NAT. HIST. BULL. SIAM SOC. 54(1): 109–138, 2006

ECOLOGY AND SITE-BASED CONSERVATION OF THE WHITE-HANDED GIBBON (*HYLOBATES LAR* L.) IN HUMAN-USE FORESTS IN MAE HONG SON PROVINCE, NORTHERN THAILAND

***Pathom Yimkao*[1] *and Sompoad Srikosamatara*[1]**

ABSTRACT

A study of gibbon ecology and distribution was conducted during Feb, 2004 – Feb, 2005 at Nam Lang Basin, Mae Hong Son Province, northern Thailand. At least 87 individuals in 6 separated *H. lar* populations inhabiting various sizes of forest fragments in Nam Lang basin were confirmed. Most groups were found in protected community forest adjacent to Karen communities. The main study group inhabited Muang Phaem used forest, which is located outside the protected areas of Lum Nam Pai and San Pan Daen WS. During the study, 3 gibbons were killed by hunters from 3 different hill tribes. The main study group (G1) ranged within about 40-61 ha in mixed deciduous bamboo forest and partly at the edge of a deciduous dipterocarp forest. Average tree height in G1's home range was 23.5 m, (range 2–42 m, SD= ±9.99, N = 264) and average diameter of 34.5 cm, (range 10–165.5 cm). At least 57 food plant species were recorded within 1 km^2 of mixed deciduous forest within the home range of group G1. The fruiting period of each species varied from about 15 days to 6 months. *Ficus* spp. produced fruits throughout the year. Starting times of the first call of group G1 ranged from 0647 to 1045 h. The culture, traditions and beliefs of Karen have played a significant role in the survival of the gibbons throughout their history. Other ethnic groups, especially Lahu from Bala and the Shan, commonly hunt gibbons. Gibbons can be conserved in Muang Phaem Forest and surrounding forest provided that Department of Parks officials are sympathetic to the local villages needs. Restoration of culture and knowledge of local minorities, together with coordinated co-management by villagers, sanctuary officials, and researchers in a site-based approach, are necessary for gibbon conservation.

Key words: conservation, Mae Hong Son, tropical deciduous forest, Karen, White-handed gibbon

INTRODUCTION

White-handed gibbons (*Hylobates lar*) occur in evergreen and moist mixed deciduous forests throughout Thailand except for the Southeast, where pileated gibbons occur (MARSHALL *ET AL.*, 1972; BROCKELMAN, 1975). In western Thailand, they occur in dry evergreen forest and adjacent deciduous forest in Huai Kha Khaeng Wildlife Santuary (HKKWS) (BHUMPAKPHAN, 1988; STEINMETZ & MATHER, 1996). In northern Thailand, they have been reported in mixed deciduous forest, dry evergreen forest and dry dipterocarp forest, in Lum Nam Pai WS (LMPWS) (SUWANNAKERD, 2001). Most studies of *H. lar*

[1]Department of Biology, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand
Recieved 29 September 2005; accepted 15 June 2006.

have been restricted to few well protected areas such as Khao Yai National Park (KYNP), part of the recent declared Dong Phaya Yen-Kao Yai World Heritage Site. Research in KYNP has concerned mostly on ecology, social behavior, and social interactions among groups. Studies on impacts of fragmentation, hunting, and human activities are needed in other areas where gibbons are more threatened.

Forty years ago, Thailand had a large population of *H. lar*, with about 75,000 km^2 of remaining forest habitat (BROCKELMAN, 1975). TILSON *ET AL.*, (1994) summarized that the population of *H. lar* in Thailand was about 110,000 individuals in a total area of about 17,000 km^2. Although *H. lar* is not included in the IUCN red list (2004) as endangered or critical locally, many populations are facing extirpation due to hunting, habitat loss, and forest fragmentation. The wild population of *H. lar* in Thailand at present is still largely unknown throughout most of its range.

Since the first study of *H. lar* by CARPENTER (1940) in Doi Chiang Dao, Chiang Mai Province, in 1938, there has been no study of gibbon populations in northern Thailand. In 1999, SRIKOSAMATARA *ET AL.* documented fragmented populations of *H. lar* distributed in Lum Nam Pai and San Pan Daen Wildlife Sanctuaries (LNPWS, SPDWS), Mae Hong Son Province. These are included within a large region of mostly cultivated land with about 60 villages of 9 minority peoples that have occupied the area for more than two centuries (SRIKOSAMATARA *ET AL.*, 1999). At present, a few populations of gibbons have been confirmed in this area, but their numbers are declining due to hunting and habitat loss through illegal logging and shifting agriculture by diverse local hill tribes, including Hmong, Red and Black Lahu, Lisu, Thai Yai, Shan, and Karen.

Among the many ethnic groups in the North, Karen are known to have the least impact on gibbons since they still obey prohibitions or taboos against the hunting and eating of gibbon meat, while other tribes have lost those traditions and beliefs. Therefore, populations now remain mostly near Karen villages and their fields. STEINMETZ & MATHER (1996) have documented a healthy population (range 2.1–4.1 groups/km^2) inhabiting dry evergreen forest near Karen villages in Thung Yai Naresuan Wildlife Sanctuary (TYNWS). However, Karen communities vary in their commitment to conservation. Karen communities therefore still have a strong influence on the survival of gibbons in their region, but the increasing immigration into the area of Shan and resident Lahu directly threatens gibbon populations.

The National Parks and Wildlife Reservation Act of 1960 marked the first systematic wildlife conservation policy in Thailand. However, under the act, only wildlife species and their habitat within protected wildlife sanctuaries were legally protected while those living outside were not. During that time, the first national development plan for economic and social policies was also declared. The contradictions between the act and the development plan caused problems in nature protection. The reliance on subsistence systems of people in the past has changed to modern dependence on free trade systems, causing social imbalances. At present, the problems still remain and have become even more complicated. A strongly site-based approach is considered to be the best way of solving problems in various situations and in different regions.

This study covers the distribution, conservation status, habitat condition, and risk factors of gibbons in the Nam Lang Basin. Relevant ecological and behavioral data on gibbons have also been obtained.

STUDY AREA

The study was conducted in or near Lum Nam Pai Wildlife Sanctuary (LNPWS) (1,181 km^2; 19° 13'–37'N, 97° 57'–99° 26'E) and San Pan Daen Wildlife Sanctuary (SPDWS) (277 km^2; 19° 33'–45'N, 98° 5'–22'E) which are located in a protected area complex in Mae Hong Son Province, North Thailand (Fig. 1). Both sanctuaries contain karst topography at 300 to 1,500 m a.s.l. and receive about 1,200–1,300 mm annual rainfall (1,598 during 12 months of the study in Muang Phaem Forest). Temperature recorded during the study ranged from 5.5 to 41°C. Land lower than 1,000 m a.s.l. was covered by tropical mixed deciduous forest, deciduous dipterocarp forest, and pine–deciduous dipterocarp forest (SANTISUK, 1988). *Pinus merkusii* and *Pinus kesiya* can be found in pine–deciduous dipterocarp forest at 800–1,000 m a.s.l., *P. merkusii* having higher density. Secondary growth and grass fields are scattered throughout the area. In both sanctuaries, there are different sizes of communities of various ethnic minorities, including Lahu, Karen, Tai, Shan, Lisu, Lua and Thai. Some, such as Lahu Nyi, still practice their traditional swidden cultivation.

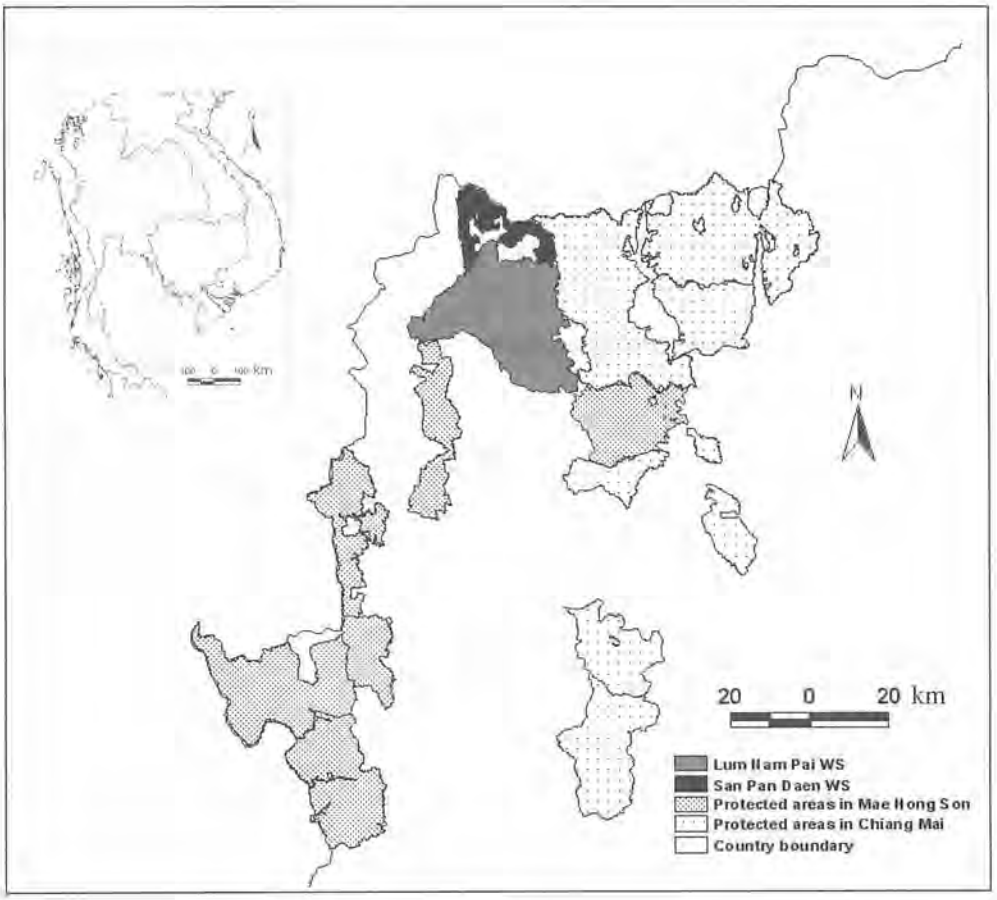

Figure 1. Location of protected areas in Mae Hong Son and Chiang Mai Provinces.

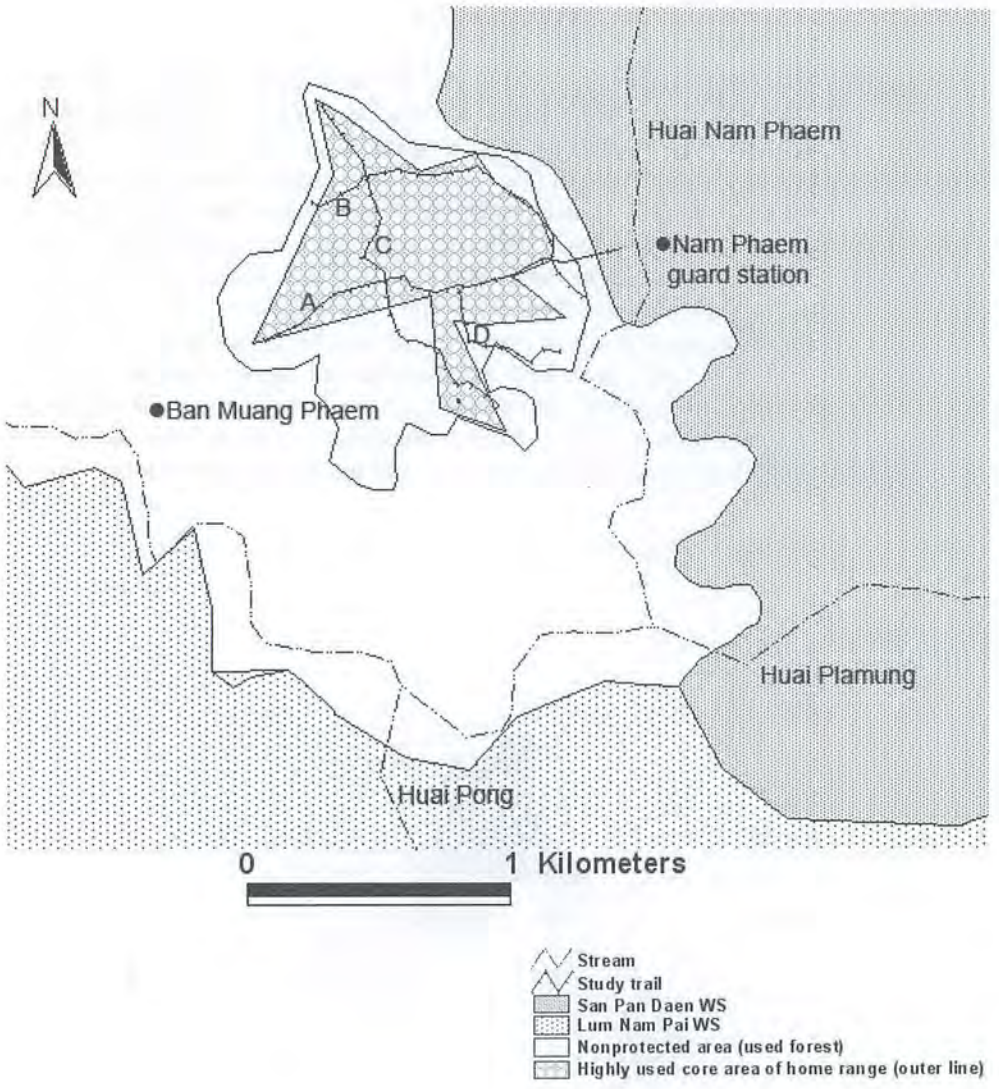

Figure 2. The main study trails in the home range of the main study group (61 ha) by GPS survey and the heavily used area (41 ha) of the main study group.

Our intensive study site (Muang Phaem Forest) is located in a community-use forest adjacent to SPDWS and LNPWS in Pang Ma Pa district (Fig. 2). The site consisted of seasonal deciduous hardwood and bamboo, fire-damaged, continuously degraded forest in rugged limestone terrain surrounded by deciduous dipterocarp and pine forest (following MAXWELL & ELLIOTT, 2001). The Pang Ma Pa area contains limestone, granite and sandstone topography, resulting in diverse forest types and plant communities (KHAMYONG *ET AL.*, 2003). In the dry season in every year most plants in the area lose their leaves.

Ban Muang Phaem in 2004 was home to more than 400 people of 109 families of Sgaw Karen in Mae Hong Son (Fig. 3). Most of these people were Buddhists but three families were Christian. Most families had their own lands and planted rice and other field crops, but also used forest products as supplementary food sources. While they hunted wildlife for protein, hunting of gibbons, hornbills and some birds was forbidden. In reserved forest around the village, grazing of livestock such as buffalos and cows was illegal under the law, but was allowed by local officials (Fig. 4). Moreover, the surrounding forest has been used for nature tourism for many years. Annual burning, grazing by domestic cattle, and elephants caused serious damage to the forest floor and understory.

At least 12 mammal species were found in the home range of the main gibbon study group, including Assamese macaque *Macaca assamensis* (one male), Phayre's langur *Trachypithecus phayrei* (1 individual), Asiatic jackal *Canis aureus*, barking deer *Muntiacus muntjak* (5 sightings, at least 4 animals), Burmese striped squirrel *Tamiops mcclellandii*, bay bamboo rat *Cannomys badius*, squirrel *Callosciurus* sp., small Indian civet *Viverra indica*, pangolin *Manis pentadactyla* L. or *Manis javanica* Des., large bamboo rat *Rhizomys sumatrensis*, northern tree shrew *Tupaia belangeri*, and rats *Rattus* spp. Large bird species included great hornbill *Buceros bicornis*, jungle fowl *Gallus gallus*, etc. Small and medium size birds that shared the fig with the gibbons included hill myna, red-whiskered bulbul, black-crested bulbul, sooty-headed bulbul, 3 species of barbet, etc.

MATERIALS AND METHODS

Gibbon Distribution Survey

Previous presence/absence data of *H. lar* in the San Pan Daen and Lum Nam Pai Wildlife Sanctuaries from interview surveys conducted by SRIKOSAMATARA and his team (1999) were used as guidelines for further surveys in seven selected villages in the Nam Lang basin. Villagers who lived near the forest were interviewed regarding the presence of gibbons heard or seen. The results of my preliminary studies conducted during May, 2002 and April–June, 2003, are also included here. The study was carried out from 25 February 2004 to 26 February 2005 in Muang Phaem Forest. The main study site covered an area about 12 km^2. Compass and GPS (Garmin GPS 12 XL) were used for locating gibbon groups. The distances to groups were estimated from their loud calls.

Behavior Study

At least 636 h on 131 observation days (mostly during 0600–1200 h) were spent searching for and observing the main study group (G1). Four major study trails (a, b, c, d) were made along the main travel routes and across the gibbons' home range for observing gibbons and phenological study of food plants. I used GPS and compass to locate positions visited by all groups of each population, and plotted them on topographic maps (1:50,000) using UTM coordiantes. Time spent in feeding, traveling, singing and other behaviors by each member of the study group was recorded in field notebooks.

Group G1 consisted of 5 members: adult male, adult female, 2 adolescents and infant (weaning) (using definitions of ELLEFSON, 1984). Age and sex classes were distinguished

by relative size and sex specific call types. One of the two adolescents was female as she participated in great call with the adult female). The group was not habituated enough to observe their behaviors systematically. Behavioral data were obtained mostly from distant observations through binoculars and telescope. The major behaviors recorded in this study were ranging or traveling, feeding, and calling (using call definitions of RAEMAEKERS *ET AL.*, 1984). Ten-minute scan sampling adapted from ALTMANN (1974) was used during longer time observation, but continuous data recording was mostly used for short-time observation. Other behaviors such as resting, grooming, sleeping, fighting, hiding, escaping were also recorded opportunistically.

Habitat, Plants, and Phenology

Seventy-eight plots of 11.3-m radius (ca. 400 m^2) at 50 m intervals along straight lines of 45° bearing were established within the home range of group G1. All trees more than 10 cm diameter at breast height (dbh) were recorded (adapted from BROCKELMAN, 1998). Some parts of the area which consisted of steep slopes or rugged limestone rock which could not be accessed or used by the gibbons were excluded. An optical rangefinder (working range 10–75 m) was used to measure the highest point of the canopy directly over 4 points on each circular plot, 11.3 m from the center point in north, south, east, and west directions. Field identification of trees more than 10 cm DBH was done by plant taxonomist J. F. Maxwell (CMU Herbarium, Dept. of Biology, Chiang Mai University). The relative abundance of trees growing in each plot was calculated. Feces dropped by the gibbons of the study group was also collected whenever possible for examination of plant seeds swallowed by the gibbons.

All food plants in the home range of G1 and neighboring groups were observed at least every 2 weeks using 8 x 40 binoculars and 20–60 power Nikon telescope for their phenology (fruiting, flowering, shoots, young leaves, mature leaves).

Fruits, flowers, and leaves of all food plant species both eaten and reported eaten by gibbons were photographed and collected throughout the study. Plant samples were preserved and sent to Chiang Mai University Herbarium for species identification.

Climate

Rainfall was recorded daily at 0600 h with a 50-ml rain gauge. Temperature was recorded two times a day at 0600 and 1800 h using a min-max mercury thermometer. Weather conditions (windy, cloudy, and sunny) were recorded every 10 minutes during gibbon observation periods.

Human Activities and their Impacts on Gibbons

On most days I stayed in the Karen village (Ban Muang Phaem) but I spent one week in the Lahu Nyi village of Ban Aela to collect detailed information on their activities in the forest which possibly affected gibbons. Observations were also made daily on activities in the village and in the forest. I noted activities in the home range of the main study group such as wood cutting, searching for non-timber products and cropping. Home interviews were carried out in the villages of Muang Phaem (more than 95% of the time staying in

the field) and Aela (7 days) which where located near populations L1 and L2, respectively. Survey of the opinions of Karen in Ban Luk Pagor (31 families) and Ban Mae U-Mong (32 families) was done during February 2005.

Local Participation

Two of the sanctuary staff were selected as field assistants to participate in parts of this study, such as gibbon surveys (adapted from BROCKELMAN & SRIKOSAMATARA, 1993), setting up study trails, plant phenology study, and forest structure measurement. Local knowledge concerning gibbons and their foods was also obtained. We conducted occasional meetings between Karen people of Muang Phaem and Lahu people of Ban Aela about land use and wildlife conservation.

Data Analysis

Microsoft Excel 2000 was used for statistical calculations for quantitative data including behavioral data, human activities (frequency of gun sounds), vegetation or habitat structure, climatic study.

All population information and related data such as risk factors (hunting rate, family structure, numbers of births and deaths, habitat alteration, fragmentation), were used for predicting future survival of the gibbons. The conservation status of the species is affected by *direct factors:* demography, poaching, hunting, deforestation rate, logging activities, and community attitudes about conservation; and *indirect factors:* government policy on land use management, agricultural programs, tourism activities, and government staff attitudes toward conservation.

RESULTS

Temperature and Rainfall

Temperature in the study site ranged from 6 to 41°C throughout the year. Average minimum and maximum temperature during summer (March–April), rainy (May–September), and winter (November–February) seasons were 15–36°C, 21–32°C, and 8.5–32°C, respectively.

During the study period, 1,598 mm of rainfall (93 rainy days of 168 days of rainy season) was recorded. Minimum and maximum rainfall was 0.2 and 62.5 mm, respectively. Average rainfall was about 17.2 mm/single raining day, and 53.3 mm per month in the rainy period of the year studied. There were three peak periods of rainfall during June to September, 2004.

Habitat of the Main Study Group

The forest within the home range of about 61 ha of the main study group (group G1) comprised five distinct types:

Type 1.—lower part, covered mainly by tropical deciduous forest (750–800 m a.s.l.). This type was classified in to 2 subtypes, Type 1m (moist) and Type 1d (dry) (Fig. 3).

Type 2.—ledge or steep slope, comprising mixed tropical deciduous forest (800–900 m a.s.l.).

Type 3.—upper part, comprising mainly tropical deciduous forest with teak on the plateau (850–900 m a.s.l.) (Fig. 4).

Type 4.—consisting mainly of secondary growth in the valley or gently sloping areas (750–800 m a.s.l.).

Type 5.—eco-tone areas between tropical mixed deciduous forest and pine-deciduous dipterocarp forest. (800–850 m a.s.l.).

The average diameter of all trees in 78 plots of 400 m^2 was 34.5 cm (SD = 23.55) (range 10–165.5 cm, N = 508). The basal area of trees calculated from dbh for the whole plots was 0.87 m^2 per 400 m^2 or 0.22%. The cliff site contained a diversity of food plant such as bamboo, *Cylathocalyx matabanicus, Ficus* spp., *Bombax insigne*, and *Bischofia javanica.*

The tree canopy surface over 4 points in each plot averaged 23 m (range 2–42 m), SD = 9.99, N = 264). The percentage of canopy cover was 86% on average in the rainy season.

Plant Species

Sixty species of 28 families of trees in the home range of group G1 were identified (Appendix 1). *Xylia xylocarpa* (Leguminosae) dominated in the middle of slope (Type 1m) and Type 3) (127 individuals or 33%). Four species of Sterculiaceae were common in the limestone plateau (Type 3). Two species of *Polyalthia, P. viridis* and *P. cerasoides* (Annonaceae) were found in the area near the temporary stream. *P. viridis* was found in the lower valley between the stream and the cliff (29 or 8%) whereas *P. cerasoides* was found mostly on limestone. Bamboos were common over the area of the home range of the study group. At least 10 species of climbers (5 used as gibbon food) were found in home range of group G1. A list of all tree species and numbers of each species in the plots (70 species of more than 30 families) is given in Appendix 1.

Distribution and Populations of Gibbons in other Surveyed Areas

In general, the features of the forest inhabited by gibbons in Nam Lang area vary from place to place. However, one characteristic shared by all places is inaccessible limestone or granite cliffs that protect them from hunting and from being easily followed. Most groups found inhabited the forest by streams adjacent to Karen villages (ranging from 300 m to 3.5 km distant). In contrast, no groups were found close to Lisu villages (except in the community's protected forest). The areas that I usually found occupied by gibbons were covered mainly by seasonal deciduous hardwood–bamboo forest, often fire-damaged, forest on rugged limestone terrain, and some parts of secondary growth. During February 2004 to February 2005, at least 9 groups were found living close to Karen (Sgaw Karen) villages, possibly 2 groups lived close to Tai Yai (Shan) villages and another 2 groups lived in inaccessible forest areas (200 m away from the highway) of Pang Ma Pa district

Figure 3. Ban Muang Phaem, the Karen village where the study was carried out. Note the limestone cliffs beyond the village that help protect gibbon groups from hunters.

Figure 4. Cattle grazing tends to degrade the forest near Ban Muang Phaem and most other villages of the province.

Figure 5. Tropical deciduous and bamboo forest (750–800 m a.s.l.) which consist of *Polyalthia viridis*, various species of *Ficus, Xylia xylocarpa*, as common species. (Lower part of the home range of the main study group) (type 1 m).

Figure 6. Tropical mixed deciduous forest with teak stand (850–900 m a.s.l.) on the plateau consisting of *Tectona grandis, Shorea siamensis*, and *Terminalia alata* as common species (the upper part of the home range of the main study group) (type 3).

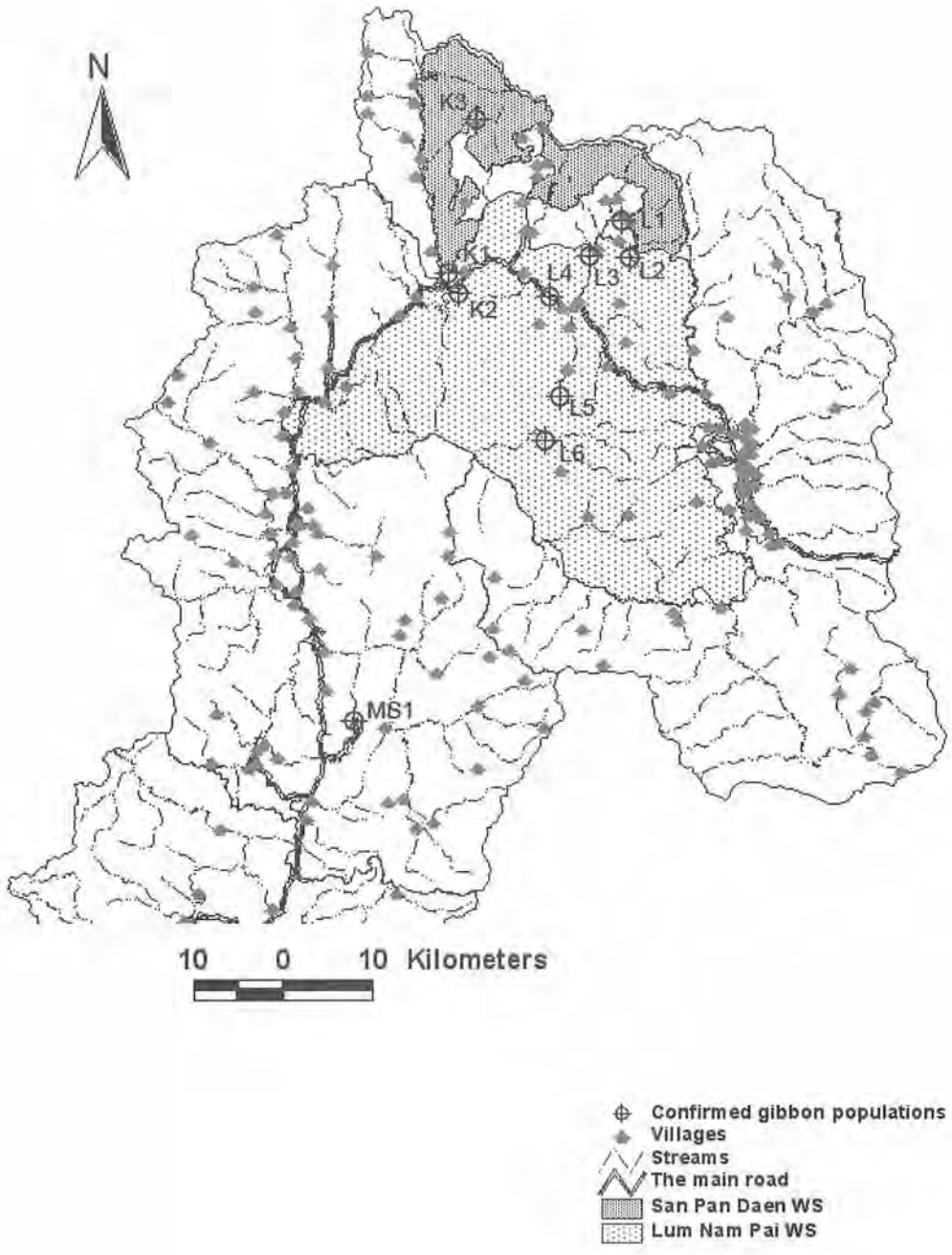

Figure 7. Map showing the distribution of 10 gibbon populations of Nam Lang (L1–L6), Nam Khong (K1–K3) and Nam Tok Mae Surin NP (MS1).

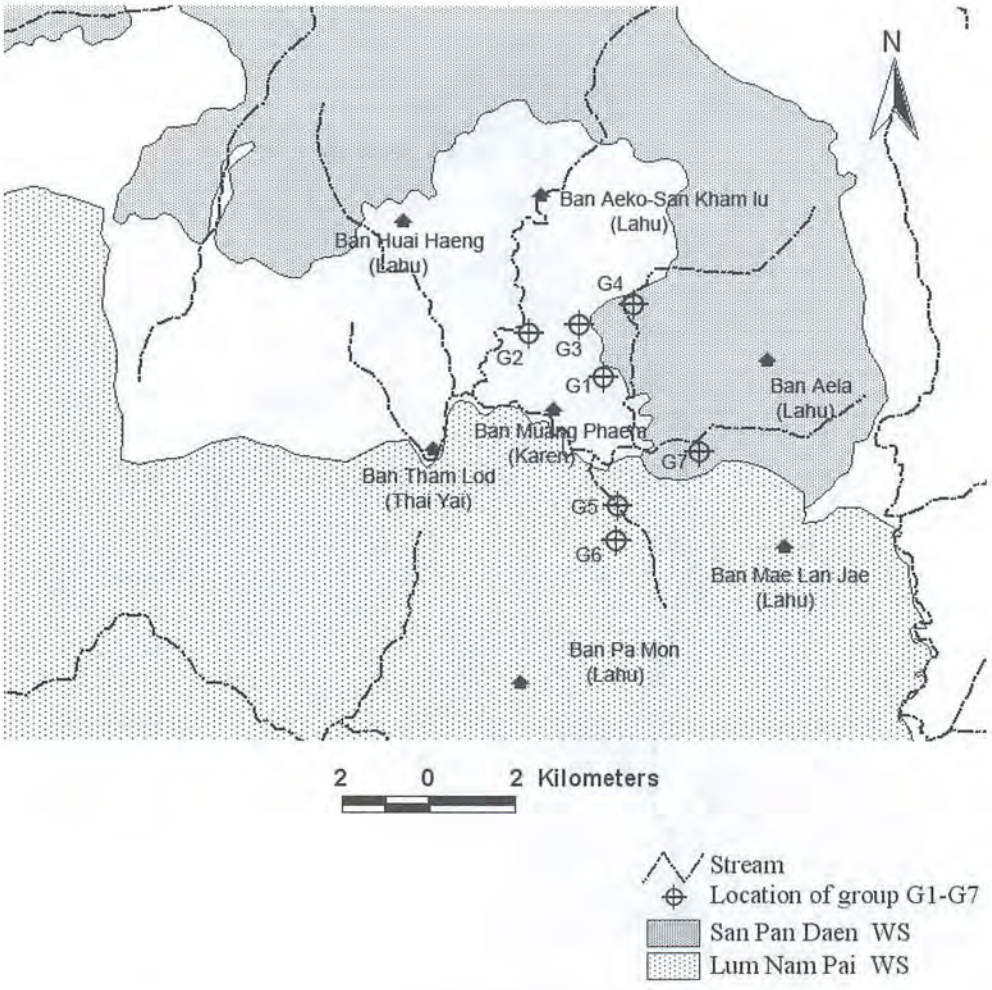

Figure 8. The distribution of population L1 (G1–G4) and population L2 (G5–G7) which are surrounded by Karen, Lahu, and Tai Yai villages in Lum Nam Pai WS and San Pan Daen WS, and the heavily-used area home to population L1.

head office. For the populations in Huai Poo Ling (Karen), Manora (Karen) villages, only interview surveys were done.

The distribution of 10 fragmented populations around the study area is shown in Figures 7 and 8. Counts were made of 7 groups in populations L1 and L2 (Table 1). Group size was 5 or 6 individuals, and average group size was 5.3, which is relatively high for gibbons, and indicates a relatively high reproduction rate. The number of subadults is rather high. This may be due to the fragmentation of the habitat which reduces opportunities for dispersal and new group formation. It is possible that some of the individuals scored as juveniles were actually subadults (unmated individuals of breeding age).

Table 1. Composition of gibbon groups in populations L1 (G1–G4) and L2 (G5–G7) in the study site of Muang Phaem Forest. D = dark pelage; L = light pelage.

Group	Adults (female, male)	Subadults	Juveniles	Infants	Total
G1	D, D	D	D	D	5
G2	L, D[1]	D	D[2], D[2]	–	5
G3	D, D	D	D, D	–	5
G4	D, D	D	D, D	D	6
G5	L, D	D	D, L	–	5
G6	D, D	D	D, D	D	6
G7	L[2], D	D	L, D	–	5
Total	**14**	**6**	**14**	**3**	**37**

[1] Unclear which adult was D or L.
[2] Individuals shot by hunters during study.

In addition to groups in populations L1 and L2, brief counts were made of an additional 11 groups, supplemented by information from interviews. These groups contained a total of approximately 52 individuals, giving an average group sixe of approximately 4.7 individuals. All of the populations combined yield an average of 4.9 individuals per group.

The dark color phase is predominent in this part of Mae Hong Son, as 13.5% of individuals in the 7 groups listed in Table 1 were dark.

During my study at least 3 gibbons were hunted (Table 1). The Bala Lahu are the most skilled and dangerous hunters in this area. They hunt almost every kind of wildlife including gibbons and hornbills. They range widely and are likely to hunt everywhere, mostly using locally made guns.

Threats by Local People

The continuous immigration of Shan people has resulted in a fast-growing human population in the study area and over much of Mae Hong Son Province. Most Shan have come to Thailand illegally by the help of local Tai Yai and their relatives who had come earlier. These people are known to cause many problems, especially wildlife hunting.

Poor management of nature tourism causes serious and long-term damage to the habitat, especially the forest area around and inside the gibbon home range that is heavily used by elephants. Because of over-eating of bamboo and destruction of small and medium size trees by the elephants, the forest has become more open and less suitable for use as foraging and traveling routes by the gibbons.

In the year of this study, a vast area of old crop fields or secondary growth near the village was cleared for planting in the next rainy season (May–June). Most rice fields were inherited from previous tribal residents, the Thai Yai, more than 40 years ago. Extension

of crop fields have reduced forest area and caused fragmentation. Gibbons in the study area now cannot easily move between forest patches and have become isolated.

Annual forest fires cause continuous degradation of the forest and suppress natural succession. Fires are started each year around late February to end of March in order to prepare the ground for crop planting. Most of the area of Mae Hong Son Province burns as the fires escape into the forests. The effects of these fires have not been well studied.

Over-grazing by free ranging buffalos and cows cause severe damage to bamboos in the home range of the gibbons. Nearly 100% of bamboo clumps growing in the areas that the animals can access and were eaten; only bamboo trunks more than 4 years old were left behind. Cows, having smaller horns than buffalo, can reach through bamboo clumps and eat up all the young shoots.

Behavior

Feeding

Feeding and resting behavior were negatively correlated. The main study group spent 21 minutes on average (SD = 7.3, N = 8) resting before the next feeding bout. Group G1 usually fed during 2–3 periods a day from 0647 to 1428 h. in 8–11 bouts (N = 72 bouts on 28 observation days). Only 1 feeding bout was observed after 1400 h (at 1428 h). The group spent about 37.9 minutes/feeding bout (range 5–110 min, SD = 26.2). *Ficus* spp were the most frequently observed foods (43%) of the 10 food species. The duration of feeding bouts depended on the amount of food available at that time, the species of food plant and the human traffic near the food trees. The group spent longest times in large and highly productive trees with large quantities of ripening fruit or flowers, such as various species of figs, *Biscofia javanica,* and *Bombax insigne* (Fig. 9).

Ranging

The main study group traveled within their territory of about 41 ha. The adult male usually led the group during daily travel for various purposes while the female and her offspring usually followed him. Normally, after encountering the observer, the group did not return to the same place the same day or even for several days if they had other food choices.

Sleeping trees

Group G1 used at least 5 locations in the home range as sleeping sites (73 observation days). Most sleeping trees were usually located on steep slopes or in the middle of a cliff. Sleeping places were a single standing trees or bamboo stems (Fig. 10) which had thick leaves or were leafless. REICHARD (1998) revealed that gibbons sometimes selected relatively isolated trees as their sleeping sites. The time for setting down for sleeping varied from early afternoon (1402 h) to early evening (1645 h, N = 6).

Morning calls

At least 1,762 minutes were spent listening to and recording vocalizations of all the groups of populations L1 (mostly group G1, the main study group) and L2. The following

Figure 9. Adult female of group G1 resting on the branch of a flowering *Bombax insigne* tree in December 2004.

Figure 10. Bamboo at the ledge, a favored sleeping place of group G1.

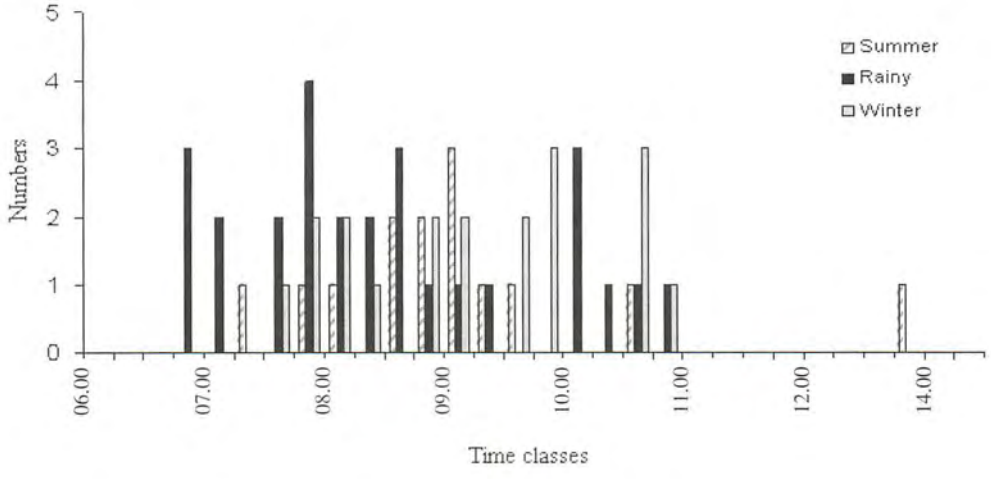

Figure 11. Seasonal comparison of frequency of starting times of morning calls emitted by the main study group. The group started their morning duet mostly during 0830–0915 h in the summer, 0645–0845 h in the rainy season, and 0745–1045 h in winter.

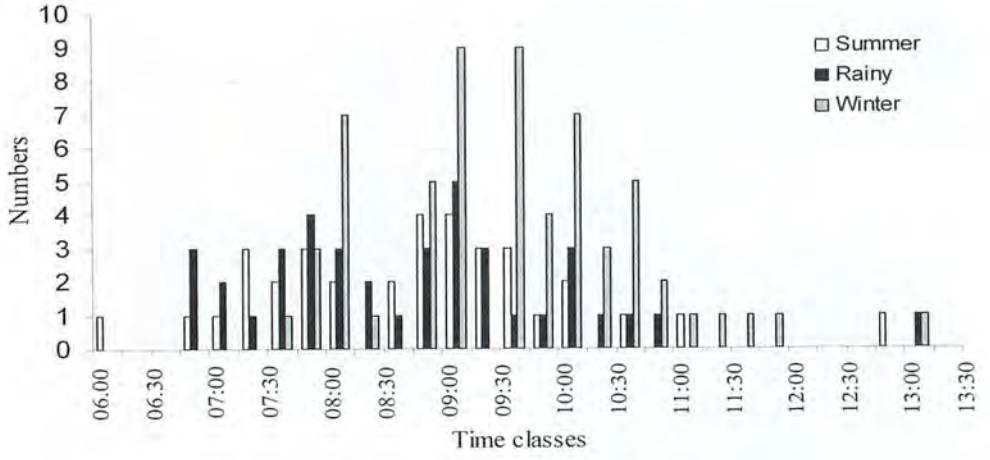

Figure 12. Seasonal comparison of frequency of starting times of morning calls emitted by all the groups, 0745–0945 h during summer, 0645–1015 h during rainy season and 0800–1045 h during winter.

were the vocalization data for group G1 and neighboring groups of L1 and separated L2.

During the year, group G1 called on 61 out of 130 (48%) of vocal survey days and more than a half (56%) of morning calls included duets with great calls by the adult female. These bouts contained from 1 to 11 female calls each. The average starting time of morning calls of group G1 was 0919 h (N = 61) while it was 0910 h (N = 109 days) for all the groups. On average mean starting times of morning calls of group G1 were slightly later in winter (0920 h, N = 14) than in summer (0907 h, N = 27) or in the rainy season (0836 h, N = 20). Starting times of morning bouts (15-min. interval samples) of group G1 ranged from 0645 to1245 h, but were mostly during 0830–0915 h in summer, 0645–0845 h in the rainy season and 0745–1045 h in winter (Fig. 11). For all the groups (including L1 and L2), song bouts were started during 0600–1315 h but mostly during about 0815–1045 h in summer, 0645–1015 h in the rainy and 0800–1045 h in winter (Fig. 12). The frequency of singing of group G1 was not very different between seasons (44% of days in winter, 46% in summer, and 48% in the rainy season). Calling after 1200 h rarely occurred and usually happened when some of the group members encountered the observer (calls were usually emitted by the adult male but the adult female joined sometimes). Group G1 sang for 26 minutes/bout on average (range 1–99, SD = 27.8, N = 61). For all groups the average duration was 20.8 minutes/bout (range 1–99, SD = 23.8, N = 117). Group G1 usually called one time per day, but on 6 days the group had 2 bouts. Alarm calls with *wow* and *ooaa* notes usually were produced when they encountered humans in the territory. If they detected a human, they usually moved quietly to another place. Great calls of individual females were distinctive.

Call interactions between groups

In fragmented habitat with low group density in my study site, the gibbons seemed to call infrequently due to conflicts between groups. Morning call bouts of 2 groups overlapped

in time only 8 times, and 3 groups had overlapping bouts only 3 times. However, more intensive study and comparison with other populations are needed to understand more about singing interactions. In this study, only 3 cases of group calls occurring during aggresssive interactions between groups were observed.

Diet

In this study, 57 species in 18 families of confirmed and potential food plants were found in the home range of the main study group, mostly fruits (Fig. 13; Appendix 2). Twenty-nine species of plants, including 10 *Ficus* (*F. altissima, F. benjamina, F. concina, F. curtipes corues, F. kerrzii, F. microcarpa* and 4 unknown species) were observed to be eaten by the gibbons, many from seeds found in feces and fruits dropped with tooth marks on them A further 13 species may have been used on the basis of data from other studies, and 9 species were classified as potential foods based on information obtained from villagers. *Ficus* spp. were the most abundant type of food tree in the home range. *Polyalthia viridis, Xylia xylocarpa, Mitrephora vandaeflora* and *Grewia eriocarpa* were most abundant among other fruit trees. These species tended to occur in clumps in the home range. This probably may help explain why the home ranges of the gibbons in this area were relatively large compared to those studies in evergreen forests in KYNP or HKKWS. Based on plant habit, food plants of group G1 may be placed into 7 categories: trees, 10 species of figs, 7 climbers, 6 shrubby trees, 2 bamboos, 1 orchid and 1 parasitic plant (Fig. 12a). Food plant species in the home range of group G1 could be divided into 4 categories according to part eaten: 10 figs, 28 other fruits, 4 flowers and 3 leaves (Fig. 12b). The gibbons also consumed insects, as evident by remains of mantids and wasps found in feces (Fig. 15).

Species identification of figs in this study is not complete because the limitations of time and imperfect plant samples. The Unknown 1, in Thai called "wild grape" (Vitaceae (Fig. 13, photo 3) was the gibbons' favorite juicy fruit. Without this plant, it may be difficult for the gibbons during early rainy season. Future expansion of crop fields will directly affect the availability of this species for group G1.

Scurrula sp. (Loranthaceae) was the most important flower food species, while other flowering species supplemented this. Both observation and fecal analysis confirmed that group G1 fed on flowers in significant amounts during the transition from winter (October–February) to summer (March–April) because the shortage of fruits. The abundance of *Scurrula* was related to the relative abundance of *Xylia xylocarpa*. The demand for *X. xylocarpa* for fuel wood directly affected the abundance of this plant. Alternative sources of firewood for villagers are required in order to ensure the availability of this plant which is important for the survival of the gibbons in this habitat.

In my study only 3 species of plants were used as leaves, 2 species of bamboo and Unknown 8 (Ze-le-cho in Karen) which grew in rugged limestone area were confirmed to be eaten by the gibbons, due to the difficulty of observing feeding by the unhabituated group. However, many more species of leaves are undoubtedly eaten.

The diversity of food plants in the range of population L1 and L2 indicated that intact and relatively undisturbed tropical deciduous forest is needed in order to ensure the survival of the gibbons in northern Thailand.

Figure 13. Some fruit plants eaten by group G1. 1, *Ficus* sp.; 2, *Bambuosa* sp.; 3, Wild grape (Vitaceae); 4, (Vitaceae); 5, *Bombax insigne*; 6, *Aeschynanthus andersonii*; 7, Nato-jor-zoo (Karen); 8, *Grewia eriocarpa*.

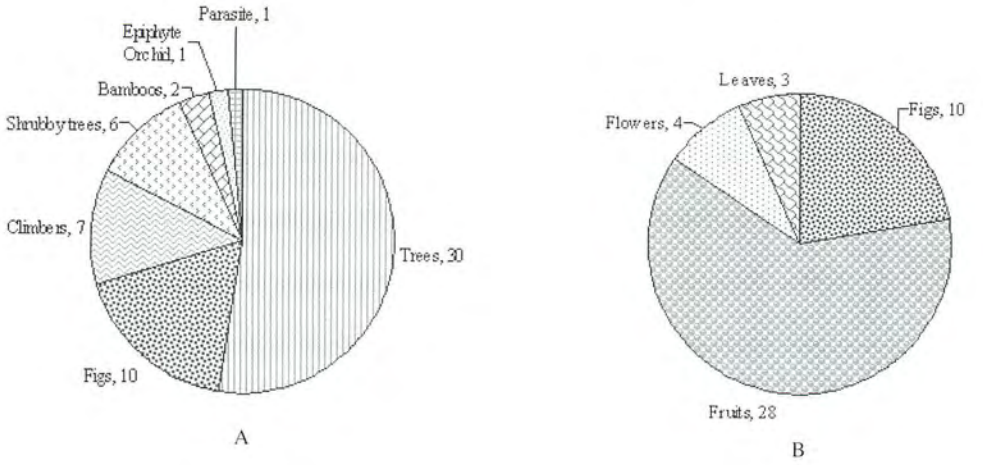

Figure 14. Proportions of food plants classified by plant habit (a) and part eaten (b) of group G1. Data was derived from my observations, confirmed specimens, and from local knowledge.

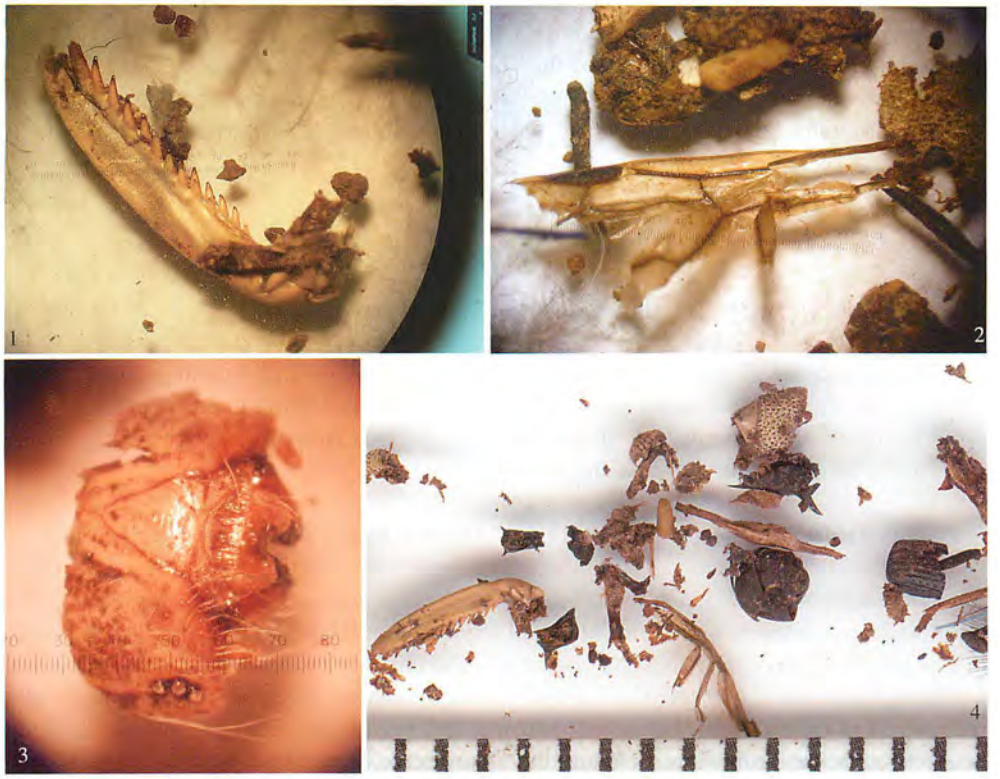

Figure 15. Parts of insects found in fresh feces collected on February 2005 in the home range of group G1. 1, front leg of mantid; 2, hymenopteran wing part; 3, head part of unknown larva; 4, overall view.

Human Activities and Ecological Services of the Forest

Since the Karen community has long been practicing agriculture, most of their time is used for working in their fields. During my study the villagers of Ban Muang Phaem spent most their time preparing the land for planting and collecting timber and non-timber products from the home range of group G1. All families had their own domestic animals including elephants, buffalos and cows. During 2001–2004, the population of elephants, buffalos and cows all increased (from 7 to 8 elephants, from 49 to 518 buffalos and from 199 to 275 cattle). These numbers are more than the forest can sustainably support. Pigs and chickens raised for household use and for traditional use spiritual sacrifices are almost stable in number. The higher population growth of cows than buffalos is resulting in greater damage to bamboo because the cows can eat bamboo shoots in the middle of the clumps. Population control of all species of domestic animals, especially cows, must be done in order to maintain gibbon habitat. Bamboo in most areas within and around the home range of the main study group is declining and will die off if the villagers do not protect it from over-harvest and over-grazing by their free ranging livestock.

In the morning, the villagers walk into the woods to their crop fields in the morning at about 0800 h and they usually return to the village about 1700 h. Groups of young man with guns also return from the woods after hunting for bush-meat, usually common squirrels and some kinds of birds. After dinner they often gather in someone's house and entertain each other with stories of their experiences. Karen villagers by nature are highly social and like to communicate with each other. Their life style has been perpetuated since their ancestors.

DISCUSSION

The Causes of Low Density

The density of gibbons in the study area was relatively low (about 1 group km^{-2}) compared to that in other study areas. This may be because of the hunting and the forest types in the area. Fragmentation of the forests in the area is one of the factors that make the density of the groups lower than normal.

The Relation between Distribution of Gibbon Populations and Hill Tribes

Gibbon populations (each with 3–6 groups) in this area were mostly found in forest close to Karen villages and their cultivated land. This reflects the role the Karen people in this area have played in conservation of this ape throughout their history. Karen culture has been widely known as an effective tool for nature conservation, but this has rarely been recognized in recent times. However, their role has been made less effective by the main active hunters, the Lahu from Bala and the Shan people. Apart from hunting impacts, one of the main factors that has limited the effectiveness of the Karen in wildlife protection is the failure of education. Nevertheless, a large and intact Karen community is in a better situation than small and isolated communities. The Lahu and Thai Yai cultures may have also played a role in conservation in the past, but do not in the present. In the broad view,

most gibbon ranges in Mae Hong Son are being continuously degraded by human activities such as nature tourism, expansion of crop fields, domestic cattle and elephants, annual forest fires, subsistence tree cutting, illegal logging, and settlement of new villages.

Habitat Structure and Gibbon Survival

This study has shown that the gibbons can utilize diverse types of forest. Given a certain diversity of food plants, the places that best support the survival of gibbon in this area have primary forest with tall trees adjacent to steep slopes or cliffs. Cliffs offer the best protection from hunters Large trees in primary forest are important in many respects for their daily activities: they provide food, sleeping places and shelter. Bamboo is also important in improving habitat quality by connecting gaps between higher canopies of trees growing within the home range.

To improve the habitat quality in Muang Phaem forest we need to find ways to stop degradation of forest caused by such activities as elephant riding tourism (which results in over-grazing in gibbon habitats). Such tourism benefits a few people for a short time, but imposes costs to the forest and wildlife. Forest degradation by over grazing by domestic cattle (cows and buffalo) and elephants should be stopped immediately.

Diet

As shown by CARPENTER (1940), ELLEFSON (1974), BHUMPAKPHAN (1988), KANWATANAKID (2000), MUANGKHUM (2001), and SUWANNAKERD (2001), fruits are the main component of gibbon diets. In this study, however, the proportion of fruit may have been rather high due to the difficulty of observing consumption of other food categories such as leaves and shoots from a distance. As in the study of WHITINGTON & TREESUCON (1991) in KYNP, figs were the most significant food type for the gibbons. The 61-ha home range of the main study group had a sufficient diversity and abundance of food plants throughout the year to support group G1 as well as sympatric animals including at least 4 great hornbills (1 family), one male Assamese macaque (*Macaca assamensis*) and one Phayre's langur (*Trachypithecus phayrei*), as well as 109 human families (*Homo sapiens* L.) throughout the year.

Factors Affecting Group Ranging

Apart from fruit availability over the year, human activities play a role in determining the ranging pattern of the gibbons in this area, as their home range is located in a heavily-used forest that was both part of the community forest of the Karen village of Ban Muang Phaem, and a protected forest of two wildlife sanctuaries. It was clear that G1 and other groups did not usually tolerate encounters with humans. The group usually avoided areas heavily used by villagers. In the limestone habitat of my study site, one factor that significantly influenced ranging pattern was the inaccessibility of the steep slopes and rocks within the home range which functioned as a kind of refuge from humans. That feature minimized the horizontal distance of group traveling and helped them to conserve energy, but the vertical distance of group travel was higher and may have increased energy expenditure.

Perhaps the most influential factor affecting ranging of the gibbons is fragmentation of the forest. Most home range of group G1 bordered agricultural land such as rice fields and the road. Only one side of about 200 m width in north part of the home range functioned as a habitat corridor for the group, allowing migration within the population L1.

Vocal and Intergroup Behavior

Because of the relatively low density of the population (about 1 group km^{-2}), there was little conflict between groups concerning competition for resources and mates. The groups therefore may have called less than those in high-density populations such in HKKWS (4 groups km^{-2}) (STEINMATZ & MATHER, 1996), and in Mo Singto, KYNP (5 groups km^{-2}) (BROCKELMAN *ET AL.*, 1998).

In areas with heavy hunting, the groups clearly produced fewer calls or even did not call at all for long periods, as in Ban Muang Phaem forest. About 10–15 years ago there was much hunting by Lahu from Bala. In the case of Huai Pla Mung, the patterns of vocalization of the groups completely changed because of the loss of the adult male. Females calling without males may induce a male male from the neighboring groups (G5 and G6) to replace the lost male. Further investigation of this group would be interesting.

Hunting and Gibbon Survival

At present, hunting by various people is still the main threat to survival of the gibbons and other wildlife species. Recent knowledge and attitudes about the value of wildlife among Karen and surrounding hill tribes are similar. They do not understand the role and the functions of wildlife except as free food or as enemies of crops. This situation seriously affects territorial and relatively sedentary animals such as gibbons, which can be hunted easily if a hunter decides to do so. Therefore, without immediate actions, gibbons will soon be extirpated from the area.

Culture and Traditional Knowledge Related to Gibbon Survival

In the past, among tribal communities in northern Thailand, wildlife management was integrated into their beliefs and traditions. CARPENTER (1940) and LEKAGUL & MCNEELY (1977) argued that in the past, Karen and Hmong liked to have a large number of gibbons in the forest because they believed that their calls would increase crop yields. Those traditions and beliefs have gradually been abandoned because the people have had to adapt to limitations of natural resources and changing life styles. As in other regions in the world, strong competition for land and natural resources among humans is the main cause of wildlife extinction and biodiversity loss. In Thailand, this has been facilitated from the early stages of social development programs controlled by government administration teams that do not use available scientific information, especially in the field of ecology, in making policy decisions and development plans.

Although the Karen of Ban Muang Phaem (and of most communities) have the ability to conserve gibbons in the area, it is impossible for them to stop hunting by coexisting hill tribes. The village of Ban Muang Phaem is surrounded by Lahu and Tai Yai villages. The forest is also on the immigration routes that have been used by Shan and others immigrating

into the country since the war between the Shan and the Myanmar government. In order to save gibbons and other wildlife, collaborative projects between Ban Muang Phaem and surrounding villages have been encouraged to find solutions and meet their local needs. This is the essence of "area-based conservation". Before the study, few actions were carried out to promote wildlife conservation. Better enforcement actions are also need to reduce hunting pressure. Effective patrolling should follow gun-shooting.

Because of conflicts over natural resources between Karen of Ban Muang Phaem and neighboring hill tribes (Lahu Nyi and Tai Yai), the forest has been steadily becoming degraded. In order to save the forest and wildlife habitat, intervention from outsiders such as researchers who understand the broad situation is urgently needed to break the ice between the diverse communities. Pioneer cooperative resource management projects must be initiated.

Interview information revealed that it was difficult for villagers themselves to maintain and transfer their own knowledge and wisdom to new generations. In the past, Thai Yai, Lahu, Lisu, and Karen did not hunt many wildlife species, including the gibbons and great hornbills. Now they ignore their traditional knowledge and hunt some of wildlife species that they were once forbidden to hunt. The main causes of the weakening of such protection is the failure of the education systen among the highlanders. Only Karen still practice the taboos prohibiting the hunting of gibbons, so most gibbon populations are found near Karen villages.

The Role of the Sanctuary in Gibbon Conservation

Since the establishment of the San Pan Daen Wildlife Sanctuary in 1999, better protection of gibbons and other wildlife has resulted through the protection the forest area from clearing and expansion of crop fields by the people of surrounding villages (Ban Aela and Ban Tham Lod). The new Nam Phaem wildlife guard station was frequently manned in the early phase of the operation. A patrol unit of 6–10 staff entered the area almost every week. Unfortunately, after the departure of the former superintendent of the sanctuary, who was the key person in the establishment the sanctuary in 2003, the protection system weakened and collapsed. Some of the most effective staff then moved to other jobs and the quality of protection declined. During the study period, in fact, wildlife protection had virtually ceased. Without their former leader, the role of most of peripheral staff was much diminished. This resulted in a large area of forest being invaded and occupied by all hill tribes. However, the presence of the four different people—Karen, Lahu, Tai Yai and Thai—was an advantage to the staff of the SPDWS working in the area. The diverse ethnic groups, with a strong chief, could be used according to their unique skills and experiences when needed.

Recruitment of enough dedicated persons like the former chief of HKKWS, Mr. Seub Nakhasathien, the well-known deceased conservationist, is too much to expect. Therefore, site-based co-management between the sanctuaries, the local communities, local provincial officer, and researchers is essential. The fate of the gibbons and other wildlife species in the area depends mainly on immediate action by all stakeholders. The sanctuaries alone cannot solve these complicated problems which are both social and ecological in nature. In addition, broader conservation and training programs for the sanctuary staff is necessary for conservation.

Is Conservation Possible?

The surviving populations of gibbons found in this study are relatively small. Most biologists may think it is useless to try to conserve them due to the limitations on dispersal and the problem of inbreeding. BROCKELMAN (1994) suggested that conserving large populations should be the first priority in gibbon conservation. However, in some human-use forests such as in Ban Muang Phaem forest, restoration of gibbon populations is neccesary. Populations L1 and L2, which have been isolated for about 20 years, need to be reconnected by establishing forest corridors to restore population size and reduce inbreeding pressure. For other gibbon populations in Mae Hong Son, long-term studies are needed in order to identify their conservation status and document the pattern of change, as suggested by CHAPMAN & PERES (2000). In Mae Hong Son there is still much information recorded in local peoples' memories. Interviewing tribal people can provide important information about the history of wildlife populations in the area that will be useful in making conservation plans.

In Mae Hong Son all minorities practice monoculture cropping. Each year the crop fields are extended. Populations of highland people in Mae Hong Son have increased each year, the primary forests have declined steadily in order to satisfy their supplementary needs. Stronger competition for natural resources adversely reduces the efficacy of traditional knowledge in wildlife conservation. In addition, economic pressures from the outside world have negative effects on their life styles. The villagers depend more on money markets and less on the wisdom inherited from their ancestors.

In terms of conservation status and resource management, Karen people in Ban Muang Phaem have exploited much more than the services of the forest can provide, leading to the loss of biodiversity without real protective action. Most villagers still practice the community labor-sharing system that they have in the past. The lack of basic awareness and broad perspective is resulting in imbalances in the social system. These social problems affect the balance and diversity of the surrounding ecosystem. However, the conservation culture of the Karen is still a strong advantage in the management of the natural environment (SANTASOMBAT, 2001).

After staying one year in Ban Muang Phaem I realized that very few adults show any concern about preserving their valuable unique knowledge and skills, while most of the young generations leave to work and study in the city. The school in the village cannot provide adequate knowledge to their children, so parents send them to study outside the village very early (about 5–6 years old). The new generation has to stay in the residence of the school for long periods so that they have little time to spend in the village to learn and absorb the Karen life style from their own parents. When they finally return to their village, most young Karen, especially males, behave in a different way from typical Karen, and look down on and ignore their own culture. This modern trend must be appreciated if we want to conserve nature and the Karen culture which traditionally has cherished gibbons and their habitat. In order to restore the gibbon population, some ancestral traditional teachings need to be restored among hill tribes who still live close to gibbon and other wildlife habitat.

A trans-boundary wildlife management strategy has been proposed for a long time as a means of biodiversity conservation when ecosystems between two neighboring countries are in contact. In the case of Thailand and Myanmar, however, this solution is problematic

because of the complexity of bilateral relations and the illegal drug trade within that zone. One possible solution for wildlife problems is establishment of additional wildlife refuges in some areas such as Ban Aela and Ban Muang Phaem forest where various wildlife species can still be found.

CONCLUSIONS

A large number of gibbon groups have been found in the forest near Karen villages in the upper part of Nam Lang River in Pang Ma Pa district, Mae Hong Son Province, Northern Thailand, but their habitats are highly fragmented. Two populations in Muang Phaem Forest are completely isolated and need to be protected immediately through special forest management, prevention of hunting, and making a forest corridor. More intensive action and study are need in this area. About 6 groups are reported occurring in Manora Forest but no information is available about their status. One of the largest populations in Mae Hong Son was reported in Huai Poo Ling, Muang district. The remaining populations are very small (mostly 1–2 groups each) but have not been surveyed. The Salween River is in an area that contains a healthy population, but proposed dam projects on the river would have serious impacts (T. Bidayabha, personal communication).

Besides habitat loss and fragmentation, combined with hunting, there are more threats in this area. Government development policies, the skirmishes along the border and in Myanmar, and political events in Myanmar have all affected the gibbons. This means that the problems in this area are much more complicated than many people have realized. Therefore, more sustained and intensive surveys of gibbon distribution and populations are needed, while local actions for gibbon conservation have to be developed and improved in the same time. Otherwise we will lose them forever.

ACKNOWLEDGMENTS

We thank Dr. Warren Y. Brockelman and Dr. John R. Milne for their improvement of the paper. Special thank to Surapon Duangkhae WFT Secretariat for his advice. This work was supported by the TRF/BIOTECT Special Program for Biodiversity Research and Training grant T_347005.

REFERENCES

ALTMANN, J. 1974. Observational study of behavior: sampling methods. *Behaviour* 49: 227–265.

BHUMPAKPHAN, N. 1988. Ecology of white-handed gibbon (*Hylobates lar* Linn.) & Phayre's langur (*Presbytis phayrei* Blyth) in Huai Kha Khaeng Wildlife Sanctuary. M.Sc. thesis, Kasetsart University, Bangkok, Thailand. 131 pp.

BROCKELMAN, W. Y. 1975. Gibbon populations and their conservation in Thailand. *Nat. Hist. Bull. Siam Soc.* 26: 133–157.

BROCKELMAN, W. Y., AND S. SRIKOSAMATARA. 1993. Estimation of density of gibbon groups by use of loud songs. *Am. J. Primatol.* 29: 93–108.

BROCKELMAN, W. Y. 1994. PHVA workshop: learning to help the gibbons of Thailand. *Primate Conservation* (14–15): 58–63.

BROCKELMAN, W. Y. 1998. Study of tropical forest canopy height and cover using a point-intercept method. Pages 521–531 *in* F. Dallmeier and J.A. Comiskey (eds.), *Forest Biodiversity Research, Monitoring and Modeling: Conceptual Background and Old World Case Studies.* Man and Biosphere series, Vol. 20. UNESCO, Paris, and Parthenon Publishing, New York.

BROCKELMAN, W. Y., U. REICHARD, U. TREESUCON, AND J. J. RAEMAEKERS. 1998. Dispersal, pair formation and social structure in gibbons (*Hylobates lar*). *Behav. Ecol. Sociobiol.* 42: 329–339.

CARPENTER, C. R. 1940. A field study in Siam of the behavior and social relations of the gibbon (*Hylobates lar*). *Comp. Psychol. Monogr.* 16: 1–212.

CHAPMAN, C. A., AND C. A. PERES. 2001. Primate conservation in the new millennium: the role of scientists. Evol. *Anthropol.* 10: 16–33.

ELLEFSON, J. O. 1974. A natural history of white-handed gibbon in the Malayan peninsula. Pages 1–136 in D. M. Rumbaugh (ed.), *Gibbon and Siamang,* Volume III. Karger, Basel. 209 pp.

KANWATANAKID, C. 2000. Characteristics of fruits consumed by the white-handed gibbon (*Hylobates lar*) in Khao Yai National Park, Thailand. M.Sc. thesis, Mahidol University, Bangkok, Thailand. 136 pp.

KHAMYONG, S., D. SANCHANTHONG AND T. PARATHAI. 2003. Quantitative flora diversity of forests in Pang Ma Pha District. Mae Hong Son Province. Report to Biodiversity Training Program (BRT), Bangkok. 316 pp.

LEKAGUL, B., AND J. MCNEELY. 1977. *Mammals of Thailand.* Kurusapha Ladprao Press, Bangkok. 758 pp.

MARSHALL, J. T., B. A. ROSS AND S. CHANTHAROJVONG. 1972. The species of gibbons in Thailand. *J. Mammal.* 53(3): 479–486.

MAXWELL, J. F., AND S. ELLIOTT. 2001. Vegetation and vascular flora of Doi Sutep Pui National Park Northern Thailand. Biodiversity Research and Training Program (BRT), Bangkok. 205 pp.

MUANGKHUM, K. 2001. Home range and seasonal forage of the white-handed gibbon (*Hybates lar*) in Huai Kha Khaeng Wildlife Sanctuary. M.Sc. thesis, Kasetsart University, Bangkok, Thailand. 123 pp.

REICHARD, U. 1998. Sleeping site, sleeping place, and presleep behavior of gibbons (*Hylobates lar*) *Am. J. Primatol.* 46: 35–62.

RAEMAEKERS, J. J. 1984. Large versus small gibbons: Relative roles of bioenergetics and competition in their ecological segregation in sympatry. Pages 209–218 in H. Preuschoft, D. J. Chivers, W. Y. Brockelman and N. Creel. (eds.) *The Lesser Apes: Evolutionary and Behavioural Biology.* Edinburgh University, Edinburgh.

SANTASOMBAT, Y. 2001. Ecotourism, culture diversity and natural management. Biodiversity Research and Training Program (BRT). Nopburee Press. Chiang Mai. 234 pp. (Thai).

SANTISUK, T. 1988. An account of the vegetation of northern Thailand. *Geological Research* Volume V, Frans Steiner Verlag Wiesbaden GMBH, Stuttgart. 101 pp.

SRIKOSAMATARA, S., S. NAOSAWAT, S. LAOYEEPA, AND V. SUTEETHORN. 1999. Status of mineral licks and wildlife in Mae Hong Son and their potentials for ecotourism industry, Pages 826–831 *in* V. Baimai *et al.* (eds.), Research Reports on Biodiversity in Thailand. Biodiversity Training Program (BRT), Bangkok. 892 pp.

STEINMETZ, R., AND R. MATHER. 1996. Impact of Karen villages on the fauna of Thung Yai Naresuan Wildlife Sanctuary: A participatory research project. *Nat. Hist. Bull. Siam Soc.* 44: 23–40.

SUWANNAKERD, S. 2001. Ecology and social behavior of white-handed gibbons (*Hylobates lar*) at Tham Nam Lod Wildlife Conservation Development and Extension Center, Mae Hong Son. M.Sc. thesis, Chiang Mai University, Chiang Mai, Thailand. 119 pp.

TILSON, R., K. CASTLE, J. SUPRIATNA, K. J. GURMAYA, W. BROCKELMAN, AND S. TUNHIKORN. 1993. Multi-disciplinary strategic planning for gibbon conservation in Thailand and Indonesia, Pages 177–197 *in* Wallis, R.A., (eds.), *Primate Conservation: The Role of Zoological Parks.*

WHITINGTON, C., AND U. TREESUCON. 1991. Selection and treatment of food plants by white-handed gibbon (*Hylobates lar*) in Khao Yai National Park, Thailand. *Nat. Hist. Bull. Siam Soc.* 39:111–122.

Appendix 1. Trees in 78 plots in the home range of group G1

Families	Species	Num.	Thai name	%
Alangiaceae	*Alangium kurzii* Craib.	ลีดง	1	
Annonaceae	*Mitrephora vandaeflora* Kurz.*	ปอแฮด	9	
	Polyalthia cerasiodes (Roxb.) Benth. ex Bedd.*	กระเจียน	3	
	Polyalthia viridis Craib.*	ยางโอน	29	7.6
Anacardiaceae	*Semecarpus cochinchinensis* Engl.	รัก	2	
	Spondias pinnata (L.f.) Kurz	มะกอก	1	
Apocynaceae	*Holarrhena pubescens* Wall. ex G.Don.	โมกหลวง	7	
Bignoniaceae	*Fernandoa adenophylla* (Wall. ex G.Don) Steenis	แคบิด	3	
	Gmelina arborea Roxb.	ซ้อ	1	
	Oroxylum indicum (L.) Kurz.	เพกา	1	
	Stereospermum colias (Buch.-Ham. ex Dillwyn) Mabb.	แคทราย	1	
Bombacaceae	*Bombax ancep* Pierre	งิ้วขาว	6	
	Bombax insigne Wall.*	งิ้วป่า	2	
Burseraceae	*Protium serratum* Engl.*	มะแฟน	6	
Combretaceae	*Anogeissus acuminata* (Roxb. ex DC.) Guill. & Perr	ตะเคียนหนู	6	
	Terminalia alata Heyne ex Roth.	รกฟ้า	10	2.6
Datiscaceae	*Tetrameles nudiflora* R.Br.	กะพง	5	
Dilleniaceae	*Dillenia* sp. (small size)*	ส้าน 1 ใบเล็ก	1	
	Dillenia sp. (big leaf size of over 50 cm)*	ส้าน 2 ใบใหญ่	2	
	Dillenia sp. (medium size)	ส้าน 3 ใบกลาง	1	
	Dillenia parviflora Griff.*	ส่านหิ่ง	3	
Dipterocarpaceae	*Shorea siamensis* Miq*	รัง	3	
Euphorbiaceae	*Aporosa villosa* (Wall. ex Lindl.) Baill.*	เหมือดโลด	1	
	Baccaurea ramiflora Lour.*	มะไฟป่า	1	
	Bischofia javanica, B. javensis Blume*	ประดู่ส้ม	1	
	Croton roxburghii N.P.Balakr.	เปล้าหลวง	3	
	Mallotus philippensis Müll.Arg.	คำแสด	1	
	Phyllanthus emblica L.	มะขามป้อม	7	
Fagaceae	*Quercus kerrii* Craib.	ก่อแพะ	5	
Guttiferae	*Garcinia* sp.		1	
Labiatae	*Premna pyramidata* Wall. ex Schaur.	สักขี้ไก่	8	
	Tectona grandis L.f.	สัก	4	
	Vitex limonifolia Wall.	ตีนนก	1	
Lauraceae	*Cinnamomum caudatum*	(อบเชย)	1	
	Litsea monopetala (Roxb.) Pers.	กะทังใบ	2	
	Phoebe lanceolata (Wall. ex Nees) Nees	ตองหอม	7	

* = Gibbon food plants

Appendix 1 (Continued).

Families	Species	Num.	Thai name	%
Leguminoceae	*Albizia lucidior* (Steud.) I.C.Nielsen	บันแถ	1	
	Bauhinia variegata L.	เสี้ยวดอกขาว	16	4.2
	Xylia xylocarpa (Roxb)	แดง	127	33.2
Lythraceae	*Lagerstroemia calyculata* Kurz	ตะแบกแดง	2	
	Lagerstroemia cochinchinensis	ตะแบก	9	
	Lagerstroemia floribunda Jack	ตะแบกผิวเรียบ	2	
Meliaceae	*Aglaia grandis**		1	
	Aphanamixis polystachya (Wall.) R. Parker	ตาเสือ ตุ้มดง	3	
	Chukrasia tabularis A.Juss.	เสียดกา	3	
Moraceae	*Ficus* spp.	ไทร	10	2.6
Rubiaceae	*Catunaregam spathulifolia* Tirveng.	มะเคว็ด	1	
	Meynia pubescens	มะหนามนึ่ง	1	
	Tarennoidea wallichii (Hook.f.) Tirveng. & Sastre.	คอไก่	1	
Simaroubaceae	*Harrisonia perforata* (Blanco) Merr. *Scan*	คนทา	2	
Sonneratiaceae	*Duabanga grandiflora* (Roxb. ex DC.) Walp.	ลำพูป่า	1	
Spindaceae	*Dimocarpus longan* Lour.	ลำไยป่า	4	
	Schleichera oleosa (Lour.) Oken.*	ตะคร้อ	5	
Staphyleaceae	*Turpinia pomifera* (Roxb.) DC.	มะกอกพราน	4	
Sterculiaceae	*Pterospermum grandiflorum* Craib.	ตองเต่าขน	2	
	Eriolaena candollei Wall.	ปอเลียง	7	
	Sterculia pexa Pierre	ปอบ้าน-ปอขาว	2	
	Sterculia urena Roxb. Var.	ปอต็อก	2	
	Sterculia villosa Roxb.	ปอตูบหูช้าง	4	
Tiliaceae	*Grewia eriocarpa* Juss.*	ปอลาย	25	6.5
	20 Unknown species			
		Total	**381**	

* = Gibbon food plants

Appendix 2. Gibbon food plants

	Species	Family	Plant habit	Fruiting/Flowering		Size (cm)
				Part eaten	Time (month, date)	
1	*Aeschynanthus andersonii* C.B. Clarke	Gesn	O	fl	10, 25–11, 5	–
2	*Alangium Kurzii* Craib.	Alan	T	fr	8, 1–8, 31	–
3	*Anaolosa ilicoides* Mast.[a]	Olac	T	fr	4, 15–5, 25	2.3 x 2.5
4	*Antidesma sootepense* Craib	Euph	S	fr	9, 10–11, 5	<0.5 (d)
5	*Anthocephalus chinensis* (Lam.) A. Rich ex Walp.	Rubi	T	fr	9, 10–1, 20	4.5 x 6
6	*Aporosa villosa* (Wall. Ex Lindl.) Baill.	Euph	T	fr	5, 1–5, 31	0.7 x 1
7	*Artocarpus lacucha* Roxb.	Mora	T	fr	4, 20–5, 10	–
8	*Baccaurea ramiflora* Lour.	Euph	T	fr	5, 5–6, 10	2.5 x 2.5
9	*Balakata baccata* (Roxb) Esser.	Euph	T	fr	7, 10–8, 10	0.8 x 1.2
10	*Bambusa* sp. 1	Gram	B	yl	4, 25–6, 5	–
11	*Bambusa* sp. 2	Gram	B	yl	7, 1–8, 10	–
12	*Bischofia javanica* Bl.	Euph	T	fr	9, 1–10, 5	0.6 x 0.7
13	*Bombax insigne* Wall.	Bomb	T	fl	12, 5–2, 10	12 (l)
14	*Cyathocalyx martabanicus* Hook.f. & Thomson.	Anno	T	fr	3, 1–5, 5	7 x 7
15	*Dillenia* spp. (*D. aurea, D. parviflora, D. indica*)	Dill	T	fr	7, 1–7, 31	2 x 2, 2.5 x 2.5, 3 x 3
16	*Dimocarpus longan* Lour.	Sapi	T	fr	2, 20–3, 10	–
17	*Diospyros coaetanea* (Craib) Fletcher.	Eben	T	fr	7, 10–7, 31	4.5 x 5.5
18	*Diospyros glandulosa* Lace.	Eben	T	fr	9, 10–9, 30	5.5 x 5.5
19	*Elaeagnus latifolia* L.	Eben	C	fr	2, 5–3, 10	1.5–2 x 3
20	*Ficus* spp (10 species).	Mora	F	fr	1, 1–12, 31	0.5–3.5 (d)
21	*Flacourtia indica* (Burm.f.) Merr.	Flac	S	fr	7, 1–8, 5 4.5	4.5 (l)
22	*Grewia eriocarpa* Juss.	Tili	S	fr	8, 15–9, 25	0.6–0.8
23	*Lannea coromandelica* (Houtt.)	Anac	T	fr	4, 20–5, 10	0.7 x 1
24	*Mangifera* sp.	Anac	T	fr	3, 25–6, 5	3–5 x 4–6
25	*Melodinus cambodiensis* Pierre ex Spire.	Apoc	C	fr	4, 10–4, 30	7 x 8
26	*Microcos paniculata* L.	Tili	T	fr	9, 20–10, 20	0.9 x 1.2
27	*Mitrephora vandaeflora* Kurz.	Anno	T	fr	7, 1–7, 31	2–2.5 x 2.5–4
28	*Mucuna pruriens* L. DC.	Legu	C	fl	12, 1–1, 25	4.3 (l)
29	*Phyllanthus emblica* L.	Euph	T	fr	9, 5–1, 31	1.7 x 1.7
30	*Polyalthia cerasoides* (Roxb.) Benth. ex Bedd.	Anno	T	fr	5, 1–6, 5	0.7 x 0.7
31	*Polyalthia viridis* Craib.	Anno	T	fr	3, 25–5, 31	2.1–2.5 x 2.8–5.1
32	*Protium serratum* Engl.	Burs	T	fr	9, 5–10, 10	0.8–1.1
33	*Schleichera oleosa* (Lour.) Oken	Sapi	T	fr	5, 10–11, 15	1.8–2.6 x 1.8–2.6
34	*Scurrula* sp.	Lora	P	fl	2, 5–3, 30	–
35	*Spondias pinnata* (L.f.) Kurz.	Anac	T	fr	1, 25–2, 20	3.2 x 3.7
36	*Syzygium* sp.	Myrt	T	fr	5, 5–6, 5	1 x 1.5

Appendix 2 (continued).

	Species	Family	Plant habit	Fruiting/Flowering		Size (cm)
				Part eaten	Time (month, date)	
37	*Tinospora crispa* (L.) Miers ex Hook.f. & Thomson	Meni	C	fl	4, 15–5, 10	1.5–1.8x1.5–1.8
38	*Xylia xylocarpa* (Roxb.)	Legu	T	fl	2, 15–3, 25	–
39	*Ziziphus rugosa* Lam.	Rham	S	fr	3, 25–4, 31	1.2–1.4 (d)
40	Unknown 1(wild grape in Thai)	Vita	C	fr	4, 1–5, 31	2 x 2
41	Unknown 2 (Nato-jor-zoo in Karen)	d	T	fr	7, 5–8, 5	2.6–3 x 3–4.6
42	Unknown 3 (Sa-glee-po in Karen)	-	T	fr	5, 1–6, 10	1.6–2 x 2.3–3
43	Unknown 4 (Ta-ju-or-sa in Karen)	-	C	fr	12, 1–2, 20	2.5–3.2 x 2.5–3.2
44	Unknown 5 (Tu-bor-khe-khorK in Karen)	-	C	fr	2, 5–3, 15	2.5–2.8 x 2.5–2.8
45	Unknown 6 (Ze-blor-mae in Karen)	-	T	fr	3, 10–4, 5	1–1.2 x 1.2–1.3
46	Unknown 7 (Se-do-sa in Karen)[b]	-	T	fr	3, 1–3, 25	5.5x8
47	Unknown 8 (Ze-le-cho) (Karen)	-	S	yl	2, 1–2, 28	–
48	Unknown 9 (Ze-sor-je) (Karen)	-	T	fr	5, 5–5, 25	2.8–3 x 3–3.2

Notes: - = data not complete; a = found in home of range group G4; b = found in home range of group G2; d = diameter; l = length; B = bamboo; C=climber; F=figs, O=orchid; P=parasite; S=shrubby tree; T=tree; fl=flower; fr=fruit; yl=young leaf.