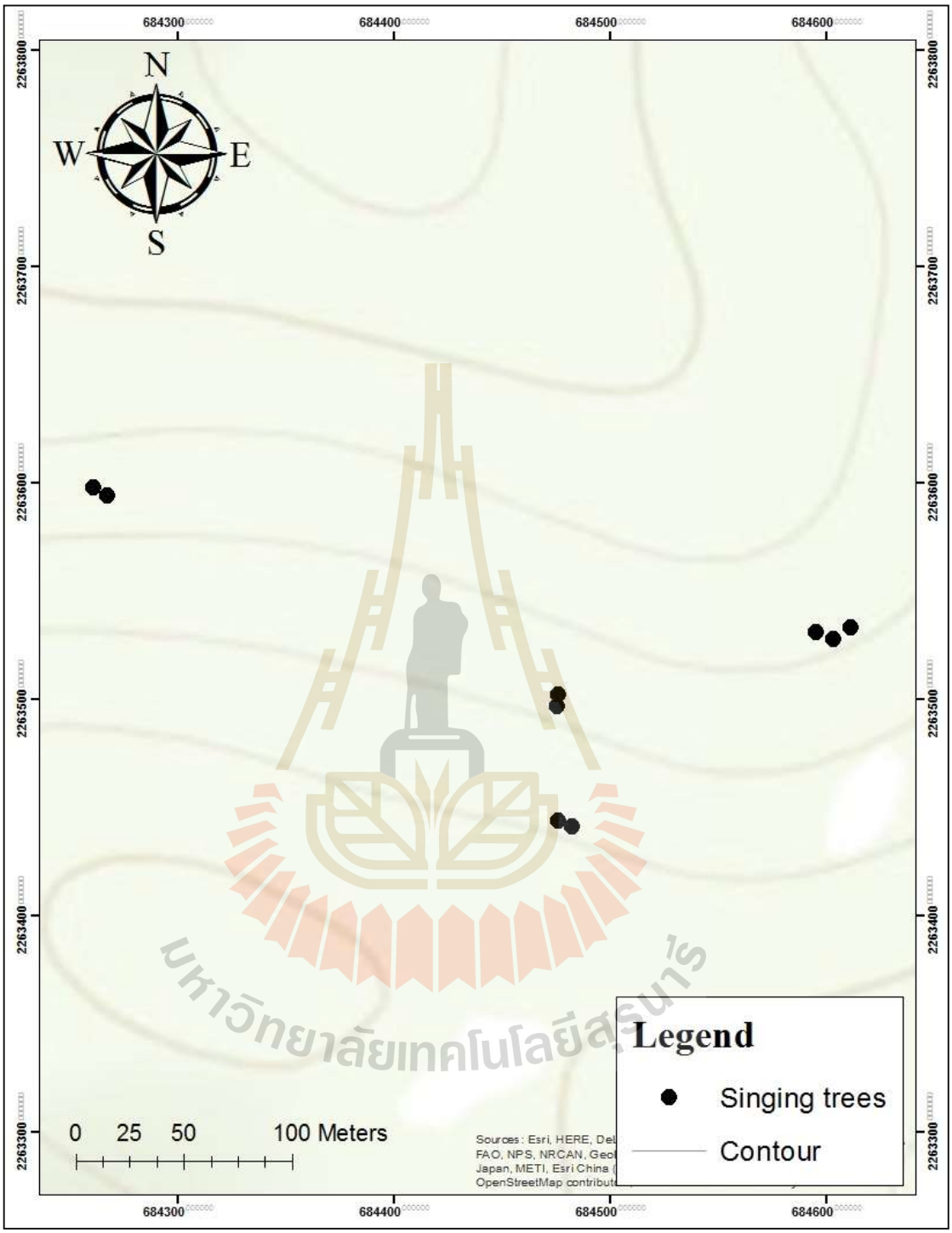

Figure 4.8 Singing trees of group 1 of Laotian black crested gibbon in Nam Kan NPA.

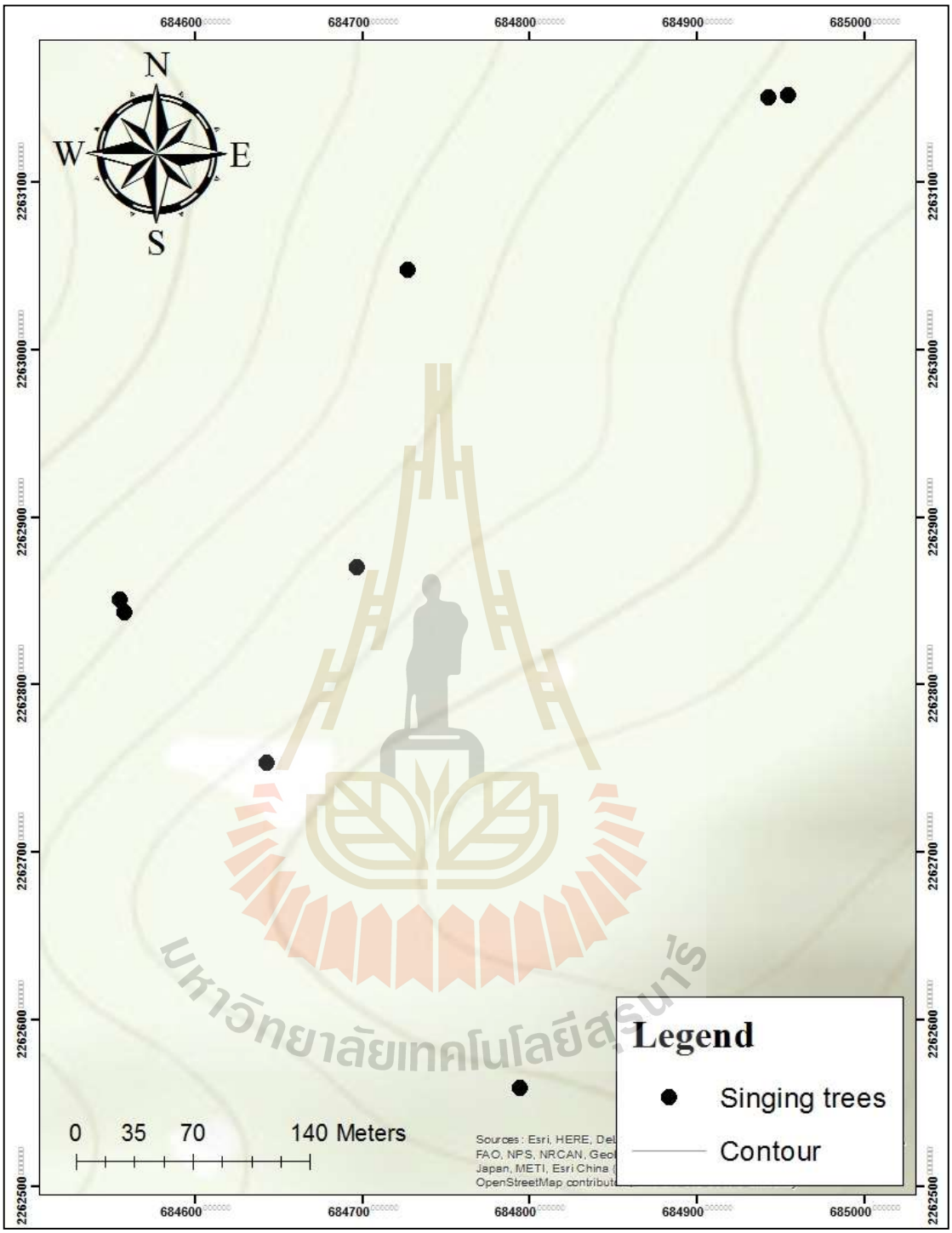

Figure 4.9 Singing trees of group 2 of Laotian black crested gibbon in Nam Kan NPA.

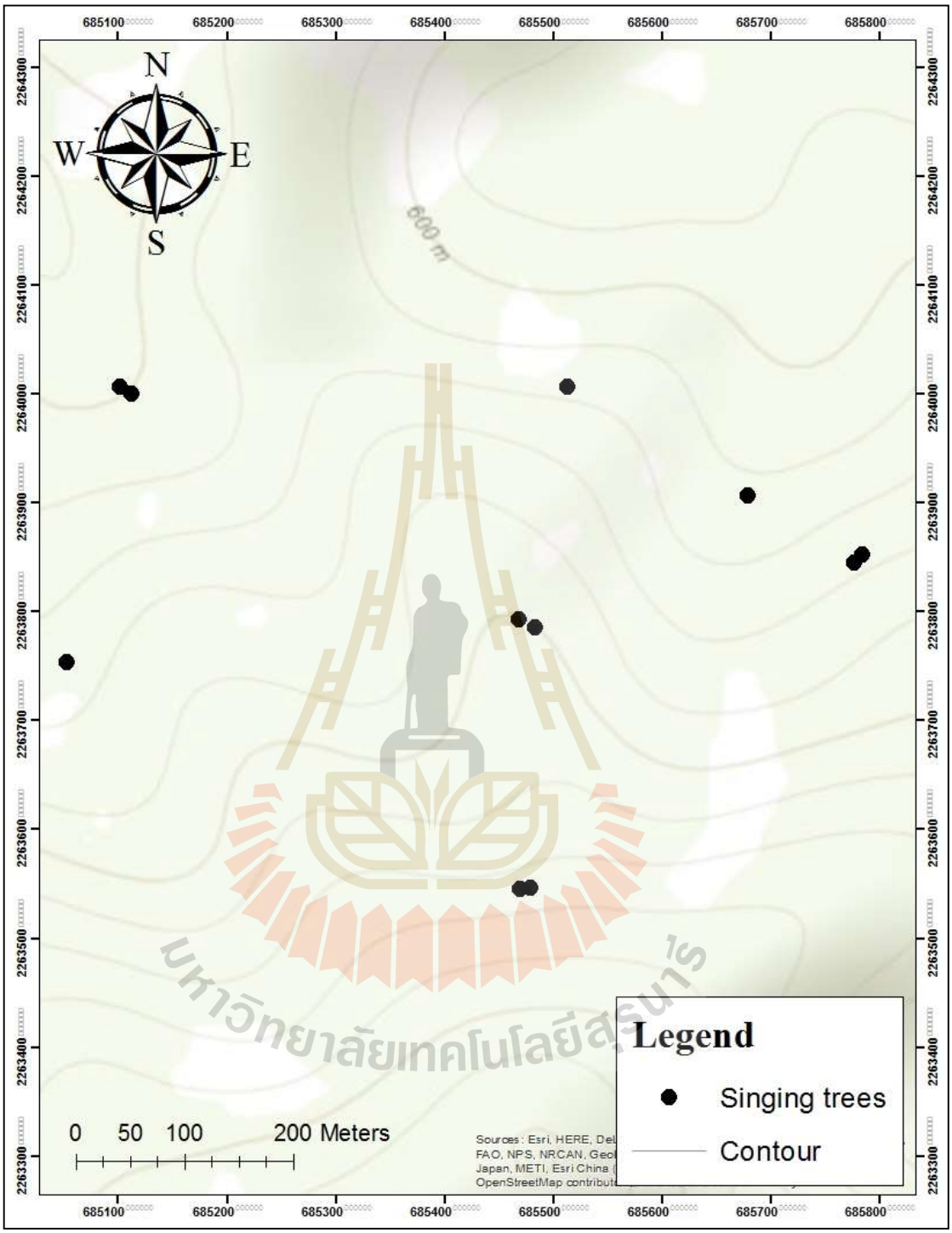

Figure 4.10 Singing trees of group 3 of Laotian black crested gibbon in Nam Kan NPA.

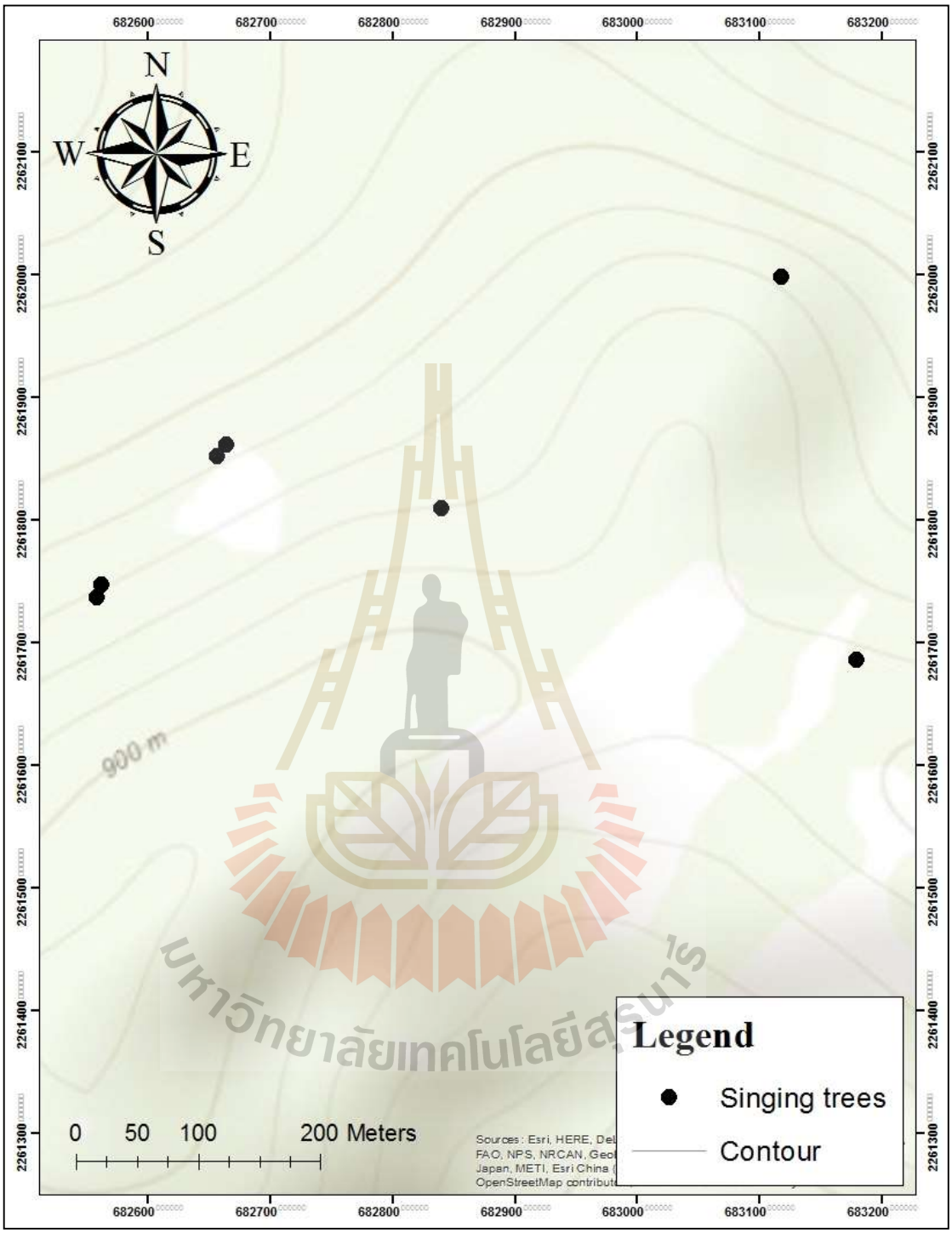

Figure 4.11 Singing trees of group 4 of Laotian black crested gibbon in Nam Kan NPA.

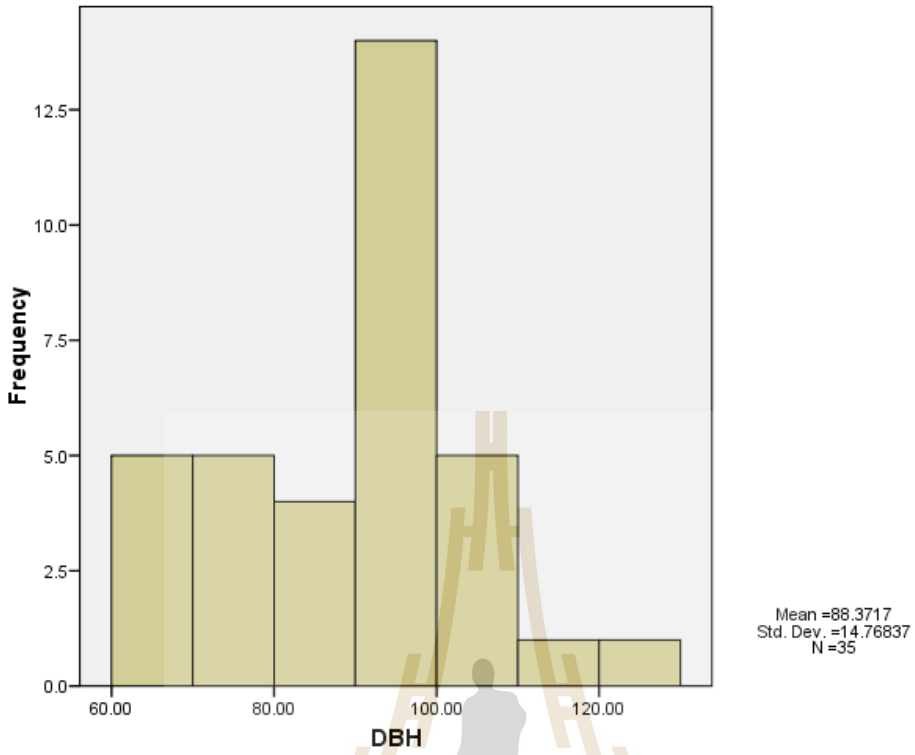

Figure 4.12 Frequency distribution of singing tree DBH (cm).

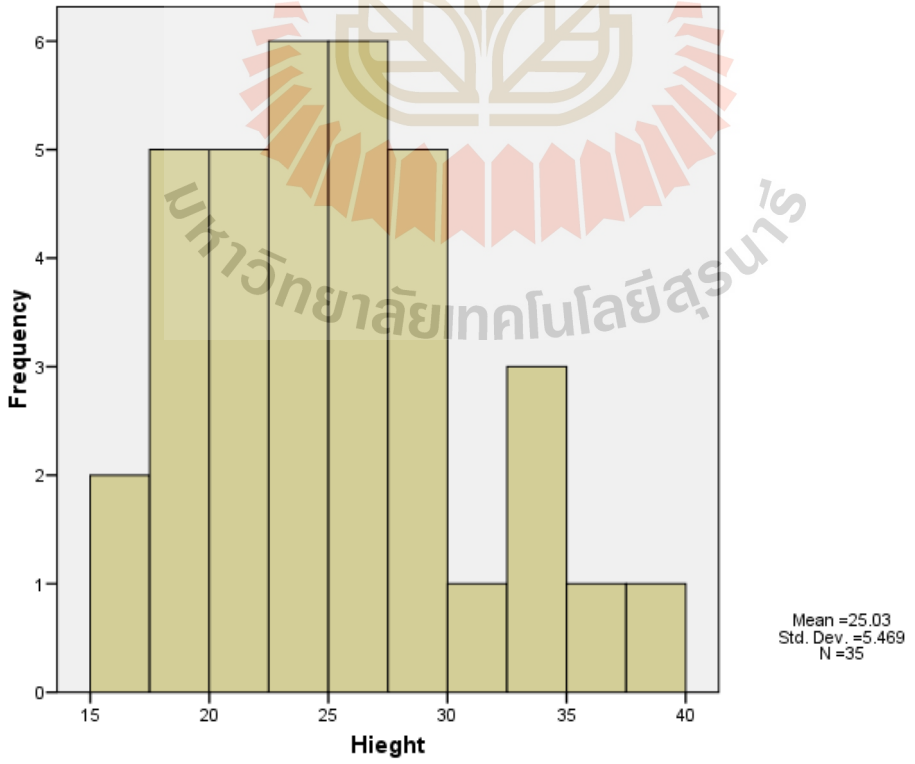

Figure 4.13 Frequency distribution of singing tree height (m).

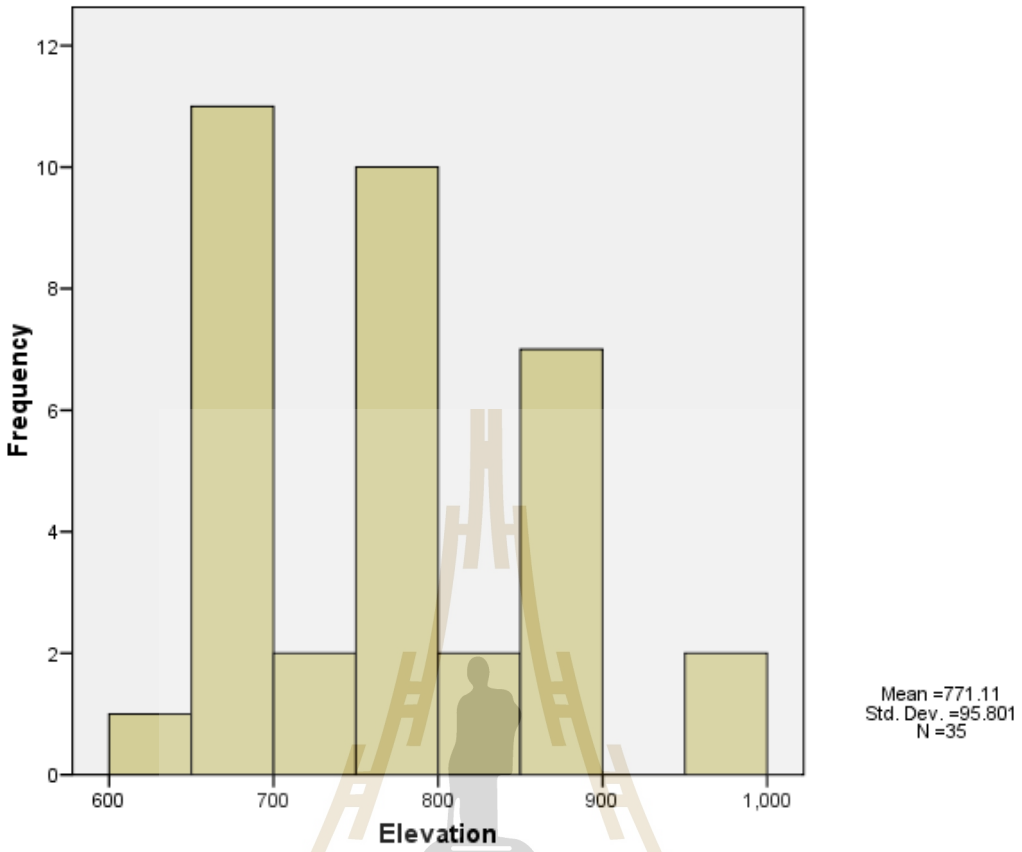

Figure 4.14 Frequency distribution of singing tree elevation (m).

4.6 Gibbon Food

Laotian black crested gibbons consume total of 15 different plants during our research but we can identify to species only 11 of them. The most favorite plant is *Spondias lakhonensis* Pierre (27.9%), followed by *Ficus hispida* L. (15.1%), *Ficus benjamina* (11.6%) and *Choerospondias axillaris* (10.4%), respectively (Table 4.11).

Table 4.11 Plants species used by gibbon group of adult males and females

No.	Local name	Scientific name	Used by gibbon groups				Total	%
			G1	G2	G3	G4		
1	Mark Hor	*Spondias lakhonensis* Pierre	19	17	20	16	72	27.9
2	Deua Pong	*Ficus hispida* L.	8	11	0	20	39	15.1
3	Mai Hai	*Ficus benjamina*	0	18	0	12	30	11.6
4	Mark Mue	*Choerospondias axillaris*	9	4	10	4	27	10.4
5	Mark Ka Mang	Unidentified 1	4	5	5	2	16	6.2
6	Ton Pao	*Dioscorea bulbifera* Loureiro	3	7	5	0	15	5.8
7	Mark Jing Kor	Unidentified 2	0	2	4	6	12	4.6
8	Mark Kok	*Spondias lutea* L.	0	8	0	0	8	3.1
9	Porsa	*Broussonetia papyrifera*	0	0	8	0	8	3.1
10	Ton Mai	Unidentified 3	0	2	2	3	7	2.7
11	Mark Kom	*Microcos paniculata* L.	0	3	0	3	6	2.3
12	Mark Kam Pom	*Phyllanthus emblica*	0	3	0	2	5	1.9
13	Mark Kor Land	Unidentified 4	0	1	0	4	5	1.9
14	Mark Fan	*Protium serratum* Guillaumin.	0	0	4	0	4	1.5
15	Mark Kor	*Quercus augustinii* Skan	0	2	0	2	4	1.5
		Total	43	83	58	74	258	100
		%	16.6	32.1	22.4	28.6	100	

Group 2 had the highest number of food plant species (13 species), followed by G4 (10 species), G3 (8 species) and G1 (5 species), respectively. G1 had the lowest number because we spent only 4 days following this group. Food plants varied among gibbon groups, only *Spondias lakhonensis*, *Choerospondias axillaris* and unidentified 1 were found in every group.

The number of plant species found in our study is a bit higher than plants found in the preliminary study of *N. c. jingdongensis* food by Lan (1993). The results show in our study plant species and percentage of eaten by Laotian black crested gibbon were less than other studies as Fan *et al*. (2009), Ni *et al.* (2014) and Kim *et al*. (2012).

Gibbons preferred fruits the most (72.8%), followed by young leaves (14.7%), flowers (6.9%) and mature leaves (5.4%), respectively (Table 4.12). All feeding plants produced fruits in our study. Gibbons ate young leaves from 13 plants, flowers from 9 plants and mature leaves from only 8 plants.

All of food plants in our study were found produced fruits. The high proportion of Laotian black crested gibbons were used as feeding food is fruit. It is the same as results found in *N. c. jingdongensis* in Yunnan (Ni *et al.*, 2014) as in (Table 4.18). In other crested gibbon species, fruits accounted for 38.6% of *Nomascus leucogenys* (Hu *et al.*, 1989) and 58% of *Nomascus nasutus* feeding time (Fan *et al*., 2011). High levels of frugivory in hylobatids has been reported by (Hasan *et al.*, 2005) in Lawachara, Bangladesh, where *Hoolock hoolock* spent 90% of feeding time on fruits. However, we did not find *N. c. lu* feeding on any animals as in some studies before.

Adult males and adult females have similar food proportion but adult males spend more time feeding on fruit more than females do (Figure 4.15). While adult females spend more time feeding on young leaves and flowers more than adult males do.

Table 4.12 Plant part eaten by Laotian black crested gibbon in Nam Kan NPA.

No.	Local name	Scientific name	Plant part				Total	%
			Fruits	Young leaf	Mature leaf	Flower		
1	Mark Hor	*Spondias lakhonensis* Pierre	68	3	1		72	27.9
2	Deua Pong	*Ficus hispida* L.	34	5			39	15.1
3	Mai Hai	*Ficus benjamina*	21	4	3	2	30	11.6
4	Mark Mue	*Choerospondias axillaris*	21	3	1	2	27	10.4
5	Mark Ka Mang	Unidentified 1	7	3	1	5	16	6.2
6	Ton Pao	*Dioscorea bulbifera* Loureiro	5	5	3	2	15	5.8
7	Mark Jing Kor	Unidentified 2	6	3	2	1	12	4.6
8	Mark Kok	*Spondias lutea* L	2	4	1	1	8	3.1
9	Porsa	*Broussonetia papyrifera*	7	1			8	3.1
10	Ton Mai	Unidentified 3	3	3		1	7	2.7
11	Mark Kom	*Microcos paniculata* L	3			3	6	2.3
12	Mark Kam Pom	*Phyllanthus emblica*	4	1			5	1.9
13	Mark Kor Land	Unidentified 4	3	1		1	5	1.9
14	Mark Fan	*Protium serratum* Guillaumin.	2	2			4	1.5
15	Mark Kor	*Quercus augustinii* Skan	2		2		4	1.5
		Total	188	38	14	18	258	
		%	72.8	14.7	5.4	6.9	100	100

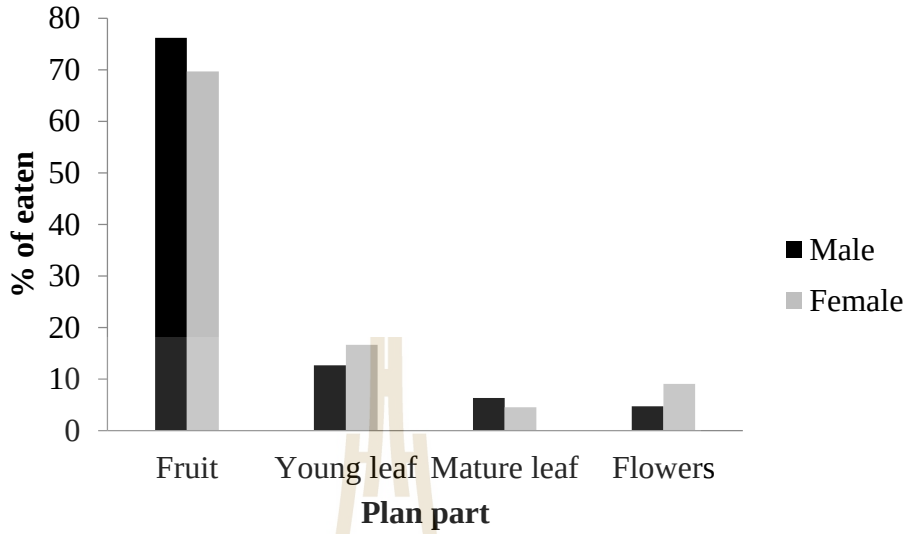

Figure 4.15 Comparison percentage part of eaten by male and female of Laotian black crested gibbon in Nam Kan NPA.

However, In Yunnan, China, black crested gibbons are folivorous-frugivorous, spending on average similar amounts of time eating leaves and fruit. Their diet varies seasonally, based on the availability of food sources including leaves, fruits, buds, and flowers. In a study in 2008 (Fan *et al*., 2009), black crested gibbons ate increased levels of figs in August and September, flowers in February and April, leaves in March, and buds and leaves in December and January. They prefer to eat fruits and figs over other foods during their first and last meals of the day (Fan *et al.*, 2008). They have also been observed eating insects, eggs, and other small organisms. One population of black crested gibbons concentrated ranging behavior, staying in valleys with more abundant food for several consecutive days before moving to another, in order to avoid frequent passages through areas with little food (Fan and Jiang, 2008).

Table 4.13 Diet proportion comparison among gibbon species.

Gibbon species	Plant species	Diet (%)				Study sites	References
		Fruit	Leave	Flower	Others		
Nomascus concolor lu	15	72.9	21.7	5.4	0	Nam Kan NPA, Lao PDR	This study
N. c. jingdongensis	12	21	72	7	0	Mt. Wuliang, Yunnan, China	Lan (1993)
N. c. jingdongensis	77	44.1	46.5	9.1	0.3	Dazhaizi, Yunnan, China	Fan *et al.* (2009)
N. c. jingdongensis	50	77.8	16.2	2.7	3.3	Bajiaohe, Yunnan, China	Ni *et al.* (2014)
N. leucogenys	NA	38.6	52.8	4.7	3.9	Southern Yunnan, China	Hu *et al.* (1989)
N. nasutus	81	58	31.2	3	7.8	Bangliang NR, Guangxi, China	Fan *et al.* (2011)
Hoolock hoolock	NA	90	5	3	2	Lawachara NP, Bangladesh	Hasan *et al.* (2005)
Hylobates moloch	68	59	27	12	2	Gunung Halimun-Salak NP, Indonesia	Kim *et al.* (2012)
Hylobates syndactylus	NA	61	17	1	21	Gunung Leuser NP, Sumatra, Malaysia	Palombit (1996)
Hylobates lar	NA	71	4	1	24	Gunung Leuser NP, Sumatra, Malaysia	Palombit (1996)
Hylobates muelleri x agilis	52	62	23.8	13.4	0.8	Central Kalimantan, Indonesia	McConkey *et al.* (2002)

NP = National Park, NPA = National Protected Area, NR = National Reserve, NA = Not available

4.7 Feeding Trees

In our study, we found a total of 131 feeding trees from 4 gibbon group. G2 had the highest number of food trees (41), followed by G4 (36), G3 (31) and G1 (23), respectively (Table 4.14). Even we followed G2 1 day less than G3, this group visited many trees per day up to 12 trees more than G3. Overall, each gibbon group visited 6 trees each day (range 2-12). Feeding tree locations of each group are shown in (Figure 4.16-4.19). All food trees are mature, big and tall. The mean DBH was 72.9 ±10.5 cm, range 59.6-99.4 (Figure 4.16), mean tree height was 25.5±4.7 m, range 17-40 (Figure.4.20) and mean elevation was 773 ± 87 m, range up to 1,000 m above sea level (Figure 4.21). Many trees were big; we found 21 trees with DBH higher than 90 cm. The highest tree was 40 m found in G1 area while 27 trees were higher than 30 m. *Spondias lakhonensis* Pierre was the biggest and highest food tree found in this study.

Table 4.14 Number of feeding trees per day of each gibbon group.

Group	Survey period	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
G1	4-7 Aug 2013	6	5	7	5	-	-	-	23
G2	1-6 Sept 2013	6	9	12	5	4	5	-	41
G3	4-10 Oct2013	5	4	6	4	6	2	4	31
G4	2-6 Nov 2013	5	4	9	12	6	-	-	36
								Total	131

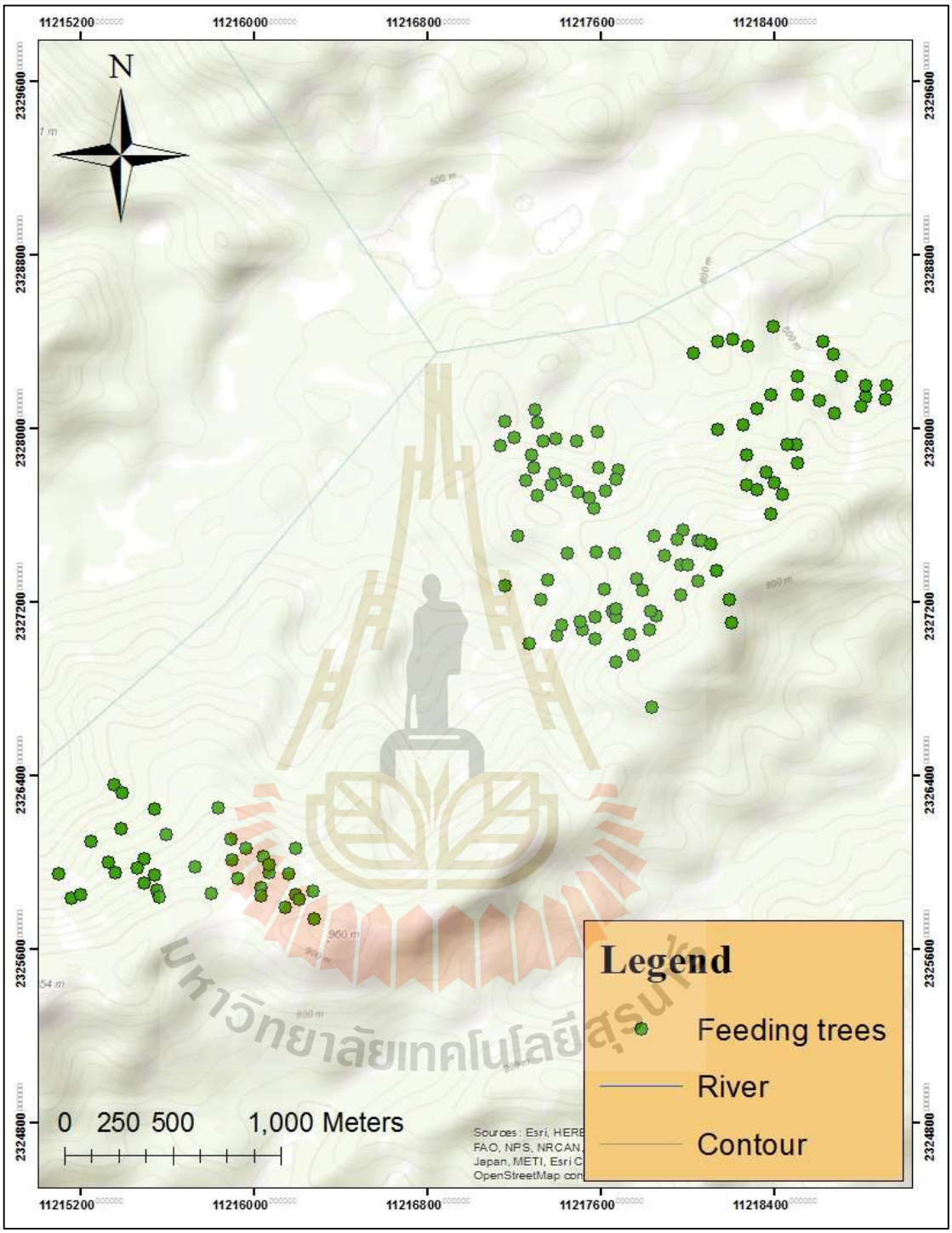

Figure 4.16 Feeding tree locations of Laotian black crested gibbon in Nam Kan NPA.

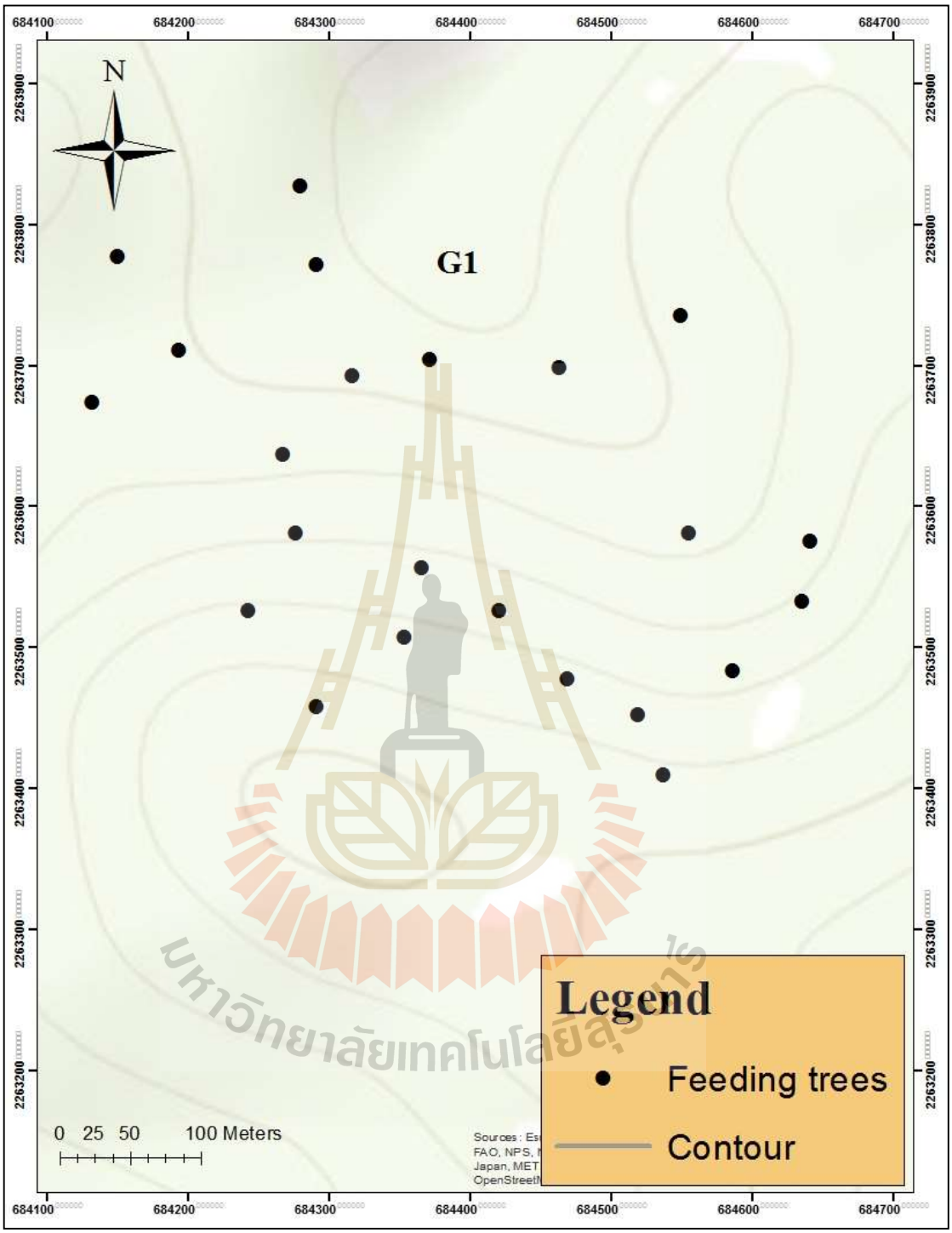

Figure 4.17 Feeding tree G1 of Laotian black crested gibbon in Nam Kan NPA.

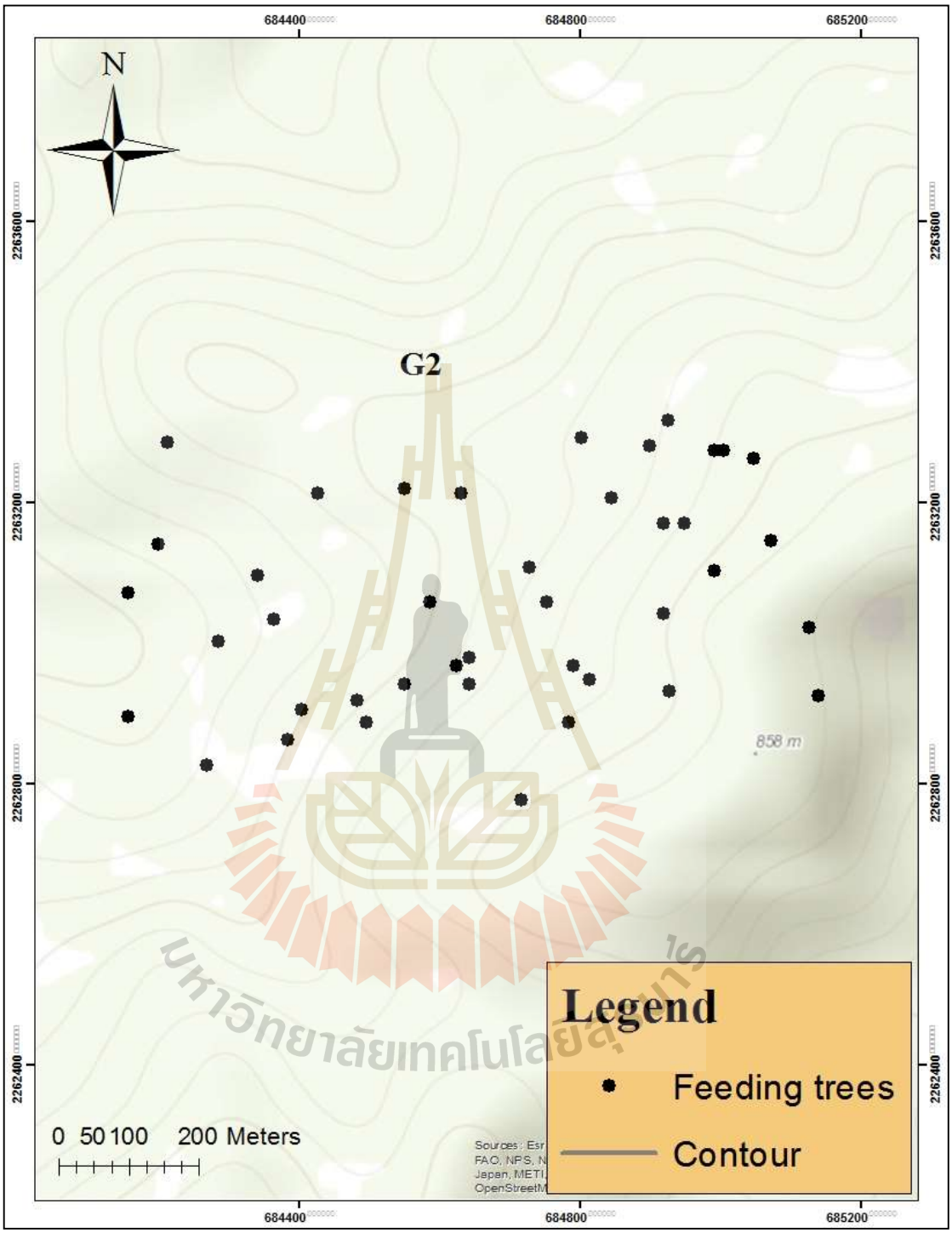

Figure 4.18 Feeding tree G2 of Laotian black crested gibbon in Nam Kan NPA.

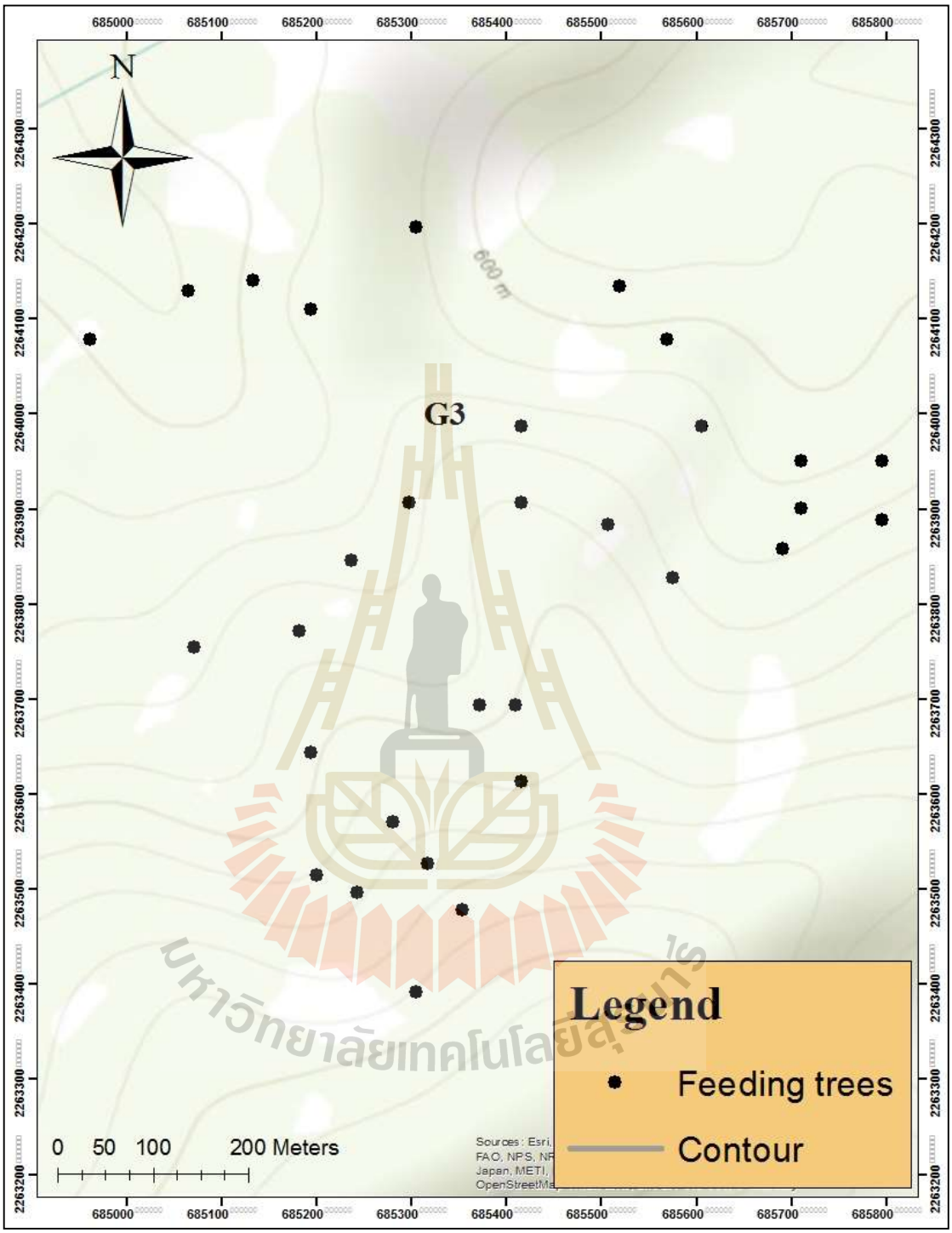

Figure 4.19 Feeding tree G3 of Laotian black crested gibbon in Nam Kan NPA.

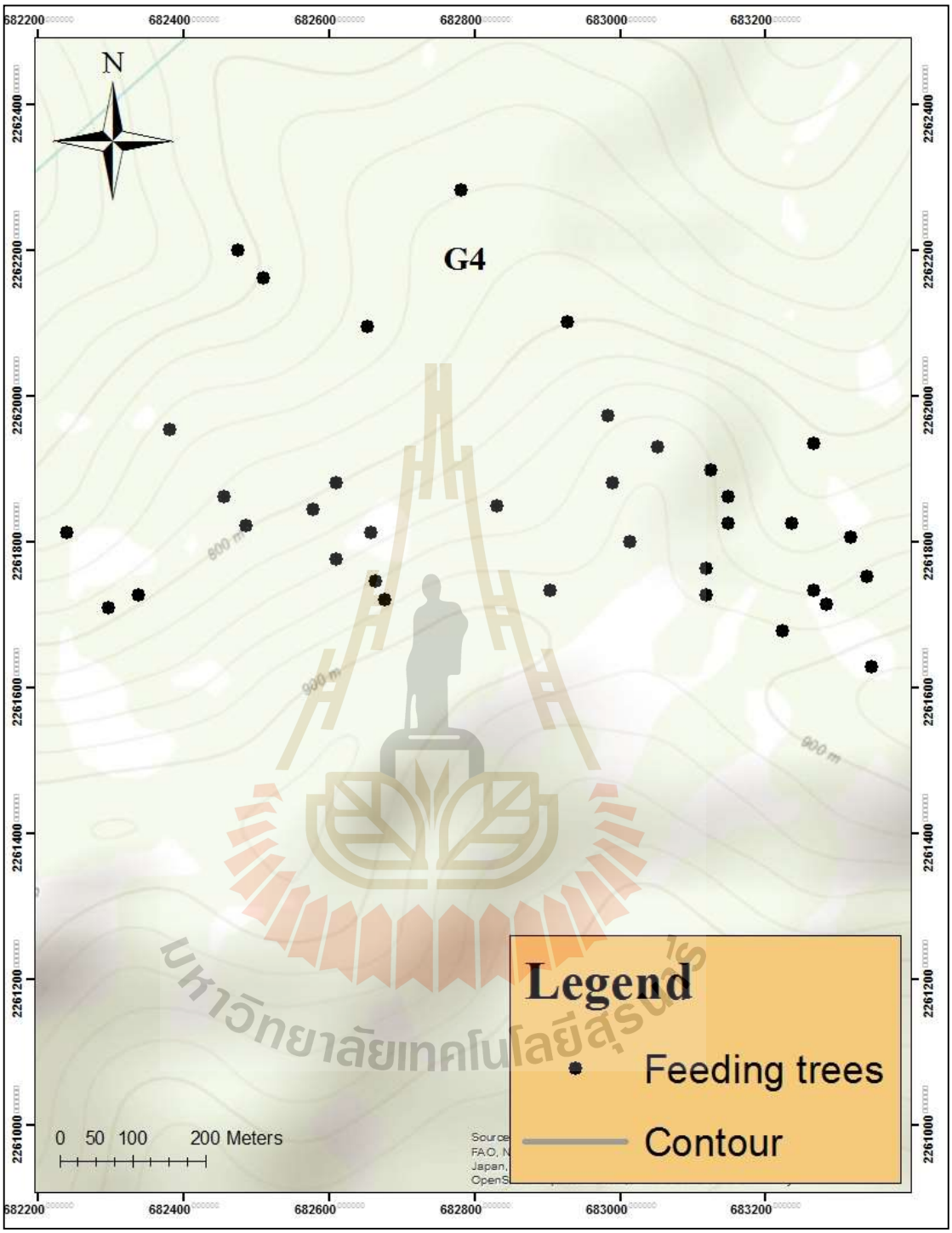

Figure 4.20 Feeding tree G3 of Laotian black crested gibbon in Nam Kan NPA.

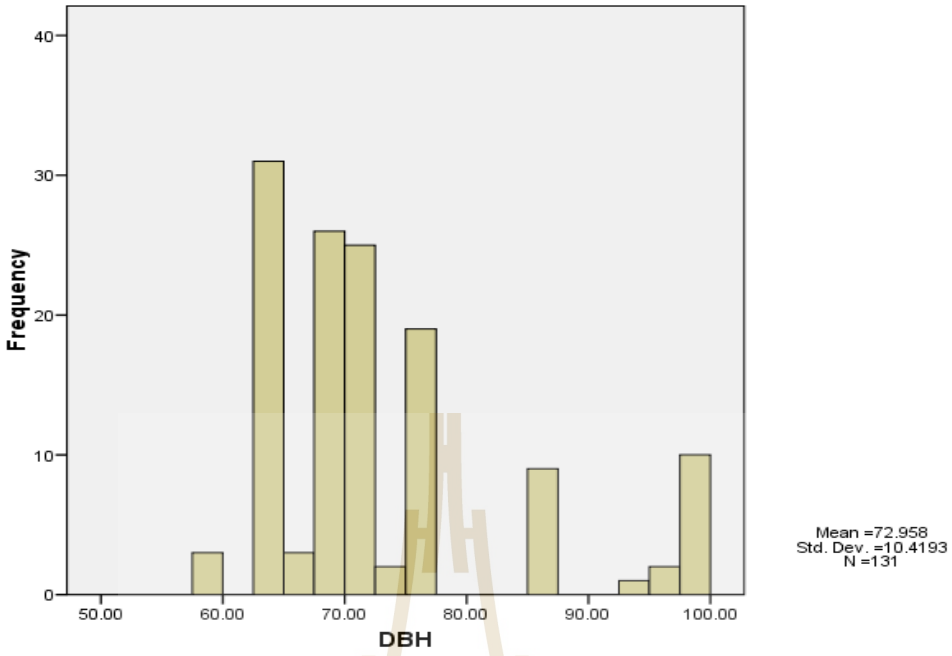

Figure 4.21 Frequency distribution of feeding tree DBH (cm).

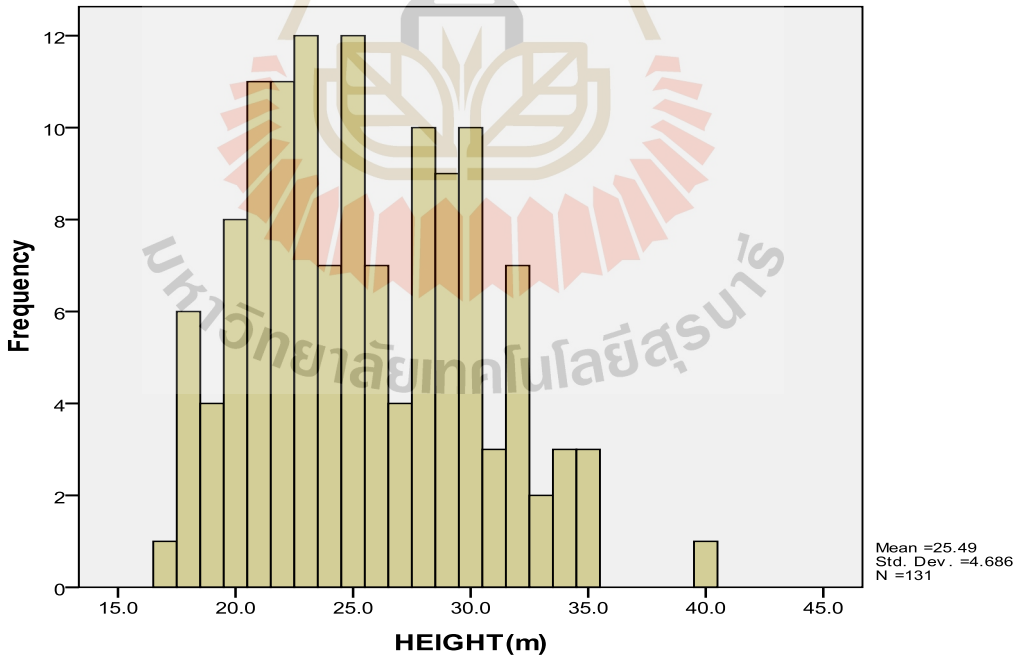

Figure 4.22 Frequency distribution of feeding tree height.

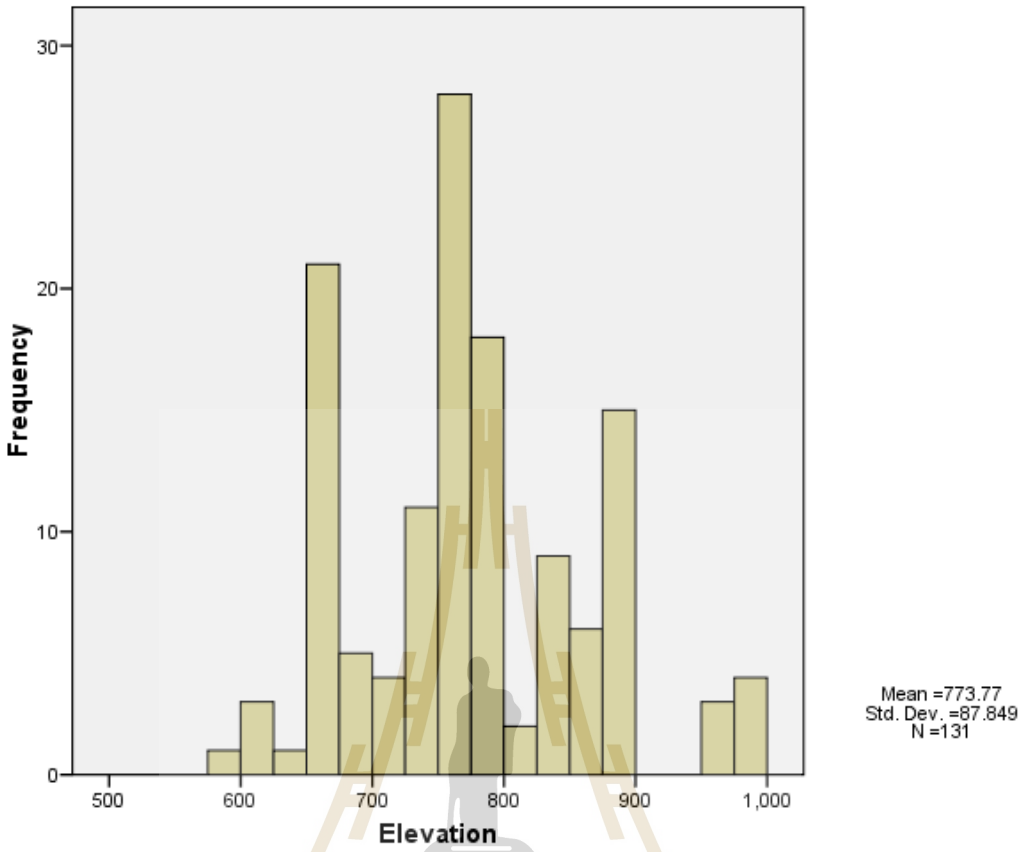

Figure 4.23 Frequency distribution of feeding tree elevation.

When compare with singing trees, feeding trees have the same average height (Figure 4.24), significantly less DBH ($p<0.05$; Figure 4.25) but stay in significant higher elevation ($p<0.05$; Figure 4.26) than singing trees.

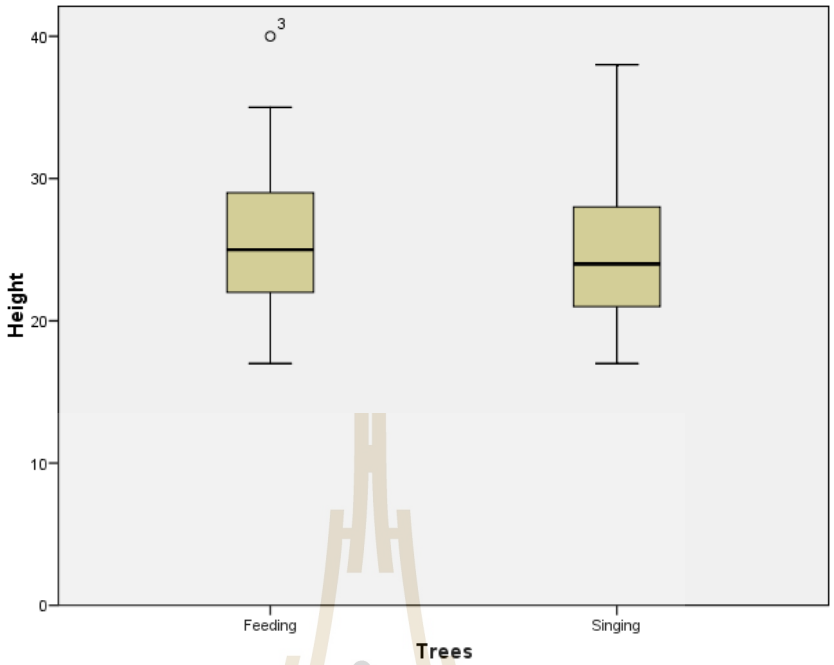

Figure 4.24 Height of feeding and singing tree comparison.

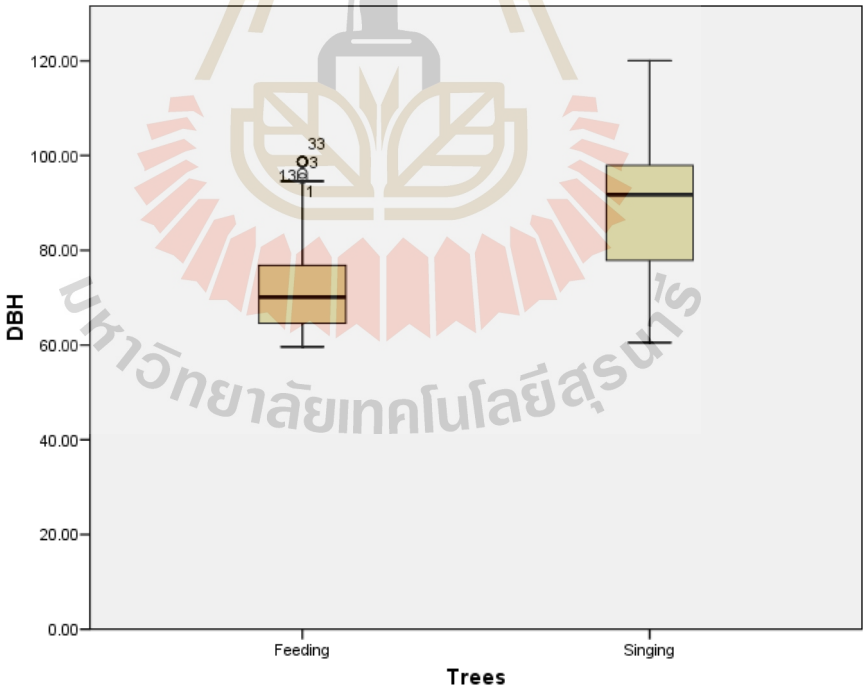

Figure 4.25 DBH of feeding and singing tree comparison.

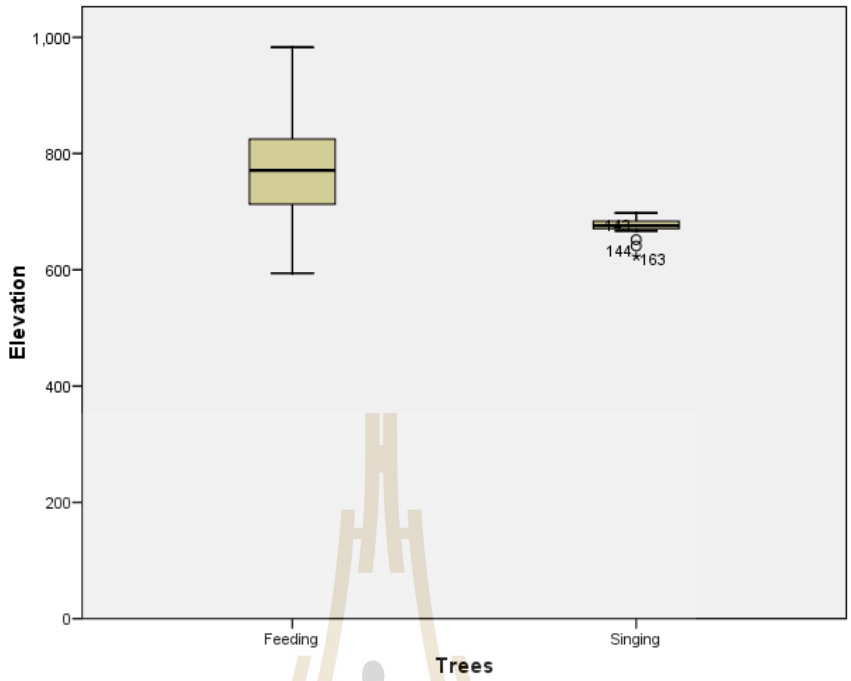

Figure 4.25 Elevation of feeding and singing tree comparison.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A total of 4 gibbon groups and 20 individuals were found and the group size average was 5.0 individuals. Two groups had one adult male and two adult females while some group had only 2 adults. This is probably from hunting.

From total of 670 observations, both adult males and adult females spent most daily time on travelling, followed by feeding and watching respectively but less time on sleeping. Adult males spent a bit more time on singing than adult females while adult females spent more time on grooming than singing. In contrast, sub adults, juveniles and infants spent most time on playing, followed by traveling and feeding, respectively. Sub adults spent least time on singing and sleeping while juveniles and infants did not sing at all.

The gibbon sang early morning calls after dawn between 06:04 to 07:36. The calls lasted 28 ± 5 minutes. From 35 singing trees found, nine plant species were identified. The highest number was *Spondias lakhonensis* Pierre, followed by *Ficus benjamina* and *Spondias axillaris* Roxb, respectively.

Gibbons consumed 15 plant species of 131 trees during our research. The most favorite plant was *Spondias lakhonensis* Pierre, followed by *Ficus hispida* L., *Ficus benjamina* and *Choerospondias axillaris*, respectively. Adult male and female gibbons

spent most of feeding time on fruits, followed by young leaves, flowers and mature leaves, respectively.

Singing trees had 25.0 ± 5.5 m mean height, 84.4 ± 14.8 cm mean DBH and 771 ± 95 m mean elevation. While, feeding trees had 25.5 ± 4.7 m height, 72.9 ± 10.5 cm DBH and 773 ± 87 m elevation. In comparison, feeding trees have the same average height, significantly less DBH but stay in significant higher elevation than those of singing trees.

Laotian black crested gibbons travel from 1.40 to 3.04 km per day. The average travel distance is 2.35 ± 0.63 km. There is no significant different daily travel distance among groups. While, gibbon foraging area ranges 9.01-37.41 ha/day with the mean of 19.17 ± 7.9 ha/day. Daily foraging area is significantly different among gibbon groups.

Gibbon Experience is one of three places in Nam Kan NPA that still supports good gibbon populations since the gibbon hunting activity is less due to Hmong's traditional taboo. The Gibbon Experience also hire local staff to deploy on site and do regular patrol but not yet effective. Gibbon population keeps declining compared to even several years ago.

5.2 Recommendations

More study of this species is still needed. A whole year study would be necessary to understand the dynamics of their food in different season. Longer time observation is needed to understand their behavior and social interaction. The same time observation is also important to compare behavior, movement and home range of each group. The researcher should spend more time following gibbons until they are familiar with so they can show true behavior.

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APPENDICES

APPENDIX A

ACTIVITY BUDGET .

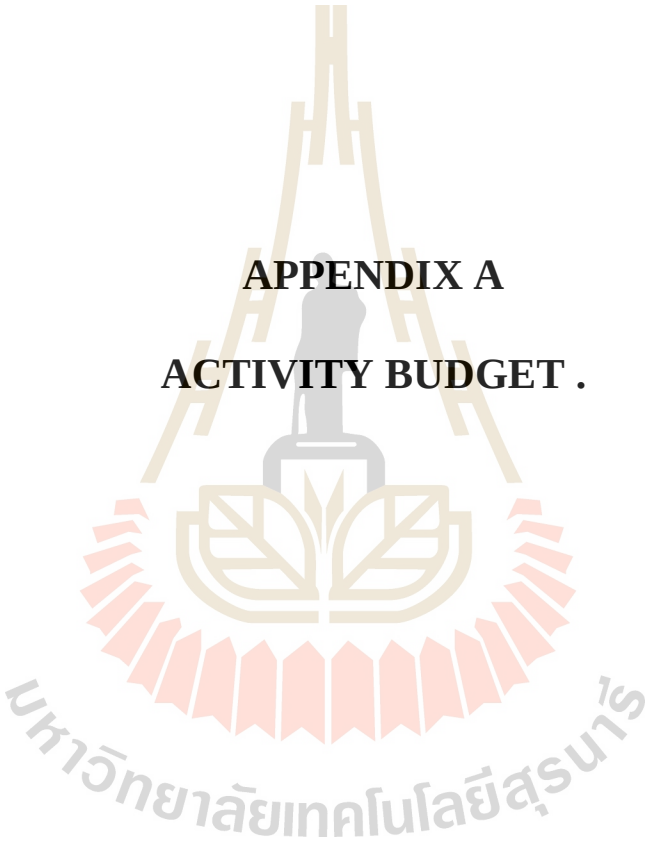

Table A1 Activity budget of adult male of Laotian black crested gibbons.

Groups	Date	Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	04-Aug-13	6:22-14:28	4	7	13	6	4	3	2	1	40
	05-Aug-13	6:56-13:36	4	6	6	3	2	1	3	1	26
	06-Aug-13	6:15-13:15	3	6	7	4	3	1	3	0	27
	07-Aug-13	6:20-15:05	3	5	6	9	2	3	2	2	32
G2	01-Sep-13	6:20-13:50	2	4	4	3	3	1	3	0	20
	02-Sep-13	6:20-14:35	3	5	7	6	2	3	2	2	30
	03-Sep-13	6:23-13:35	4	6	9	8	3	1	3	1	35
	04-Sep-13	6:10-14:55	3	6	7	2	5	2	2	0	27
	05-Sep-13	6:55-14:40	4	5	8	8	5	1	3	1	35
	06-Sep-13	6:22-14:42	4	9	7	10	3	0	3	1	37
G3	04-Oct-13	6:34-14:44	4	4	6	4	2	1	2	0	23
	05-Oct-13	6:15-13:45	4	7	8	5	4	2	0	1	31
	06-Oct-13	6:54-14:14	2	6	6	3	2	2	3	1	25
	07-Oct-13	6:45-13:15	4	4	7	5	3	1	2	2	28
	08-Oct-13	6:20-14:50	4	6	8	5	4	2	2	1	32
	09-Oct-13	6:25-13:25	2	6	7	7	2	2	2	1	29
	10-Oct-13	6:34-14:44	3	5	8	4	2	2	2	0	26
G4	02-Nov-13	6:15-14:30	3	5	6	6	3	3	3	1	30
	03-Nov-13	6:56-13:20	3	6	8	7	2	4	3	2	35
	04-Nov-13	6:15-12:50	4	5	8	4	4	3	1	1	30
	05-Nov-13	6:17-13:49	3	6	10	7	2	2	3	2	35
	06-Nov-13	6:34-14:44	3	7	11	5	4	4	3	0	37
Total			73	126	167	121	66	44	52	21	670

Table A2 Activity budget of adult female of Laotian black crested gibbons.

Group	Date	Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	04-Aug-13	6:22-14:28	2	6	11	3	6	1	2	1	32
	05-Aug-13	6:56-13:36	4	7	12	8	2	1	4	2	40
	06-Aug-13	6:15-13:15	3	7	4	4	3	1	2	2	26
	07-Aug-13	6:20-15:05	3	4	8	4	2	1	2	1	25
G2	01-Sep-13	6:20-13:50	2	2	5	5	3	3	2	1	23
	02-Sep-13	6:20-14:35	2	6	3	6	2	2	1	2	24
	03-Sep-13	6:23-13:35	2	4	7	3	2	4	1	2	25
	04-Sep-13	6:10-14:55	4	5	7	3	2	2	3	1	27
	05-Sep-13	6:55-14:40	2	6	6	4	5	2	3	1	29
	06-Sep-13	6:22-14:42	2	8	8	5	2	1	2	2	30
G3	04-Oct-13	6:34-14:44	3	9	6	4	2	3	2	2	31
	05-Oct-13	6:15-13:45	4	8	6	8	5	1	2	2	36
	06-Oct-13	6:54-14:14	4	7	8	2	4	4	0	2	31
	07-Oct-13	6:45-13:15	4	6	10	7	2	2	4	3	38
	08-Oct-13	6:20-14:50	4	6	5	6	4	2	1	2	30
	09-Oct-13	6:25-13:25	2	6	4	4	3	3	1	1	24
	10-Oct-13	6:34-14:44	4	8	5	3	1	3	3	2	29
G4	02-Nov-13	6:15-14:30	4	4	9	4	5	1	1	2	30
	03-Nov-13	6:56-13:20	4	6	8	6	7	2	0	0	33
	04-Nov-13	6:15-12:50	4	6	9	3	6	5	1	2	36
	05-Nov-13	6:17-13:49	3	2	12	6	5	2	3	2	35
	06-Nov-13	6:34-14:44	3	9	7	10	3	0	3	1	36
Total			69	132	160	108	76	46	43	36	670

Table A3 Activity budget of sub adult of Laotian black crested gibbons.

Groups	Date	Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	04-Aug-13	6:22-14:28	1	2	5	3	3	9	3	1	27
	05-Aug-13	6:56-13:36	1	3	4	2	5	8	1	1	25
	06-Aug-13	6:15-13:15	1	6	2	2	4	7	3	1	26
	07-Aug-13	6:20-15:05	1	4	3	2	3	8	3	1	25
G2	01-Sep-13	6:20-13:50	1	8	3	2	3	6	3	1	27
	02-Sep-13	6:20-14:35	1	9	3	3	3	8	3	1	31
	03-Sep-13	6:23-13:35	1	6	2	2	3	10	4	1	29
	04-Sep-13	6:10-14:55	1	7	4	1	2	8	2	1	26
	05-Sep-13	6:55-14:40	1	6	2	3	4	5	3	1	25
	06-Sep-13	6:22-14:42	1	9	6	4	2	8	2	1	33
	Total		10	60	34	24	32	77	27	10	274

Table A4 Activity budget of juvenile of Laotian black crested gibbons.

Group	Date	Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	04-Aug-13	6:22-14:28	0	4	8	2	1	12	1	1	29
	05-Aug-13	6:56-13:36	0	3	7	3	3	8	2	0	26
	06-Aug-13	6:15-13:15	0	5	8	3	2	7	3	1	29
	07-Aug-13	6:20-15:05	0	5	9	2	3	8	1	0	28
G2	01-Sep-13	6:20-13:50	0	3	6	3	3	12	1	0	28
	02-Sep-13	6:20-14:35	0	2	5	1	4	9	3	1	25
	03-Sep-13	6:23-13:35	0	4	7	2	2	6	2	0	23
	04-Sep-13	6:10-14:55	0	4	6	2	4	7	1	0	24
	05-Sep-13	6:55-14:40	0	3	7	2	4	8	3	1	28
	06-Sep-13	6:22-14:42	0	4	7	3	5	9	2	1	31
G3	04-Oct-13	6:34-14:44	0	5	3	2	3	11	1	0	25
	05-Oct-13	6:15-13:45	0	7	4	2	3	13	1	1	31
	06-Oct-13	6:54-14:14	0	6	3	1	4	7	2	1	24
	07-Oct-13	6:45-13:15	0	8	5	4	3	5	1	1	27
	08-Oct-13	6:20-14:50	0	6	5	2	2	7	2	0	24
	09-Oct-13	6:25-13:25	0	8	3	2	4	7	1	0	25
	10-Oct-13	6:34-14:44	0	7	5	1	5	8	3	1	30
	Total		0	84	98	37	55	144	30	9	457

Table A5 Activity budget of infant of Laotian black crested gibbons.

Groups	Date	Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
G1	04-Aug-13	6:22-14:28	0	3	6	2	2	13	2	0	28
	05-Aug-13	6:56-13:36	0	4	7	3	3	9	5	1	32
	06-Aug-13	6:15-13:15	0	3	6	2	2	11	2	0	26
	07-Aug-13	6:20-15:05	0	4	8	2	2	14	3	0	33
G2	01-Sep-13	6:20-13:50	0	5	7	2	3	13	2	1	33
	02-Sep-13	6:20-14:35	0	4	5	3	2	12	3	0	29
	03-Sep-13	6:23-13:35	0	5	6	2	3	12	2	0	30
	04-Sep-13	6:10-14:55	0	6	6	3	3	9	2	1	30
	05-Sep-13	6:55-14:40	0	4	7	3	2	10	3	0	29
	06-Sep-13	6:22-14:42	0	7	6	4	3	9	1	1	31
	Total		0	45	64	26	25	112	25	4	301

APPENDIX B

ACTIVITY BUDGET BY TIME

Table B1 Adult male activity budget by time.

Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
6:00	37			6	3	1	6		53
7:00	36	6	28	19	14	8	12		123
8:00		32	22	16	6	7	4		87
9:00		21	24	16	10	8	6		85
10:00		26	23	18	7	8	5		87
11:00		16	24	18	14	4	7	3	86
12:00		19	17	16	6	5	7	13	83
13:00		5	19	10	5	2	5	5	51
14:00		1	8	2	1	1			13
15:00			2						2
Total	73	126	167	121	66	44	52	21	670

Table B2 Adult female activity budget by time.

Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
6:00	30		2	4	5		3		44
7:00	39	8	25	18	17	5	10		122
8:00		33	16	17	6	4	5		81
9:00		24	30	14	9	5	3		85
10:00		18	23	12	8	9	12		82
11:00		17	22	16	9	8	3	9	84
12:00		15	18	10	9	7	4	19	82
13:00		14	19	15	9	6	2	6	71
14:00		3	4	2	4	2	1	2	18
15:00			1						1
Total	69	132	160	108	76	46	43	36	670

Table B3 Sub adult activity budget by time.

Time	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
6:00	4			4	3	6	2		19
7:00	6	2	7	4	4	8	4		35
8:00		8	6	5	5	9	4		37
9:00		6	8	5	4	8	4		35
10:00		9	9	6	4	11	5		44
11:00		12	6	4	3	8	2	3	38
12:00		8	7	6	5	11	3	5	45
13:00		8	4	4	5	6	4	2	33
14:00		3	7	5	3	9			27
15:00			4						4
Total	10	56	58	43	36	76	28	10	317

Table B4 Juvenile activity budget by time.

	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
6:00				2	6	14	3		25
7:00		10	11	7	9	18	3		58
8:00		13	9	4	6	16	4		52
9:00		11	10	4	10	18	3		56
10:00		12	12	7	9	19	5		64
11:00		14	14	5	11	17	6	1	68
12:00		13	9	7	6	18	4	6	63
13:00		10	15	6	5	16	4	2	58
14:00		14	14	6	6	15			55
15:00			12						12
Total	0	97	106	48	68	151	32	9	511

Table B5 Infant activity budget by time.

	Sing	Feed	Travel	Watch	Groom	Play	Rest	Sleep	Total
6:00				2	4	10	1		17
7:00		3	8	3	2	8	2		26
8:00		7	10	3	4	12	2		38
9:00		6	6	2	4	16	3		37
10:00		8	8	5	3	11	5		40
11:00		5	7	3	4	16	4	1	40
12:00		2	8	4	3	13	3	2	35
13:00		7	9	4	4	14	5	1	44
14:00		7	8	3	2	15			35
15:00			5						5
Total	0	45	69	29	30	115	25	4	317

APPENDIX C

SINGING TREES OF LAOTIAN BLACK CRESTED GIBBONS IN NAM KAN NATIONAL PROTECTED AREA

Table C1 Singing trees of Laotian black crested gibbons in Nam Kan National protected Area.

No	Date	Scientific name	High(m)	DBH(Cm)	UTM		Elevation
					X	Y	
1	04-Aug-13	*Dipterocarpus alatus* Roxb.	28	63.06	684611	2263533	673
2	04-Aug-13	*Bauhinia nervosa* (Wall.ex Benth)	35	70.06	684586	2263508	771
3	05-Aug-13	*Chukrasia tabularis* A. Juss.	34	92.68	684482	2263441	671
4	06-Aug-13	*Ficus benjamina*	23	81.21	684476	2263502	755
5	06-Aug-13	*Spondias lakhonensis* Pierre	18	71.66	684267	2263594	763
6	07-Aug-13	*Micrococs paniculata*	19	60.51	684187	2263600	731
7	07-Aug-13	*Spondias axillaris* Roxb	18	62.74	684519	2263502	771
8	07-Aug-13	*Spondias lakhonensis* Pierre	27	81.53	684672	2263521	713
9	08-Aug-13	*Ficus benjamina*	29	111.78	684482	2263551	851
10	01-Sep-13	*Dipterocarpus alatus* Roxb.	23	74.52	684697	2262870	832
11	02-Sep-13	*Chukrasia tabularis* A. Juss.	26	95.22	684525	2262839	677
12	03-Sep-13	*Dipterocarpus alatus* Roxb.	19	94.59	683794	2262599	652
13	03-Sep-13	*Spondias lakhonensis* Pierre	20	96.18	683843	2262753	623
14	04-Sep-13	*Ficus benjamina*	23	91.72	683954	2262642	775
15	05-Sep-13	*Chukrasia tabularis* A. Juss.	30	100	684955	2263152	868
16	06-Sep-13	*Ficus benjamina*	33	120.06	684555	2262851	686
17	06-Sep-13	*Spondias lakhonensis* Pierre	26	95.54	684727	2263048	683
18	04-Oct-13	*Dipterocarpus alatus* Roxb.	17	99.36	685679	2263907	870
19	05-Oct-13	*Spondias lakhonensis* Pierre	22	102.87	685673	2263778	674
20	06-Oct-13	*Ficus benjamina*	24	62.42	685513	2264006	888
21	07-Oct-13	*Spondias lakhonensis* Pierre	19	102.55	685016	2263969	984
22	07-Oct-13	*Dipterocarpus alatus* Roxb.	28	78.03	685102	2264006	781

Table C1 (Continued).

No	Date	Scientific name	High(m)	DBH(Cm)	UTM		Elevation
					X	Y	
23	08-Oct-13	*Ficus benjamina*	34	91.08	685126	2264110	672
24	08-Oct-13	*Dipterocarpus alatus* Roxb.	38	98.73	685470	2263545	884
25	08-Oct-13	*Spondias lakhonensis* Pierre	23	94.9	685747	2263926	776
26	09-Oct-13	*Dioscorea bulbifera* Loureiro	21	77.71	685784	2263852	798
27	09-Oct-13	*Protium serratum* (Wall.) Engl	25	89.17	685483	2263785	667
28	10-Oct-13	*Microcos paniculata*	17	69.11	685053	2263754	893
29	02-Nov-13	*Spondias lakhonensis* Pierre	21	95.54	683217	2261777	972
30	02-Nov-13	*Dipterocarpus alatus* Roxb.	22	90.13	683327	2261666	785
31	03-Nov-13	*Bauhinia nervosa* (Wall.ex Benth)	24	97.13	682259	2261672	891
32	04-Nov-13	*Spondias lakhonensis* Pierre	26	102.87	682363	2261746	841
33	05-Nov-13	*Ficus benjamina*	28	85.03	682357	2261949	671
34	06-Nov-13	*Ficus benjamina*	29	102.87	683118	2261998	778
35	06-Nov-13	*Spondias lakhonensis* Pierre	27	90.45	683143	2261838	669

APPENDIX D

PLANT SPECIES USED AS FOOD BY LAOTIAN BLACK CRESTED GIBBONS IN NAM KAN NPA

Table D1 Plant species used as food by Laotian black crested gibbons in Nam Kan NPA.

No.	Date	Scientific name	High (m)	DBH (Cm)	UTM		Elevation
					X	Y	
1	04-Aug-13	*Ficus hispida* L.	28	95.2	684641	2263576	860
2	04-Aug-13	*Ficus benjamina*	35	94.6	684635	2263533	691
3	04-Aug-13	*Spondias lakhonensis* Pierre	40	96.2	684586	2263484	594
4	04-Aug-13	*Euphoraiceae*	25	74.8	684537	2263410	711
5	04-Aug-13	*Ficus benjamina*	29	67.8	684519	2263453	752
6	04-Aug-13	*Sponddias lutea* L.	30	66.6	684469	2263478	776
7	05-Aug-13	*Dioscorea bulbifera* Loureiro	22	59.6	684291	2263459	795
8	05-Aug-13	*Microcos paniculata*	32	68.8	684353	2263508	625
9	05-Aug-13	Unidentified	23	70.1	684242	2263527	619
10	05-Aug-13	*Spondias lakhonensis* Pierre	29	76.8	684276	2263582	809
11	05-Aug-13	*Broussonetia papyrifera*	26	70.4	684365	2263557	760
12	06-Aug-13	Unidentified	20	63.1	684420	2263527	725
13	06-Aug-13	*Quercus augustinii* Skan	24	98.7	684267	2263637	825
14	06-Aug-13	*Spondias axillaris* Roxb	23	69.4	684132	2263674	771
15	06-Aug-13	*Euphoraiceae*	30	77.1	684193	2263711	671
16	06-Aug-13	Unidentified	29	64.6	684150	2263778	755
17	06-Aug-13	*Spondias lakhonensis* Pierre	25	86.3	684279	2263828	763
18	06-Aug-13	Unidentified	27	67.8	684291	2263772	731
19	07-Aug-13	*Spondias lakhonensis* Pierre	32	71	684316	2263693	771
20	07-Aug-13	Unidentified	25	62.7	684371	2263705	713
21	07-Aug-13	*Spondias lakhonensis* Pierre	35	64.6	684463	2263699	851
22	07-Aug-13	*Protium serratum (Wall.)* Engl	26	70.4	684549	2263736	832
23	07-Aug-13	*Quercus augustinii* Skan	22	71.7	684555	2263582	677
24	01-Sep-13	*Ficus hispida* L.	25	74.8	684813	2262949	652
25	01-Sep-13	*Ficus benjamina*	35	67.8	684783	2262888	623
26	01-Sep-13	*Spondias lakhonensis* Pierre	30	66.6	684715	2262778	775
27	01-Sep-13	*Dioscorea bulbifera* Loureiro	25	59.6	684623	2262968	868
28	01-Sep-13	Unidentified	24	68.8	684494	2262888	686
29	01-Sep-13	*Leguminosae*	30	70.1	684641	2262943	683

Table D1 (Continued).

No.	Date	Scientific name	High (m)	DBH (Cm)	UTM		Elevation
					X	Y	
30	02-Sep-13	Unidentified	20	76.8	683855	2262532	870
31	02-Sep-13	*Protium serratum* (Wall.) Engl	23	70.4	683769	2262434	674
32	02-Sep-13	*Ficus hispida* L.	32	63.1	683616	2262581	619
33	02-Sep-13	*Quercus augustinii* Skan	22	98.7	683702	2262624	809
34	02-Sep-13	*Euphoraiceae*	26	68.8	683855	2262569	760
35	02-Sep-13	Unidentified	28	70.1	684267	2262827	725
36	02-Sep-13	*Spondias lakhonensis* Pierre	23	76.8	684383	2262863	825
37	02-Sep-13	Unidentified	21	70.4	684549	2262943	771
38	02-Sep-13	*Quercus augustinii* Skan	30	63.1	684641	2262980	671
39	03-Sep-13	*Ficus hispida* L.	17	98.7	684156	2263072	755
40	03-Sep-13	*Broussonetia papyrifera*	22	69.4	684211	2263287	763
41	03-Sep-13	Unidentified	24	77.1	684426	2263214	731
42	03-Sep-13	*Ficus benjamina*	28	64.6	684340	2263097	771
43	03-Sep-13	*Leguminosae*	18	86.3	684549	2263220	674
44	03-Sep-13	*Spondias lutea* L.	20	70.1	684586	2263060	888
45	03-Sep-13	*Spondias axillaris* Roxb	29	76.8	684924	2263318	983
46	03-Sep-13	Unidentified	22	70.4	684991	2263275	781
47	03-Sep-13	*Ficus benjamina*	30	63.1	684918	2263171	672
48	03-Sep-13	*Euphoraiceae*	24	98.7	684991	2263103	884
49	03-Sep-13	*Protium serratum (Wall.)* Engl	22	68.8	684752	2263060	776
50	03-Sep-13	Unidentified	21	70.1	684789	2262968	798
51	04-Sep-13	*Leguminosae*	18	76.8	685139	2262925	667
52	04-Sep-13	*Spondias lakhonensis* Pierre	32	70.4	684482	2262919	893
53	04-Sep-13	*Spondias lakhonensis* Pierre	29	63.1	684402	2262906	972
54	04-Sep-13	*Spondias lutea* L.	23	67.8	684727	2263109	785
55	04-Sep-13	*Broussonetia papyrifera*	27	66.6	684844	2263207	891
56	05-Sep-13	*Spondias axillaris* Roxb	20	59.6	684918	2263042	841
57	05-Sep-13	*Spondias lakhonensis* Pierre	21	68.8	685126	2263023	671

Table D1 (Continued).

No.	Date	*Scientific name*	High (m)	DBH (Cm)	UTM		Elevation
					X	Y	
58	05-Sep-13	*Ficus benjamina*	31	70.1	684801	2263293	725
59	05-Sep-13	*Dioscorea bulbifera* Loureiro	34	76.8	685004	2263275	825
60	06-Sep-13	Unidentified	23	70.4	684948	2263171	771
61	06-Sep-13	*Leguminosae*	25	63.1	684629	2263214	671
62	06-Sep-13	Unidentified	26	98.7	684899	2263281	755
63	06-Sep-13	*Quercus augustinii* Skan	25	69.4	685047	2263263	763
64	06-Sep-13	*Microcos paniculata*	24	77.1	685071	2263146	731
65	04-Oct-13	*Ficus benjamina*	19	64.6	685796	2263950	771
66	04-Oct-13	*Ficus hispida* L.	28	86.3	685796	2263889	674
67	04-Oct-13	*Spondias lakhonensis* Pierre	34	67.8	685710	2263901	888
68	04-Oct-13	Unidentified	27	71.2	685575	2263828	983
69	04-Oct-13	*Broussonetia papyrifera*	21	62.7	685507	2263883	781
70	05-Oct-13	*Protium serratum* (Wall.) Engl	30	63.1	685415	2263907	672
71	05-Oct-13	Unidentified	31	98.7	685409	2263693	884
72	05-Oct-13	*Microcos paniculata*	25	69.4	685691	2263858	776
73	05-Oct-13	Unidentified	20	77.1	684961	2264079	798
74	06-Oct-13	*Spondias axillaris* Roxb	23	64.6	685065	2264129	667
75	06-Oct-13	*Quercus augustinii* Skan	26	86.3	685133	2264141	893
76	06-Oct-13	*Euphoraiceae*	18	70.1	685194	2264110	972
77	06-Oct-13	*Spondias lakhonensis* Pierre	22	76.8	685237	2263846	785
78	06-Oct-13	*Spondias axillaris* Roxb	24	70.4	685298	2263907	891
79	06-Oct-13	*Spondias lutea* L.	30	63.1	685415	2263987	725
80	07-Oct-13	Unidentified	23	98.7	685519	2264135	825
81	07-Oct-13	*Spondias lakhonensis* Pierre	25	68.8	685569	2264079	771
82	07-Oct-13	Unidentified	20	70.1	685605	2263987	671
83	07-Oct-13	Unidentified	21	76.8	685710	2263950	755
84	08-Oct-13	*Spondias lakhonensis* Pierre	18	70.4	685071	2263754	763
85	08-Oct-13	*Broussonetia papyrifera*	22	63.1	685182	2263772	731

Table D1 (Continued).

No.	Date	Scientific name	High (m)	DBH (Cm)	UTM		Elevation
					X	Y	
86	08-Oct-13	*Ficus hispida* L.	26	67.8	685194	2263643	771
87	08-Oct-13	*Microcos paniculata*	28	69.4	685200	2263514	713
88	08-Oct-13	*Dioscorea bulbifera* Loureiro	23	77.1	685280	2263570	851
89	08-Oct-13	*Spondias lakhonensis* Pierre	21	64.6	685243	2263496	832
90	09-Oct-13	*Ficus benjamina*	19	86.3	685317	2263527	771
91	09-Oct-13	Unidentified	18	67.8	685305	2263392	674
92	10-Oct-13	Unidentified	21	71.2	685354	2263478	888
93	10-Oct-13	*Spondias lakhonensis* Pierre	20	62.7	685372	2263693	983
94	10-Oct-13	Unidentified	25	63.1	685415	2263613	781
95	10-Oct-13	Unidentified	28	98.7	685305	2264196	672
96	02-Nov-13	*Spondias lakhonensis* Pierre	29	69.4	683339	2261752	884
97	02-Nov-13	*Ficus benjamina*	21	77.1	683266	2261734	776
98	02-Nov-13	*Microcos paniculata*	20	64.6	683235	2261826	798
99	02-Nov-13	Unidentified	18	98.7	683149	2261826	667
100	02-Nov-13	*Spondias lutea* L.	32	69.4	682983	2261973	893
101	03-Nov-13	Unidentified	29	77.1	682830	2261850	972
102	03-Nov-13	*Spondias axillaris* Roxb	23	64.6	682664	2261746	785
103	03-Nov-13	*Broussonetia papyrifera*	28	86.3	682609	2261777	891
104	03-Nov-13	*Ficus hispida* L.	22	69.4	682296	2261709	725
105	04-Nov-13	*Protium serratum* (Wall.) Engl	32	77.1	682240	2261813	825
106	04-Nov-13	*Quercus augustinii* Skan	28	64.6	682486	2261823	771
107	04-Nov-13	*Euphoraiceae*	33	86.3	682381	2261955	671
108	04-Nov-13	Unidentified	30	67.8	682609	2261881	755
109	04-Nov-13	*Spondias axillaris* Roxb	21	71.2	682658	2261813	763
110	04-Nov-13	Unidentified	34	62.7	682474	2262200	731
111	04-Nov-13	*Dioscorea bulbifera* Loureiro	29	63.1	682510	2262163	771
112	04-Nov-13	*Ficus hispida* L.	24	63.1	682652	2262096	674
113	04-Nov-13	Unidentified	19	67.8	682928	2262102	888

Table D1 (Continued).

No.	Date	Scientific name	High (m)	DBH (Cm)	UTM		Elevation
					X	Y	
114	05-Nov-13	*Leguminosae*	21	69.4	683125	2261899	983
115	05-Nov-13	*Spondias lakhonensis* Pierre	22	77.1	681317	2261807	781
116	05-Nov-13	*Euphoraiceae*	21	64.6	683266	2261936	672
117	05-Nov-13	*Dioscorea bulbifera* Loureiro	19	86.3	632535	2262022	884
118	05-Nov-13	*Leguminosae*	26	67.8	682455	2261863	776
119	05-Nov-13	*Spondias lakhonensis* Pierre	25	71.2	682578	2261844	798
120	05-Nov-13	*Quercus augustinii* Skan	32	62.7	682338	2261727	667
121	05-Nov-13	*Ficus hispida* L.	29	63.1	682903	2261734	893
122	05-Nov-13	Unidentified	28	62.7	682676	2261721	671
123	05-Nov-13	Unidentified	30	63.1	683051	2261930	755
124	05-Nov-13	*Protium serratum* (Wall.) Engl	25	98.7	683149	2261863	763
125	05-Nov-13	*Spondias lakhonensis* Pierre	23	69.4	683118	2261764	731
126	06-Nov-13	*Sponddias lutea* L.	28	77.1	683346	2261629	771
127	06-Nov-13	*Broussonetia papyrifera*	22	64.6	683223	2261678	713
128	06-Nov-13	*Dioscorea bulbifera* Loureiro	33	86.3	683014	2261801	851
129	06-Nov-13	Unidentified	27	70.1	683284	2261715	832
130	06-Nov-13	*Spondias lakhonensis* Pierre	31	76.8	683118	2261727	771
131	06-Nov-13	Unidentified	23	70.4	682989	2261881	675

CURRICULUM VITEA

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Research Publication

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