How do cao vit gibbon live in the degraded forest: habitat and feeding ecology

Final report to Conservation Leadership Programme

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Introduction

The eastern black crested gibbon, *Nomascus nasutus*, has only recently been recognized as a species distinct from the western black crested gibbon, *Nomascus concolor* (Brandon-Jones *et al.*, 2004), and is now considered to be the rarest ape in the world (Mittermeier *et al.*, 2007) and is categorized as Critically Endangered by IUCN (IUCN 2008). Two subspecies are recognized, the Hainan gibbon (*N. n. hainanus*) and the cao vit gibbon (*N. n. nasutus*), being separated on coloration (Geissmann *et al.*, 2000; Mootnick, 2006) and territorial call (Geissmann et al., 2003). Recently, significant genetic differences have been identified between the two species (Roos *et al.*, 2007) and many now regard them as two distinct species cao vit gibbon or eastern black crested gibbon (*N. hainanus)* and Hainan gibbon (*N. nasutus)* (Geissmann, 2007).

The historical distribution of the cao vit gibbon lies to the east of the Red River in southern China and northern Vietnam (Geissmann *et al.,* 2000). It was thought to be extinct in China from the 1950s (Tan, 1985) and in Vietnam from the 1960s (Geissmann *et al.*, 2003). In January 2002, a small remnant population was re-discovered in Trung Khanh District, Cao Bang Province, Vietnam, close to the Chinese border (La *et al.*, 2002). Geissmann *et al.* (2003) confirmed that at least five groups, comprising at least 26 individuals were present in a forest area of less than 3,000 ha. Several surveys followed in the same forest block, the most significant being in September 2004 when eight groups with 37 individuals were recorded (Trinh, 2004). In September 2006, a survey in

contiguous forest close to the border in China recorded three groups of 19 individuals (Chan *et al.*, 2008). Two of the groups were observed travelling between China and Vietnam. In September 2009, a survey team led by Fauna and Flora International (FFI) carried out a transboundary census of the entire known habitat of cao vit gibbons in China and Vietnam. A total 18 groups and 110 individuals have been recorded during this survey (Le et al., 2008) (Fig. 1).

Since November 2007, FFI and Conservation Leadership Programme (CLP) funded my team to study the ecology and behaviour of cao vit gibbons in Chinese border and tried to contribute to the conservation of this Critically Endangered species.

Study site

The study area is located in Bangliang forest patch (22°55′N, 106°29′-30′E), Jingxi County, southern of Guangxi Province, China, which is near to the Chinese-Vietnam border and share the border with Cao Bang Province, Vietnam. The area is characterized by a typical karst limestone landscape consisting of densely packed outcrops, sharp-peaked mountains with very steep slopes, ridges and vertical cliffs, interspersed with lowland valleys. The altitude above sea-level ranges from 486 to 926 m elevation. The habitat types are sub-lower montane forests in the centre of the karst limestone block, surrounded by heavily degraded secondary forest and scrub. The land is often being cultivated on valley bottoms. The entire limestone block is largely unbroken and surrounded on all sides by intensely cultivated land and settlements in the broad flat alluvial valleys. Two branches of the Quay Son River surround the limestone block from the south west to the north east. The area of good forest occupied by gibbons in Chinese border is about 3 Km^2 and in Vietnam is about 17 Km^2 (Fig. 1).

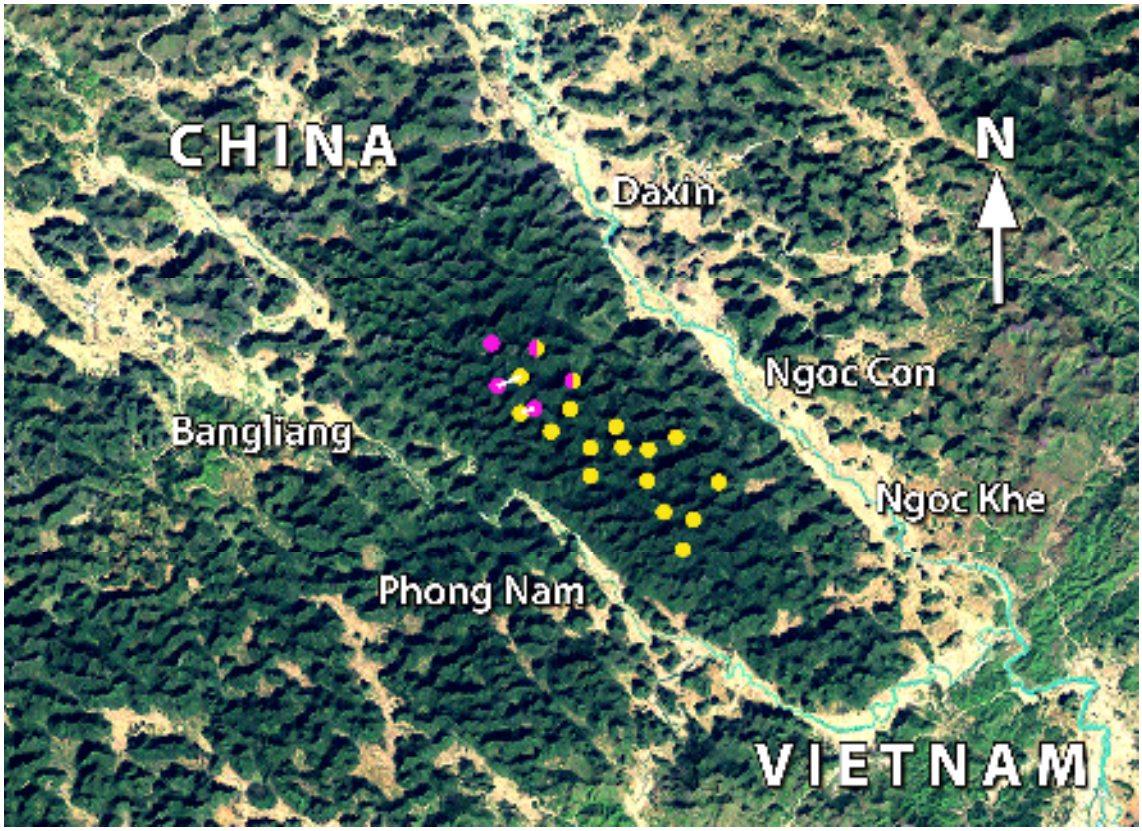

Fig. 1. Map showed the location of the last cao vit gibbon population in China-Vietnam border and group distribution in September 2007. Yellow dots represent gibbon groups in Vietnam, red dots represent gibbon groups in China, and mixed dots represent gibbon groups travelled between countries. This map was made by Paul Insua-Cao.

A HOBO pro RH/Temperature Data Logger (RG3-M) was used to record the temperature every half hour and rainfall continuously in the nearest village, Bangliang, from January 2008 to December 2008. The annual mean temperature was 20.3˚C and varied seasonally; the lowest was in February (9.8˚C) and the highest in September (26.6˚C) (Fig. 2). The minimum recorded temperature was 2.7˚C in February 2008, and the maximum was 40.6˚C in September 2009. The precipitation was 1803.8 mm, with a wet season from June to November during which 82.2% of the rainfall occurred (Fig. 2).

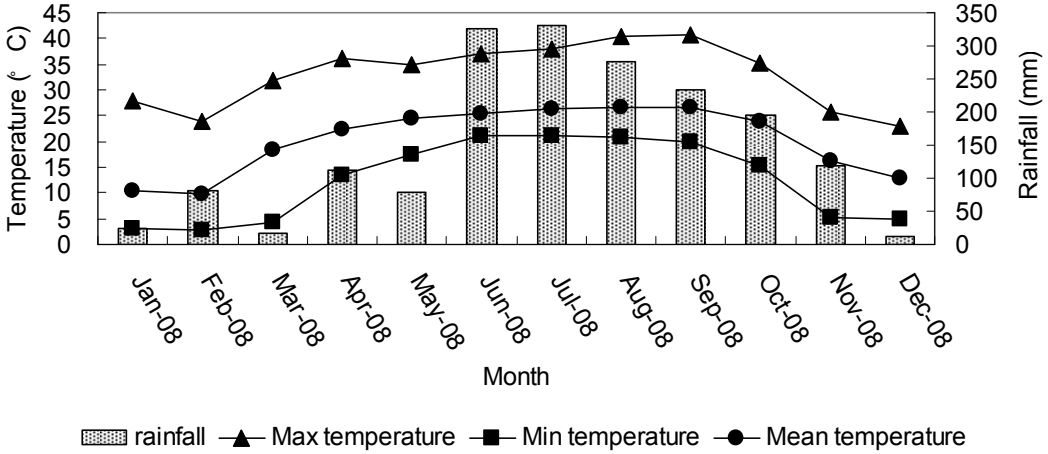

Fig. 2. Monthly mean, highest and lowest temperature (˚C) and rainfall (mm) in Bangliang forest patch, Jingxi County, Guangxi

Study animals

Five cao vit gibbon groups have been heard in Bangliang forest patch in the gibbon census in September 2007, but only 4 of them were repeatedly observed during the latter research.

We classified gibbons to six categories: adult male, adult female, sub-adult male, sub-adult female, juvenile and infants. Cao vit gibbon is sexual dimorphism in the pelage. Adult males have blackish hair, with brownish hair on their chest. Adult females are buffish to orange buff in color with a black crown streak extends past the nape, and can cross the shoulders. Long white hairs tightly encircle the face of adult female, creating an extremely wide face ring. We tried to identify adult females by their body color, face ring, shape of crown stripe, and depended infants. Sub-adult males had a similar body size to adult males and are able to sing solo bouts, but are not paired with females. Sub-adult females have a similar coloration to adult females, sometimes changing from black to yellow, but are not paired with males. Juveniles were independent, with a smaller body length than adults and black coloring. Infants were distinguished as small individuals that were at least partially dependent on their mothers for transportation. Gibbon groups usually defend exclusive territory and group members maintain close spatial relationship during diurnal activities. We identified different groups by combining group location, organization and characters of adult females.

Habitat survey and phenology

We have set 44 20×20m plots in different altitude within the gibbon's home range in December 2007 and January 2008. In each plot, the following data has been collected: the coordinate and altitude of each plot, plant species, tree height, trunk height, DBH, the crown diameter of trees (DBH≥10cm). We collected the plant herbarium specimens for identification by Xu Weibin, Guangxi Institute of Botany.

All the 911 tree individuals, lianas and epiphytes climbed on the trees in the plots have been monirtored for the seasonal availability of food parts (fruit, figs, leaves, buds, flowers, animals and other) between 14-17th every month. An abundance value was assessed for each plant parts ranging from 0–4 (0 = 0%; 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%). For fruiting trees, the percentage of the crop that was ripe was estimated because gibbons usually not feed unripe fruit. We calculated monthly food abundance indices for plant parts eaten by the gibbons. We multiplied the abundance value with DBH of each plant individuals. We then summed all these individual scores to yield a monthly abundance index for each plant part. As we were interested only in assessing the relationship between the gibbon's feeding behavior and the relative abundance of food items, plant species not eaten by gibbons were not included in calculating the food abundance scores. Because the gibbons spent few time feeding in flowers, we did not calculate the abundance for flowers.

Behavioural observation

Since December 2007, we spent 25-28 days every month in the forest to study gibbon's ecology and behaviour in the forest except February 2008 because of snow storm and the traditional Spring Festival in China. Because most of our time in December 2007 was spent to do the plant plots and January 2008 was spent to train students and field assistants to record gibbon's behaviour, we did not include the data in December 2007 and January 2008 in this report. In the beginning of our research, we planned to choose G1 and G2 as our focus groups for behavioural study. But G2 shifted its home range in May 2008 and spent more time in Vietnam which made us difficult to observe G2 (see the population dynamics results for detail information). Therefore, our behavioural

study was focused on only one group (G1) from March to July 2008. Since August 2008, we started to observe G4, and we also occasionally observed G2 and G3. But G3 spent very little time in our study site, behavioural data of this group was very limited.

Because of the steep slopes and sharp stones in the karst limestone landscape, it is impossible to follow the gibbons in our study site. We observed gibbons from several observation posts at a distance 50-500 m, mostly between 100-300 m, through binoculars (Steiner safari 8×30) or a spotting scope (Leica Apo-Televid77 20-60). This method has been used to observe white-headed langur (*Trachpithecus leucocephalus*) (Jin et al., 2009; Li et al., 2003) and Francois' langur (*Trachpithecus francoisi*) (Zhou et al., 2006) in karst forest.

Each day we attempted to locate the group by listening for the loud morning calls and searching where calls were heard, visiting the sleeping sites of previous day, and by searching fruit trees that gibbons frequently visited. Once finding the group, we attempted to observe members until they entered a sleeping site. During observation, data concering group size and age/sex composition were recorded. We also made many photos of different individuals for identification.

To study the habitat use, a 100×100m grid system was superimposed on a topographical map. The group's location was recorded refer to the obvious landmarks and emergent trees on the grid system every half an hour. And then the home range of groups was determined by the used grids and minimum convex polygon method.

Scan method with 5 minutes interval was used to record the activity of gibbons. For each 5 min of observation, we made a 1-min scan to recorde the behavior of every visible members. We recorded activity as resting, traveling, feeding, grooming, calling, playing, and other. Resting includes any inactive posture (sitting, lying, and hanging); the category also includes instances of auto-grooming, which always occurred during rest. Traveling comprises movement (bipedal walk, suspension, leap, bridge, and climb). Feeding comprises picking, chewing, or swallowing food. Grooming refers manipulation, stroking, or picking through the hair of another individual. Calling comprises only the duet calling

at the time of the 5-min scan. Playing refers to social play between ≥2 individuals, and includes solo play of the infant when near its mother. We record conflict activity between groups, alarm calling, and unidentified behavior as other. When an individual is feeding, we record the food species and specific part eaten (fig, fruit, leaves, buds, flower, animals, and other). If we could not identify the food species, we made pictures, discribed the character of leaves, flowes and fuirts and sometimes sketched a breif figure for later identification. Unique or unusual behaviors was recorded ad libitum.

Results

Group composition

Four cao vit gibbon groups were repeatedly observed during this study from December 2007 to March 2009. Each of the four groups has one adult male, two adult females, 2-4 juveniles and 1-2 infants (Table 1). Group 4 had 8 individuals in September 2007, and increased to 9 individuals after an adult female gave birth on November 16, 2008. This group was the biggest gibbon group of all gibbon species in the world. Besides these four groups, a floating group with 4 individuals was observed twice in both February and April within the study site (Table 1). But this group did not occupy a territory when we were writing this paper in May 2009.

Table 1. Social organization of four groups and one floating group in Bangliang forest patch, Jingxi County, Guang

Group	Adult males	Adult females	Sub-adult males	Sub-adult females	Juveniles[a]	Infants
G1	1	2	0	0	2-1	2[b]
G2	1	2	0	0	2	1[b]
G3	1	2	0	0	2	1
G4	1	2	0	0	4	1+1[b]
GF	1	1			2	

a. One juvenile in G1 disappeared in the cold winter February 2008.

b. Four babies were born during the study. See the context of the paper for more detailed information.

Population dynamics

Out of four groups in this area, only one group (G1) lives exclusively within China; the other three groups traveled between China and Vietnam (Fig. 1). The Vietnamese government built a national marker stone in the study site and built a 2-m wide footpath in the forest for patroling marker stones in May 2008. Many detonators were used to demolish the limestones and made loud noises in the forest. Because these activities occurred in G2's home range, G2 shifted its home range and invaded into G3's home range during the construction of the footpath and marker stone. G3 moved back into Vietnamese side and we could rarely observe this group. In October 14 and 21 2008, we once again contacted this group in its former home range. It still had 1 adult male, 2 adult females, 2 juvenile and 1 dependent infant (Table 1).

One juvenile in G1 dissapeared in the cold winter February 2008. Because it was a small juvenile and not achieved adulthood, it was considered to be dead. Four infants were born during the study. One female in G1 gave birth sometime between October 25 and Novermber 5 2008. Another female in G1 gave birth between Novermber 29 and December 2, 2008. A female in G4 gave birth on Novermber 16, 2008, and one female in G2 gave birth on February 20, 2009 (Table 1). All four adult females in G1 and G4 had dependent babies after December 2008. The mean group size for the four resident groups was 6.0 in December 2007, and was 7.0 for three resident groups (G3 had moved out from the site) in March 2009.

Habitat degradation in history

In 1970s, local people collected timber of *Burretiodendron hsienmu* for furniture making from the forest patch. Nearly all big trees of *Burretiodendron hsienmu* have been cut before 1990.

Fuelwood collection has posed serious threats on the forest. Five villages, 2097 families live around the forest at present. Nearly half (I do not have the accurate percentage) of these families collected fuelwood from cao vit gibbon's habitat before the rediscovery of gibbons in the area. Because the fuelwood is heavy and difficult to be move out from the karst forest, they usually collect fuelwood from the forest near to villages. 35 km fuelwood

could be used 5 to 10 days in one family. Therefore, 1000 families would consume 1000×70/(5 -10)×365=2,555,000 - 5,110,000 Km in one year. In the early stage, local people preferred *Cephalomappa sinensis* , *Cyclobalanopsis sp.* and *Burretiodendron hsienmu* as fuel wood. But after these trees have been depleted near the villages, they also used other species. One person even burn out a hill to get fuel wood.

Around 1999, local people started to make charcoal for money. They preferred *Cephalomappa sinensis* , *Cyclobalanopsis sp.* and *Burretiodendron hsienmu* to make charcoal. Because charcoal is light and easy be carried out, local people live in the center of the forest to make charcoal. Most of big trees of *Cephalomappa sinensis* and *Cyclobalanopsis sp.* have been cut for charcoal making. More than 32 holes for charcoal making have been located within G1's home range, and nearly coved all area where it could be made a hole.

In 2001 and 2002, a company purchase wood of *Burretiodendron hsienmu, Broussonetia papyrifera, Ficus glaberrima, Ficus hookeriana*, and *Spondias lakonensis* in surround villages. The price for each species was listed below:

Burretiodendron hsienmu：5 cm (thickness) × 12cm (width) × 3 m (length): 120-200 RMB

Broussonetia papyrifera：20 cm (diameter) × 2 m (length): 20 RMB

Ficus glaberrima：20 cm (diameter) × 2 m (length): 20 RMB

Ficus hookeriana：18 cm (diameter) × 2 m (length): 15 RMB

Spondias lakonensis：20 cm (diameter) × 2 m (length): 20 RMB

Because the wood was very heavy, it was very difficult to the local people to carry out wood from the karst forest, they only cut those trees of these species near the village.

All these activities have caused the forest degradation in past. Based on the interview information, one or two gibbon groups disappeared between 1999 and 2006 in this area.

The forest degradation was thought to be a main reason for that. Fortunately, all these have been stopped after the rediscovery of the cao vit gibbons in this small forest in 2006.

Habitat structure and plant diversity

We measured 911 tree individuals with DBH≥ 10 cm in the 44 plots, of them 838 individuals were identified to species. We recorded 114 species of tree from 79 Genera and 40 Families (appendix I); 51 species of woodiness liana or epiphyte from 38 Genera and 26 Families (appendix II). The ten dominate families with various tree species included Moraceae, Urticaceae, Euphorbiaceae, Lauraceae, Fagaceae, Juglandaceae, Aceraceae, Bignoniaceae, Tiliaceae, and Rubiaceae. And the ten dominate tree species were *Lapotea urentissima*, *Platycarya longipes*, *Ficus glaberrima*, *Acer tonkinense*, *Cinnamomum saxatile*, *Radermachera hainanensis*, *Cephalomappa sinensis*, *Burretiodendron hsienmu*, *Cyclobalanopsis Oerst*, and *Quercus glauca*. Tree species was much difference between different zones. Trees located in bottom were higher in tree height and trunk height than those in ridge and slope of the hills (Table 2). On average, the tree height is only 9 m, the highest tree is 32 m, which is much lower than those in other gibbon's habitat.

We also recorded the number of trees have been recently cut in each plot and tried to identify the species for each stub. There were 39 individual trees have been cut in recent years in 9 plots. Half of these cut trees (20/39) were *Cephalomappa sinensis. And 3 Ficus glaberrima, 2 Burretiodendron hsienmu, 2 Lagerstroemia suprareticulata, 1 Acer tonkinense, 1 Cinnamomum saxatile, and 1 Cyclobalanopsis oerst* have been cut. The rest 9 trees could not be identified. Although the number of trees have been cut was not so much, but our plots were placed within gibbon’s habitat which seemed to have the best forest in the site. The forest not used by gibbons in which we did not have plots was much worse than the forest inhabited by gibbons. More trees in the forest not used by gibbons have been cut, but we did not measure the accurate number of it.

Table 2. Tree characteristics in different habitat zone (bottom, ridge, slope and col).

Habitat zone	Characteristics	N	Minimum	Maximum	Mean	SD
Bottom of Valley	Height (m)	208	3	32	9.4	3.15
	Trunk height (m)	208	1	28	4.8	2.82
	DBH (cm)	208	10	94	18	30.17
	Diameter of crown (m)	208	2	15	4.9	2.04
Ridge	Height (m)	151	3	14	7.9	1.90
	Trunk height (m)	151	1	8	3.4	1.75
	DBH (cm)	151	10	63	17.4	25.56
	Diameter of crown (m)	151	2	9	4.7	1.55
Slope	Height (m)	359	3	20	8.9	2.90
	Trunk height (m)	359	1	15	4.0	2.38
	DBH (cm)	359	10	102	16.9	28.13
	Diameter of crown (m)	359	2	16	4.8	1.70
Col	Height (m)	193	5	24	9.4	2.85
	Trunk height (m)	193	1	12	4.2	2.60
	DBH (cm)	193	10.2	61.1	17.6	23.36
	Diameter of crown (m)	193	1.5	14	5.25	2.08

Food availability

There was significant variation in the food availability for gibbons in our study site (Kruskal-Wallis Test: χ^2=23.677, P=0.000) (Fig. 3). Fruit production was highest from September to November, while the relative abundance of buds peaked in April. Figs lacked the pattern of seasonal abundance observed in fruits and buds, but few figs were available in January and February 2009 (Fig. 3). The mature leaves eaten by the gibbons were available throughout the year, although their relative abundance was reduced during the dry winter season (Fig. 3).

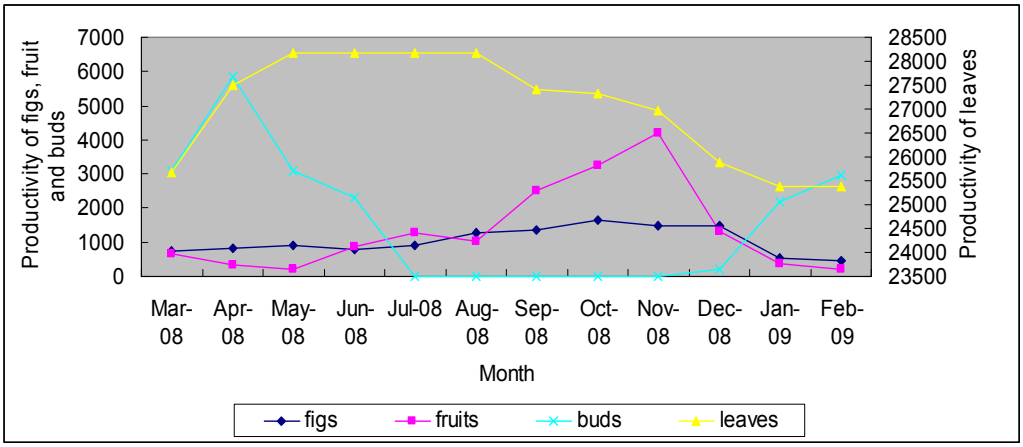

Fig. 3. Food availability for cao vit gibbons in Bangliang forest patch from March 2008 to February 2009.

Sample size of each group

In each month, we tried to observe G1 5 full days. If it was not achieved due to heavy rain and/or fog, we observed G1 at least 50 hours (Table 3). We observed G1 824 hours in 121 days, and have 16934 records between March 2008 and March 2009. The members of G2 were scared during the construction of the footpath and marker stone in May 2008. They were very afraid of human beings and always fled to the back of hills in Vietnam side to avoid us observers. Our observation posts could cover 40% of G2's home range. But the observation hours for G2 were only 69 hours, although we could observe it nearly every month (Table 3). G4 became another focus group since August 2008. 60-70% home range of this group was in China. And our observation posts could cover

70-80% of its home range. Because this group travelled between China and Vietnam, full-day-observation was difficult. We also tried to observe G4 50 hours in each month. But it was not achieved in some month because heavy rain and/or fog, or G4 spent more time outside our observation posts. We observed G4 336 hours in 50 days, and have 7677 records (Table 3).

Table 3. Sample size for three cao vit gibbon groups in Bangliang forest patch between March 2008 and March 2009.

G1	Month	Observation days	Hours	Scans	Records
	08-Mar	7	62	538	1414
	08-Apr	9	54	466	1025
	08-May	16	81	667	1515
	08-Jun	7	55	510	1114
	08-Jul	14	56	420	849
	08-Aug	9	69	568	1425
	08-Sep	12	72	592	1351
	08-Oct	10	70	568	1241
	08-Nov	7	63	633	1294
	08-Dec	9	62	582	1284
	09-Jan	9	64	604	1401
	09-Feb	6	59	596	1316
	09-Mar	6	57	613	1705
	Total	121	824	7357	16934
G2	Total	25	69	471	1113
G4	08-Aug	2	8	55	177
	08-Sep	5	31	244	740
	08-Oct	8	59	433	1082
	08-Nov	11	68	577	1440
	08-Dec	2	14	103	299
	09-Jan	7	45	366	1107
	09-Feb	9	65	547	1306
	09-Mar	6	46	454	1526
	Total	50	336	2779	7677

Home range size

During the study, we recorded 1434, 554, and 96 locations for G1, G4 and G2 respectively. G1, G4 and G2 used 66, 66 and 32 quadrants respectively (Fig. 4-6).

Because some forest within the group's home range was destroyed and not used by gibbons, and part of G4 and G2's home range was out of the study area, this method was thought to under-estimate the home range size for all the three groups.

Minimum convex polygon method was also used to estimate the home range size. Because part of G2 and G4's home range was outside of our observation area, we combined the group's singing sites outside the area and observation records to estimate the group's home range. The home range size for G1, G2 and G4 was estimated to be 115.2, 102.4 and 119.1 ha, respectively (Fig. 7). Because the singing sites sometimes were not locat in the borderline of group's home range, this method would still under-estimate the group's home range.

The results differences between these two methods was partly caused by the fact that G2 and G4 spent many time outside our observation area, but it was mainly caused by the forest destruction and unsuitable habitat within the group's home range. G1 and G4 never used or simply passed many quadrants within their' home ranges which resulted in many lacuna in the quadrant use map (Fig. 4 and Fig. 6).

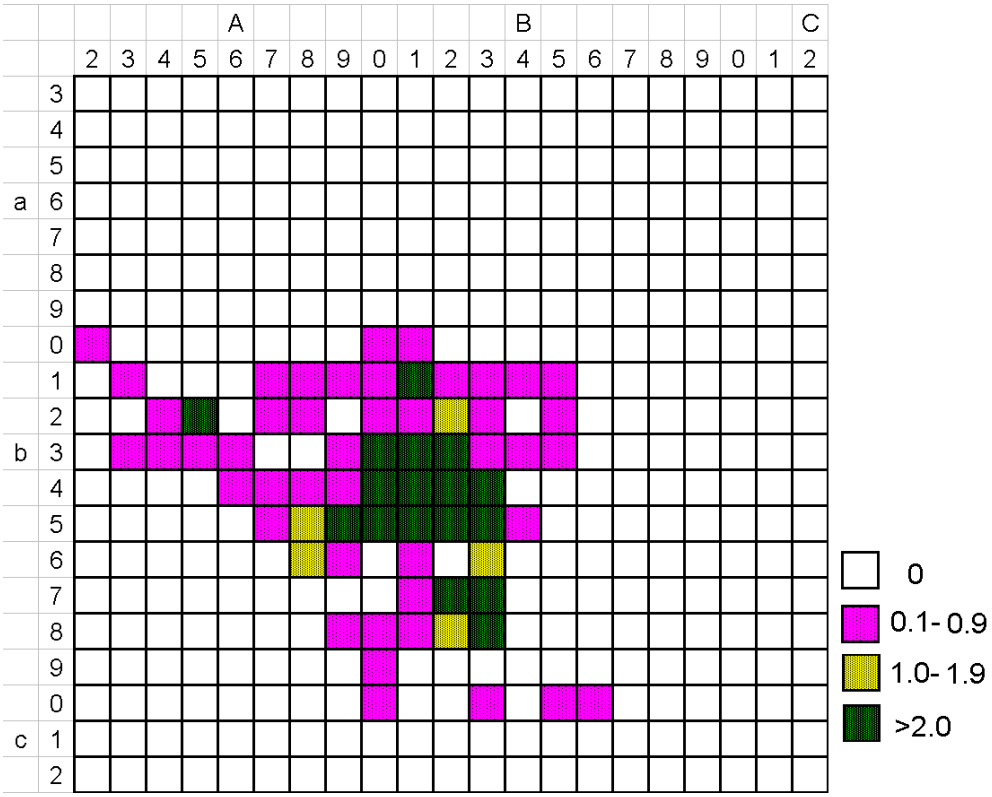

Fig. 4. The quadrant use by G1 from March 2008 to March 2009.

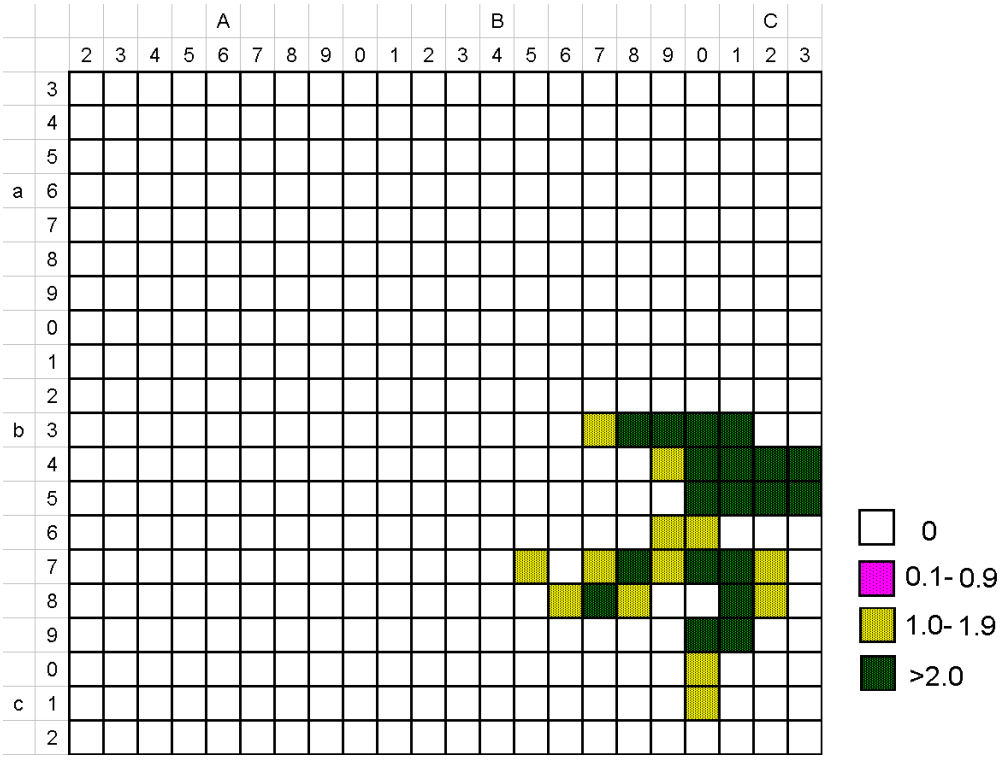

Fig. 5. Quadrant use by G2 from March 2008 to March 2009.

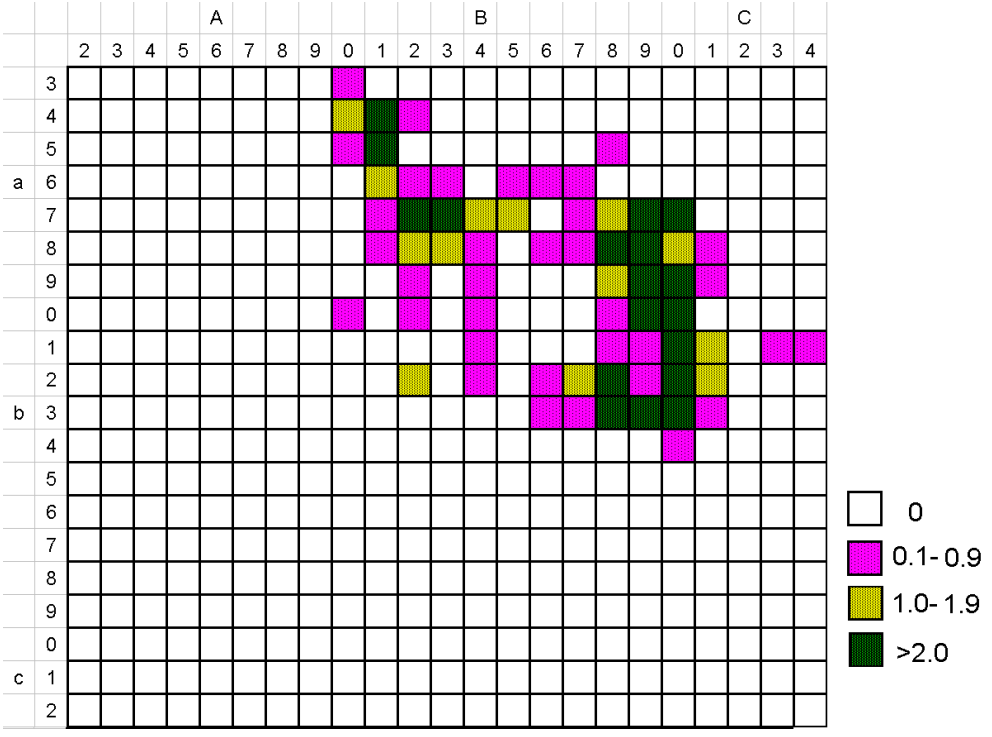

Fig. 6. Quadrant use of G4 from August 2008 to March 2009.

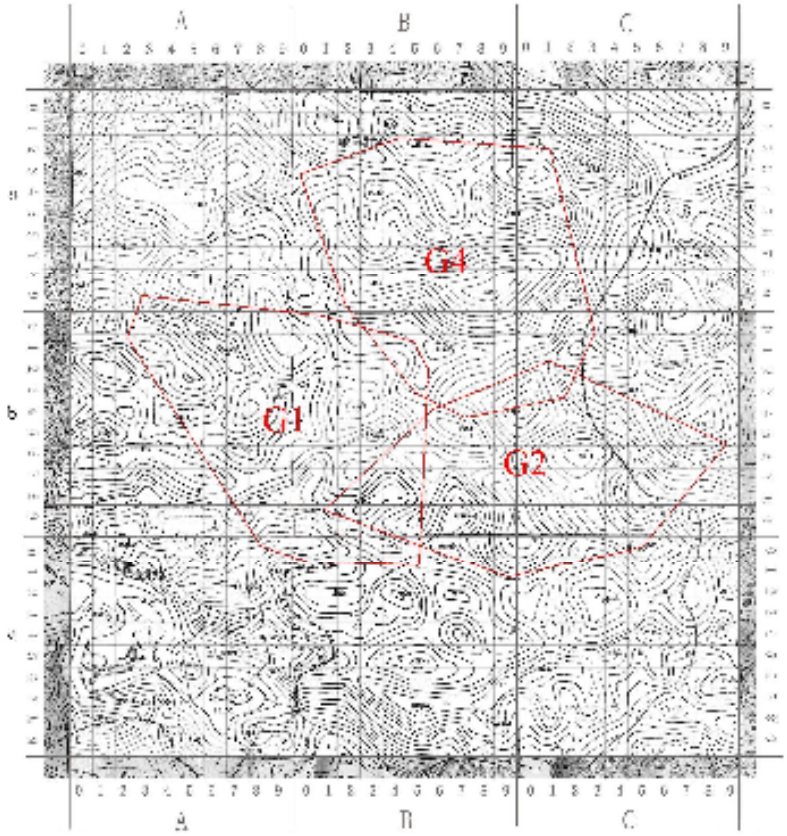

Fig. 7. Estimated home range of three cao vit gibbons by using the minimum convex polygon method. Those points outside our observation area were gibbon's singing sites.

Diet

Gibbons' diet usually showed diurnal variation (Fan et al., 2009). To avoid the influence of the diurnal variation on the monthly diet and annual diet, we used the means of hourly percentage of time feeding on each plant part as the monthly diet. But the sample size for G4 in August and December 08 was too small to use this method (Table 3), we used the percentage of time feeding on each plant as the monthly diet for these two months. In the analysis of the important food species in each month, defined as the minimum number of foods comprising 75% of the diet (Hill, 1997), only those records in which both species and the specific part of the plant eaten could be identified were used.

Cao vit gibbons have been observed consumed 63 different plant species and several animal species including spiders, stick insect, cicadas, grasshopper and worms. There were 41 trees, 16 vines, 2 epiphytes, 1 bamboon, 1 shrub, 1 herbage and 1 lichen.

All but 6 of the food plants were identified and assigned to 43 genera from 33 families (Table 4).

In the all 5432 records in which species could be identified, 6 most consumed species accounted for 62.8% of the total records (Table 5). All but 1 of these 6 species are tree species, and *Tetrastigma pubinerve* is vine. *Broussonetia papyrifera* is common in the area, and provide buds for gibbons in February to April and fruit in May and June. Sometimes, gibbons also consumed the leaves of *Broussonetia papyrifera* in other month. *Ficus glaberrima* is a dominate species in the forest (Table 5 and results of habitat survbey). Different individuals provided figs in different month and some trees fruit twice in one year. Gibbons could feed on this species nearly the year around. *Tetrastigma pubinerve* is a common vine species in the area. It climbed onto 54 out of 911 trees in the plots. And gibbons could feed on leaves, buds and fruit during November and February. *Ficus hookeriana* and *Spondias lakonensis* are emergent trees, and are not common in the site. *Choerospondias axillaries* is a rare species in the site. It did not present in our plots (Table 5). Gibbons mainly fed on the fruit of these three species, but they also consumed buds and leaves of them occasionally.

Table 5. Six most consumed species by cao vit gibbons in Bangliang from March 2008 to March 2009.

Species	Percentage of the total records (%)	Cumulative proportion	Percentage of tree individuals in the plots (%)
Broussonetia papyrifera	20.3	20.3	1.8
Ficus glaberrima	14.9	35.2	4.8
Tetrastigma pubinerve	8.7	43.8	5.9
Ficus hookeriana	8.2	52.0	0.4
Spondias lakonensis	5.6	57.6	0.4
Choerospondias axillaris	5.2	62.8	0.0

Table 4. Food species consumed by cao vit gibbon in Bangliang from March 2008 to March 2009.

Family	Species	Life form	Part(s) eaten	% of the total records	Month(s) Consumed
Lauraceae	*Cinnamomum parthenoxylon*	T	L, Fl	0.9	Apr.- Jun.
	Machilus rehderi	T	L	0.0	Apr.
	Neolitsea ellipsoidea	T	L, B, Fr	1.2	Mar.- May., Jul., Nov.
	Cinnamomum saxatile	T	L, Fr	1.0	Feb., Apr., May, Nov.
Menispermaceae	*Diploclisia glaucescens*	V	Fl	0.1	Mar.
Linaceae	*Tirpitzia ovoidea*	T	L	0.0	Mar.- May.
Actinidiaceae	*Actinidia indochinensis*	V	Fr	0.3	Nov., Dec.
Cucurbitaceae	*Unidentified*	V	Fr	0.2	Jan., Feb.
	Trichosanthea kirilowii	V	L	2.8	Jan., Feb., Apr., May, Aug.
Saurauiaceae	*Saurauia thyrsiflora*	T	Fr	1.2	Feb., Aug., Sep., Dec.
	Saurauia trisyala	T	Fr	0.1	Aug.
Guttiferae	*Garcinia bracteata*	T	Fr	0.0	Oct.
Tiliaceae	*Burretiodendron hsienmu*	T	L, B	1.9	Jan., Mar.- Jun.
Urticaceae	*Cephalomappa sinensis*	T	L	1.0	Jan.- May, Dec.

	Sapium rotundifolium	T	Fr	0.0	Sep.
Rosaceae	*Eriobotrya cavaleriei*	T	L	0.1	May.
Caesalpiniaceae	*Bauhinia rubro-villosa*	V	L, Fr	0.9	Jan., Apr.- Jun.
Papilionaceae	*Millettia reticulata Benth.*	V	Fl	0.0	Apr.
Fagaceae	*Cyclobalanopsis glauca*	T	L	0.5	Mar., May.
Ulmaceae	*Celtis bungeana*	T	L	1.1	Feb. -Jul., Nov., Dec.
	Ulmus tonkinensis	T	B	0.0	Mar.
Moraceae	*Ficus hookeriana*	T	L, Fr	8.2	Year around
	Ficus auriculata	T	Fr	0.3	Aug., Oct.
	Broussonetia papyrifera	T	L, B, Fr	20.3	Feb.- Jul., Dec.
	Ficus glaberrima	T	L, Fr	14.9	Year around
	Ficus virens	T	Fr	0.6	May, Dep.
	Ficus erecta Thunb. var. beecheyana	T	Fr	0.0	Sep.
	Ficus cyrtophylla	T	Fr	1.1	Jun.- Aug., Oct.
	Cudrania cochinchinensis	V	L, Fr	1.4	Jan., Feb., Sep.- Nov.
	Ficus microcarpa	T	Fr	1.2	May, Dec.

	Ficus gibbosa	T	Fr	0.0	May.,Aug.
Urticaceae	*Oreocnide frutescens*	T	L, Fr	1.2	Jan.- Mar.
Icacinaceae	*Iodes vitiginea*	V	L, Fr	2.9	Jan., Feb., May.- Oct.
Loranthaceae	*Scurrula parasitica*	E	Fl, Fr	2.8	Jan.- Jun.
Rhamnaceae	*Ziziphus mauritiana*	T	Fr	0.1	Nov.
	Ziziphus pbuinervis	T	L, B, Fr	0.8	Jan., Mar.- May., Sep.
Vitaceae	*Tetrastigma planicaule*	V	L, Fr	0.0	May.- Jul.
	Tetrastigma kwangsiense	V	L, Fr	1.4	Apr.- Oct.
	Tetrastigma pubinerve	T	L, B, Fr	8.7	Nov.- Feb.
	Tetrastigma delavayi	V	L, Fr	0.1	Feb., Mar., Oct.
	Tetrastigma obtectum	V	L	0.1	Mar., Apr.
Rutaceae	*Evodia calcicola*	T	L	0.1	May.
Meliaceae	*Toona sinensis*	T	L, B	0.8	Feb., Mar., May.
Anacardiaceae	*Spondias lakonensis*	T	Fr, B	5.6	Aug.- Nov.
	Choerospondias axillaris	T	Fr, B, L	5.2	May., Aug.- Nov.
	Pistacia weinmannifolia	T	Fr	0.0	Mar.
Alangiaceae	*Alangiumi kurzii*	T	Fl	0.1	May.

Araliaceae	*Schefflera minutistellata*	T	L, Fr	2.7	Mar., Apr.
Ebenaceae	*Diospyros kaki var. silvestris*	T	Fr	0.4	Oct., Nov.
Sapotaceae	*Madhuca pasquieri*	T	L	0.4	Jan.- Mar., Dec
Myrsinaceae	*Rapanea kwangsiensis*	T	Fr	0.7	Nov., Dec.
	Embelia subcoriacea	V	L, Fr	0.5	Feb., May., Jun.
Rbiaceae	*Pavetta hongkongensis*	T	Fr	0.4	Nov., Dec.
Convolvulaceae	*Cuscuta chinensis*	E	E	0.9	Jan., Feb.
Araceae	*Rhaphidophora*	V	L	0.0	Jan., Feb.
Palmae	*Caryota urens*	T	Fr	0.0	Sep.- Nov.
Gramineae	*Indocalamus calcicolus*	T	B	1.2	Mar.- Dec., Jan.
	Lichen unidentified	L		0.0	Mar.
	Animales	A	M	7.7	Mar.- Jan.
	Other			5.6	

Plant type: T = tree; V = vine; E = epiphyte; A = animal; L = lichen.
Part eaten: L = leaves; Fr = fruit; Fl = flowers; B = buds; M = meat.

During the study period, cao vit gibbon spent more time feeding on fruit (21.8-49.8%) and figs (15.4-33.1%). In descending order, the remainder of the diet was made up leaves (16.6-23.4%), buds (11.4-22.2%), animals (3.1-9.0%), and flowers (0.0-0.9%) (Table 6).

There was significant seasonal variation in cao vit gibbon's diet (Kruskal-Wallis test: G1:χ^2 = 49.814, df = 6, *p* = 0.000, n = 13; G4 : χ^2 = 26.868, df = 6, *p* = 0.000, n = 8) (Table 6). Food availability has a significant influence on gibbon's diet. There was a positive correlation between the fruit productivity and the fruit proportion in gibbon's diet, although the p value for G4 was > 0.05 (Spearman correlation : G1: r = 0.937, p = 0.000, n = 12; G4 = 0.667, p = 0.102, n = 7). And they ate more buds when buds were more available (Spearman correlation :G1: r = 0.792, p = 0.002, n = 12; G4 = 0.900, p = 0.006, n = 7). The productivity of figs and leaves did not correlate with the proportion of figs and leaves in gibbon's diet. It seemed that gibbons ate more animals when they were more abundant from June to October (Table 6), but we did not measure the abundance of animals in this study. Because gibbons spent few time feeding in flowers, we did not test the correlation between the diet and flower productivity.

The seasonal important food species also varied from month to month (Table 7). Although there were some differences between G1 and G4 in each month, they shared the majority important food species in the same month.

Table 6. Monthly percent of feeding time spent by the cao vit gibbons on each plant part in Bangliang forest patch from March 2008 to March 2009.

G1	Month	Leaves	Buds	Fruit	Figs	Animals	Flowers	Other
	08-Mar	10.3	45.0	19.1	15.2	0.1	9.3	1.0
	08-Apr	53.4	2.4	14.7	27.0	2.4	0.2	0.0
	08-May	59.7	2.7	4.0	28.7	3.5	1.5	0.0
	08-Jun	2.6	5.4	40.9	6.6	43.8	0.7	0.0
	08-Jul	40.0	0.3	23.2	28.3	8.3	0.0	0.0
	08-Aug	0.9	1.7	38.8	40.6	18.0	0.0	0.0
	08-Sep	0.0	1.8	65.6	18.5	14.1	0.0	0.0

	08-Oct	0.0	0.8	71.4	9.1	18.7	0.0	0.0
	08-Nov	0.2	0.4	52.6	40.3	6.5	0.0	0.0
	08-Dec	6.3	2.1	49.5	40.6	1.5	0.0	0.0
	09-Jan	52.2	5.5	11.7	30.3	0.3	0.0	0.0
	09-Feb	50.9	9.9	8.4	30.8	0.0	0.0	0.0
	09-Mar	27.7	70.7	1.4	0.1	0.0	0.0	0.2
	mean	23.4	11.4	30.9	24.3	9.0	0.9	0.1
G2	mean	19.1	22.2	21.8	33.1	3.1	0.7	0.0
G4	08-Aug*	0.0	0.0	80	0.0	20	0.0	0.0
	08-Sep	0.0	0.0	90.5	1.3	8.2	0.0	0.0
	08-Oct	1.4	0.0	90.5	1.6	6.5	0.0	0.0
	08-Nov	5.1	1.0	63.4	28.8	1.3	0.0	0.4
	08-Dec*	17.1	1.4	35.7	45.7	0.0	0.0	0.0
	09-Jan	62.5	1.1	16.5	18.5	0.0	0.0	1.4
	09-Feb	35.1	19.3	18.9	26	0.0	0.0	0.7
	09-Mar	11.7	83.9	1.9	1.0	0.0	0.0	1.5
	mean	16.6	13.3	49.7	15.4	4.5	0.0	0.6

Table 7. Monthly important food species for three cao vit gibbon groups in Bangliang.

Group	Month	Number of records	Number of plants fed on	Number of important species	Important food species(%)
G1	08-Mar	435	21	3	*Broussonetia papyrifera* (46.9) *Schefflera minutistellata* (21.0) *Scurrula parasitica* (9.8)
	08-Apr	305	22	7	*Ficus glaberrima* (28.9) *Scurrula parasitica* (15.7) *Ficus hookeriana*(10.0) *Burretiodendron hsienmu* (7.1) *Broussonetia papyrifera* (5.0) *Cinnamomum parthenoxylon* (4.6) *Trichosanthea kirilowii* (3.9)
	08-May	343	30	9	*Ficus glaberrima* (33.4) *Burretiodendron hsienmu* (11.7) *Cinnamomum parthenoxylon* (5.2) *Ficus virens* (5.2) *Neolitsea ellipsoidea* (4.9) Animals (4.2) *Trichosanthea kirilowii* (4.2) *Broussonetia papyrifera* (3.9) *Cephalomappa sinensis* (3.9)
	08-Jun	201	13	2	Animals (46.77)

					Iodes vitiginea (28.4)
	08-Jul	227	10	2	*Ficus hookeriana* (50.3)
					Broussonetia papyrifera (26.8)
	08-Aug	214	14	5	Animals (17.4)
					Choerospondias axillaris (17.4)
					Ficus glaberrima (16.9)
					Ficus cyrtophylla (14.1)
					Saurauia thyrsiflora (10.3)
	08-Sep	213	14	4	*Choerospondias axillaris* (27.2)
					Spondias lakonensis (18.8)
					Ficus microcarpa (17.8)
					Animals (12.7)
	08-Oct	192	13	3	*Spondias lakonensis* (34.4)
					Choerospondias axillaris (23.4)
					Animals (18.8)
	08-Nov	299	16	4	*Tetrastigma pubinerve* (35.7)
					Ficus hookeriana (24.9)
					Ficus glaberrima (13.8)
					Cinnamomum saxatile (8.1)
	08-Dec	296	16	3	*Tetrastigma pubinerve* (34.7)
					Ficus glaberrima (23.5)
					Ficus hookeriana (21.3)
	09-Jan	379	20	6	*Tetrastigma pubinerve* (22.6)
					Ficus glaberrima (17.5)
					Ficus hookeriana (11.8)
					Trichosanthea kirilowii (10.2)
					Celtis bungeana (7.2)
					Cudrania cochinchinensis (6.3)
	09-Feb	345	26	7	*Ficus glaberrima* (37.2)
					Trichosanthea kirilowii (11.9)
					Tetrastigma pubinerve (7.7)
					Oreocnide frutescens (6.3)
					Embelia subcoriacea (5.6)
					Cuscuta chinensis (5.3)
					Toona sinensis (4.9)
	09-Mar	444	14	1	*Broussonetia papyrifera* (86.7)
G2	Total	271	23	6	*Ficus hookeriana* (21.0)
					Broussonetia papyrifera (18.1)
					Ficus glaberrima (14.4)
					Choerospondias axillaris (8.1)
					Spondias lakonensis (7.7)
					Toona sinensis (5.9)
G4	08-Aug	35	6	3	*Ziziphus pbuinervis* (42.9)
					Choerospondias axillaris (22.9)

				Animals(20.0)
08-Sep	105	5	2	*Spondias lakonensis* (45.7) *Choerospondias axillaris* (44.8)
08-Oct	144	8	3	*Spondias lakonensis* (47.9) *Choerospondias axillaris* (25.0) *Tetrastigma kwangsiense* (17.4)
08-Nov	296	14	3	*Tetrastigma pubinerve* (35.5) *Ficus glaberrima* (26.0) *Actinidia indochinensis* (17.9)
08-Dec	70	10	3	*Tetrastigma pubinerve* (32.9) *Ficus glaberrima* (30.0) *Ficus hookeriana* (15.7)
09-Jan	161	14	5	*Ficus glaberrima* (23.6) *Trichosanthea kirilowii* (21.1) *Oreocnide frutescens* (15.5) *Tetrastigma pubinerve* (8.7) *Celtis bungeana* (8.7)
09-Feb	291	20	6	*Ficus glaberrima* (35.1) *Broussonetia papyrifera* (12.0) *Oreocnide frutescens* (10.7) *Trichosanthea kirilowii* (8.2) *Tetrastigma pubinerve* (7.9) *Embelia subcoriacea* (6.5)
09-Mar	464	10	1	*Broussonetia papyrifera* (77.8)

Important food species defined as the minimum number of foods comprising 75% of the diet. Numbers in parentheses indicate percentage of records.

Time budget

We used the means of hourly percentage of time dedicated on each activity as the monthly time budget. But the sample size for G4 in August and December 08 was too small to use this method (Table 3), we used the percentage of time dedicated on each activity as the monthly time budget for these two months.

Resting is the dominate behavior of cao vit gibbons. They spent 29.5-39.8% of their time resting. Feeding and traveling were the second (21.6-26.5%) and third (19.1-21.4%) common activities, followed by grooming (8.8-11.7%). Playing and other activities comprised 3.7-10.8% and 3.0-7.6% of the group's activities, respectively (Table 8). The group with more juveniles seemed spent more time in playing while less time in resting.

Time budget varied from month to month (Kruskal-Wallis test: G1:χ^2 = 65.525, df = 5, p = 0.000, n = 13; G4 :χ^2 = 27.827, df = 5, p = 0.000, n = 8) (Table 8).We used Spearman correlation to test the relationship between the monthly diet proportion and the monthly time budget. Gibbon's diet has a significant influence on their time budget. Because the data of G2 was too limited to analyze the monthly percentage, we used the means of G2 as one case (N = 22, Table 8). The gibbons increased their feeding and resting time and decreased their grooming and playing time when they ate more leaves and buds. Conversely, they decreased feeding and resting and increased grooming and playing time when they ate more fruit and animals (Table 9).

Table 9. Spearman rank correlation between monthly variations in time budget and dietary proportion.

	Leaves		Buds		Fruit		Animals	
	r	P	r	P	r	P	r	P
Feeding	0.530	0.011	0.669	0.001	-0.707	0.000	-0.598	0.003
Resting	0.579	0.005	0.525	0.012	-0.738	0.000	-0.625	0.002
Grooming	-0.706	0.000	-0.556	0.007	0.741	0.000	0.568	0.006
Playing	-0.790	0.000	-0.711	0.000	0.893	0.000	0.595	0.003

Table 8. Time budget of cao vit gibbons in Bangliang forest patch from March 2008 to March 2009.

G1	Month	Feeding	Resting	Traveling	Grooming	Playing	Other
	08-Mar	31.5	39.6	21.2	4.4	0.2	3.2
	08-Apr	31.2	31.6	29.1	5.1	0.3	2.7
	08-May	22.3	42.9	26.9	5.6	0.4	0.5
	08-Jun	18.2	30.4	25.3	19.3	4.0	2.9
	08-Jul	26.7	33.8	21.9	11.3	4.2	2.0
	08-Aug	14.4	37.7	20.8	18.0	4.1	5.0
	08-Sep	15.7	32.4	19.4	20.2	8.7	3.6
	08-Oct	17.6	34.2	17.9	9.5	13.7	7.0
	08-Nov	23.1	37.8	17.7	11.0	7.5	2.8
	08-Dec	24.4	41.2	14.7	11.3	4.3	4.1
	09-Jan	28.0	49.1	16.4	4.6	0.0	1.9
	09-Feb	28.4	51.9	12.0	6.0	0.0	1.6
	09-Mar	29.2	54.7	5.3	7.4	0.8	1.7
	mean	23.9	39.8	19.1	10.3	3.7	3.0
G2	mean	26.5	29.5	20.2	8.8	7.4	7.6
G4	08-Aug*	19.8	26.6	23.7	9.0	13.0	7.8
	08-Sep	18.3	15.7	16.7	20.9	25.9	2.5
	08-Oct	13.3	15.8	17.8	17.0	25.4	10.7
	08-Nov	20.8	21.8	27.1	11.5	15.6	2.1
	08-Dec*	23.4	41.5	22.4	9.7	2.7	0.3
	09-Jan	17.2	48.0	21.0	7.6	0.8	5.6
	09-Feb	25.2	34.3	28.3	8.5	1.9	1.9
	09-Mar	34.9	38.6	14.1	9.3	1.4	1.6
	mean	21.6	30.3	21.4	11.7	10.8	4.1

Conclusions

1. Social organization. In the current research, all four cao vit gibbon groups consisted of 1 adult male, 2 adult females and 2-6 offspring and the mean group size varied between 6-7 individuals. On the Vietnamese side, most of cao vit gibbon groups observed since the rediscovery of this population in 2002 also have 2 adult females (Geissmann et al., 2002; Le et al., 2008). These observations suggested that many cao vit gibbons live in multi-female groups which is contrary to the traditional adult-pair gibbon group organization, but share the same organization with black crested gibbon (*N.*

concolor) in Dazhaizi (Fan et al., 2006) and Hainan gibbons (*N. hainanus*) (Zhou et al., 2005). Both adult females in G1 and G4 in the current study produced offspring, and we did not observe extra-group copulation during the research. The mating system for these groups appears to be polygynous. But why some gibbon groups are polygynous while the others are monogamous is still unclear based on our preliminary study.

2. Population dynamics. During this research period from December 2007 to March 2009, this small population has a small increase due to four babies were born and one juvenile disappeared.

3. Species status of cao vit gibbon. Four infants were born during our study period. One notable characteristic was these infants were born black, while infants of all other Nomascus gibbon species are born buff yellow. Combined with differences in adult pelage (Geissmann *et al.*, 2000; Mootnick, 2006), vocalization (Geissmann et al., 2003) and genetics (Roos *et al.*, 2007), this new difference in infant coloration confirms that cao vit gibbon is a distinct species from the black crested gibbon and Hainan gibbon.

4. Forest degradation. Fuelwood collection, charcoal making, selective logging in the forest caused the forest degradation in history. Fortunately, these activities have been stopped after the rediscovery of cao vit gibbons in 2006.

5. Habitat survey. We measured 911 tree individuals with DBH≥ 10 cm in the 44 plots, of them 838 individuals were identified to species. We recorded 114 species of tree from 79 Genera and 40 Families; 51 species of woodiness liana or epiphyte from 38 Genera and 26 Families. On average, the tree height is only 9 m, the highest tree is 32 m, which is much lower than those in other gibbon's habitat. 39 trees have been cut down in recent years in the plots. Although the number of trees have been cut was not so much, but our plots were placed within gibbon’s habitat which seemed to have the best forest in the site. The forest not used by gibbons in which we did not have plot was much worse than the forest with gibbons.

6. Food availability. We monitored the food availability of gibbons between 14-17th each month. Fruit production was highest from September to November, while the relative

abundance of buds peaked in April. Figs lacked the pattern of seasonal abundance observed in fruits and buds, but few figs were available in January and February 2009. The mature leaves eaten by the gibbons were available throughout the year, although their relative abundance was reduced during the dry winter season.

7. Sample size of behavioral observation. We observed G1 824 hours in 121 days, and have 16934 records between March 2008 and March 2009. The observation hours for G2 were only 69 hours, although we could observe it nearly every month. We observed G4 336 hours in 50 days, and have 7677 records from August 2008 to March 2009.

8. Home range. During the study, G1, G4 and G2 used 66, 66 and 32 100×100m quadrants respectively (Fig. 4-6). Because some forest within the group's home range was destroyed and not used by gibbons, and part of G4 and G2's home range was out of the study area, this method was thought to under-estimate the home range size for all the three groups. The home range size for G1, G2 and G4 was estimated to be 115.2, 102.4 and 119.1 ha respectively by using minimum convex polygon method.

9. Diet. Cao vit gibbons have been observed consumed 63 different plant species and several animal species including spiders, stick insect, cicadas, grasshopper and worms. There were 41 trees, 16 vines, 2 epiphytes, 1 bamboon, 1 shrub, 1 herbage and 1 lichen. All but 6 of the food plants were identified and assigned to 43 genera from 33 families (Table 4). Six most consumed species (*Broussonetia papyrifera, Ficus glaberrima, Tetrastigma pubinerve, Ficus hookeriana, Spondias lakonensis, and Choerospondias axillaries)* accounted for 62.8% of the total records. Cao vit gibbon spent more time feeding on fruit (21.8-49.8%) and figs (15.4-33.1%). In descending order, the remainder of the diet was made up leaves (16.6-23.4%), buds (11.4-22.2%), animals (3.1-9.0%), and flowers (0.0-0.9%) (Table 6). The diet showed significant seasonal viriation. Fig species provided stable food resources for gibbons. Gibbons spent more time feeding on fruit and buds when they were available. They also ate more animals when they were abundant from June to October (Table 6). Leaves were fallback food resources for gibbons. They ate more leaves when fruit and buds were not available, but the leave proportion in gibbon's diet did not correlate with the productivity of leaves.

10. Time budget. Resting is the dominate behavior of cao vit gibbons. They spent 29.5-39.8% of their time resting. Feeding and traveling were the second (21.6-26.5%) and third (19.1-21.4%) most common activities, followed by grooming (8.8-11.7%). Playing and other activities comprised 3.7-10.8% and 3.0-7.6% of the group's activities, respectively (Table 8). Time budget varied from month to month. The gibbons increased their feeding and resting time and decreased their grooming and playing time when they ate more leaves and buds. Conversely, they decreased feeding and resting and increased grooming and playing time when they ate more fruit and animals (Table 9). In summary, black-crested gibbons employed high-effort activities when they ate more fruit and animals, and energy-conservation patterns when they ate more leaves and buds.

Conservation applications

After one year's research, we obtained some important information about cao vit gibbon's ecology. Fuelwood collection, charcoal making, selective logging caused the forest degradation in history. Cao vit gibbon's forest in China is much lower than other gibbon's forest in south-east Asia. They heavily relied on few important food species and some of these species (*Ficus hookeriana, Spondias lakonensis, and Choerospondias axillaries*) was very rare in the forest. Unfortunately, 4 out of 6 most consumed species have been cut in the area near the villages. It was thought to be an important reason of the disappearance of one or two gibbon groups in the study area. Gibbons would have a big problem in survive and reproductive if trees of these species have been cut. Trees cutting by local people have caused the degradation of the gibbon's forest, but they did not cut gibbon's important food trees in the centre of the forest. It appeared to be the main reason why cao vit gibbons could survive in this degraded forest. But if we can plant some important food trees in the forest, gibbons would have a nice future and the gibbon capacity of this small forest would be increased.

Because some forest within the group's home range was destroyed by fuelwood collection and charcoal making or naturally not suitable for gibbons, cao vit gibbon groups occupied a large home range while they never use some place within their home ranges. Cao vit gibbons maybe have a smaller home range in good forest in Vietnam.

The construction of pathway and maker stone by Vietnam government disturbed gibbon's behaviour and destroyed gibbon's habitat. With the effective negotiation by FFI and I and Chinese government and Vietnam government, both the governments gave up an idea to build a patrol way across the forest for their national defence armies. Gibbons still could travel freely between China-Vietnam border which ensured the gene flow of this small population.

Gibbon population in China has a small increase and the forest is getting better. A new nature reserve will be established in the near future. And a floating group have been observed several times and they seemed to looking for a home range in the area. This good news implied cao vit gibbon could survive to a long time if effective conservation activities have been implemented. But their population size is still very small and their habitat is also very limited, this population maybe is vulnerable to natural disaster or other random factors. A long-term population monitoring and transboundary conservation campaign is very helpful for the long-term survive of this small population.

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Appendix I: Tree species in Cao Vit gibbon's habitat in Bangliang, Guangxi

167 桑科 Moraceae

大青树 *Ficus hookeriana*

对叶榕 *Ficus hispida*

光榕 *Ficus glaberrima*

苹果榕 *Ficus oligodon*

石山榕 *Ficus virens*

歪叶榕 *Ficus cyrtophylla*

斜叶榕 *Ficus tinctoria*

岩木瓜 *Ficus tsiangii*

构树 *Broussonetia papyrifera*

136 大戟科 Urticaceae

圆叶乌桕 *Sapium rotundifolium*

虾公木 *Bridelia fordii*

石山巴豆 *Croton euryphyllus*

秋枫 *Bischofia javanica*

灰岩棒柄花 *Cleidion bracteosum*.

禾串土密树 *Bridelia insulana*

肥牛树 *Cephalomappa sinensis*

盾叶木 *Macaranga henricorum*

11 樟科 Lauraceae

樟树 *Cinnamomum camphora*

207 胡桃科 Juglandaceae

圆果华香 *Platycarya longipes*

200 槭树科 Aceraceae

樟叶槭 *Acer coriaceifolium*

角叶槭 *Acer sycopseoides*

东京槭 *Acer tonkinense*

257 紫葳科 Bignoniaceae

海南菜豆树 *Radermachera hainanensis*

212 五加科 Araliaceae

鸭脚木 *Schefflera sp.*

通脱木 *Tetrapanax papyrifer*

球序鸭脚木 *Schefflera glomerulata*

黄毛葱木 *Aralia decaisneana*

多核鸭脚木 *Schefflera delavayi*

大果树参 *Dendropanax macrocarpus*

葱木 *Aralia sp.*

128 椴树科 Tiliaceae

蚬木 *Burretiodendron hsienmu*

232 茜草科 Rbiaceae

铁屎米 *Canthium dicoccum*

茜木 *Pavetta hongkongensis*

岩樟 *Cinnamomum saxatile*

崖楠 *Phoebe yaiensis*

香果新木姜子 *Neolitsea ellipsoidea*

狭叶润楠 *Machilus sp.*

润楠一种 *Machilus sp.*

粗壮琼楠 *Beilschmiedia robusta*

细叶楷木 *Pistacia weinmannifolia*

岭南酸枣 *Spondias lakonensis*

黄连木 *Pistacia chinensis*

72 千屈菜科 Lythraceae

网脉紫薇 *Lagerstroemia suprareticulata*

113 水东哥科 Saurauiaceae

水东哥 *Saurauia trisyala*

聚锥水东哥 *Saurauia thyrsiflora*

165 榆科 Ulmaceae

越南榆 *Ulmus tonkinensis*

假玉桂 *Celtis philippinensis*

194 芸香科 Rutaceae

柚子 *Citrus grandis*

石山吴茱萸 *Evodia calcicola*

龙州水锦树 *Wendlandia oligantha*

粗叶水锦树 *Wendlandia scabra var*

205 漆树科 Anacardiaceae

野漆树 *Toxicodendron succedaneum*

盐肤木 *Rhus chinensis*

小果绒毛漆 *Toxicodendron wallichii? var. microcarpum*

山焦 *Mitrephora maingayi*

阔叶瓜馥木 *Fissistigma chloroneurum*

瓜馥木一种 *Fissistigma sp.*

瓜馥木 *Fissistigma sp.*

190 鼠李科 Rhamnaceae

毛脉枣 *Ziziphus pbuinervis*

滇刺枣 *Ziziphus mauritiana*

茶叶雀梅藤 *Sageretia camellifolia*

包叶木 *Chaydaia rubrinervis*

197 楝科 Meliaceae

香港海木 *Dysoxylum hongkongense*

香椿 *Toona sinensis*

四瓣崖摩 *Amoora tetrapetala*

米仔兰 *Aglaia odorata*

黄皮 *Clausena lansium*

柑桔 *Citrus reticulata*

长果黄皮 *Clausena dolichocarpa*

223 紫金牛科 Myrsinaceae

密花树 *Rapanea neriifolia*

广西密花树 *Rapanea kwangsiensis*

222 山榄科 Sapotaceae

紫荆木 *Madhuca pasquieri*

山胶木 *Sinosideroxylon pedunculatum*

88 海桐花科 Pittosporaceae

广西海桐 *Pittosporum kwangsiense*

8 番荔枝科 Annonaceae

中华密榴木 *Miliusa sinensis*

118 桃金娘科 Myrtaceae

紫凌木 *Decaspermum gracilentum*

海南蒲桃 *Syzygium cumini*

65 亚麻科 Linaceae

米葚芭 *Tirpitzia ovoidea*

224 安息香科 Styracaceae

龙州安息香 *Styriax longzhounica*

263 马鞭草科 Verbenaceae

楝树 *Melia azedarach*

126 山竹子科 Guttiferae (Clusiaceae)

金丝李 *Garcinia paucinervis*

大苞藤黄 *Garcinia bracteata*

143 蔷薇科 Rosaceae

大叶桂樱 *Laurocerasus zippeliana*

大花枇杷 *Eriobotrya cavaleriei*

春花木 *Rhaphiolepis indica*

221 柿科 Ebenaceae

野柿 *Diospyros kaki var. silvestris*

山榄叶柿 *Diospyros siderophylla*

93 大风子科 Flacourtiaceae

伊桐 *Itoa orientalis*

韶子 *Nephelium chryceum Bl.*

182 铁青树科 Olacaceae

蒜头果 *Malania oleifera*

120 野牡丹科 Melastomataceae

细叶谷木 *Memecylon scutellatum*

147 苏木科 Caesalpiniaceae

仪花 *Lysidice rhodostegia*

163 壳斗科 Fagaceae

滇桂豆腐柴 *Premna confinis*

白毛紫珠 *Callicarpa candicans*

210 八角枫科 Alangiaceae

疏叶八角枫 *Alangiumi kurzii var*

八角枫 *Alangium chinense*

151 金缕梅科 Hamamelidaceae

大叶蚊母树 *Distylium macrophyllum*

162 榛木科 Corylaceae

云贵鹅耳栎 *Carpinus pubescens*

229 木犀科 Oleaceae

厚边木犀 *Osmanthus marginatus*

128 杜英科 Elaeocarpaceae

日本杜英 *Elaeocarpus japonicus*

171 冬青科 Aquilifoliaceae

扣树 *Ilex kaushue*

130 梧桐科 Sterculiaceae

粉苹婆 *Sterculia euosma*

198 无患子科 Sapindaceae

青冈栎 *Quercus glauca*

姜叶柯 *Lithocarpus litseifolius*

厚缘青冈 *Cyclobalanopsis thorelii*

滇南青冈 *Cyclobalanopsis austroglauca*

长叶粉背青冈 *cyclobalanopsis pseudoglauca*

细叶青冈 *Cyclobalanopsis gracilis*

Appendix II: Wood liana species and epiphyte species in different zone in cao vit gibbon's habitat in Bangliang, Guangxi

山谷物种 (Bottom of the valley)：

193 葡萄科 Vitaceae

扁担藤 *Tetrastigma planicaule*

七小叶崖爬藤 *Tetrastigma delavayi*

广西崖爬藤 *Tetrastigma kwangsiense*

毛脉崖爬藤 *Tetrastigma pubinerve*

毛葡萄 *Vitis pentagona*

崖爬藤 *Tetrastigma obtectum*

173 卫矛科 Celastraceae

青江藤 *Celastrus hindsii*

212 五加科 Araliaceae

球序鸭脚木 *Schefflera glomerulata*

320 天南星科 Araceae

地苷 *Pothos pilulifer*

麒麟尾 *Epipremnum pinnatum*

28 胡椒科 Piperaceae

复毛胡椒 *Piper bonii*

190 鼠李科 Rhamnaceae

复萼翼核果 *Ventilago calyculata*

223 紫金牛科 Myrsinaceae

231 萝藦科 Asclepiadaceae

凸脉球兰 *Hoya nervosa*

251 旋花科 Convolvulaceae

菟丝子 *Cuscuta chinensis*

3 五味子科 Schisandraceae

异形南五味子 *Kadsura heteroclita*

103 葫芦科 Cucurbitaceae

栝楼 *Trichosanthea kirilowii*

256 苦苣苔科 Gesneriaceae

芒毛苣苔 *Aeschynanthus acuminatus*

197 茶茱萸科 Icacinaceae

小果微花藤 *Iodes vitiginea*

185 桑寄生科 Loranthaceae

红花桑寄生 *Scurrula parasitica*

230 夹竹桃科 Apocynaceae

山橙 *Melodinus suaveolens*

山脊物种 (Ridge)：

185 桑寄生科 Loranthaceae

枫香槲寄生 *Viscum liquidambaricolum*

厚叶酸藤子 *Embelia subcoriacea*

147 苏木科 Caesalpiniaceae

红背叶羊蹄甲 *Bauhinia rubro-villosa*

167 桑科 Moraceae

枳藤 *Cudranis fruticosa*

147 苏木科 Caesalpiniaceae

老虎刺 *Pterolobium punctatum*

148 蝶形花科 Papilionaceae

猪腰豆 *Whitfordiodendron filipes*

广寄生 *Taxillus chinensis*

红花桑寄生 *Scurrula parasitica*

槲寄生 *Viscum coloratum*

190 鼠李科 Rhamnaceae

梗花雀梅藤 *Sageretia henryi*

复毛胡椒 *Piper bonii*

190 鼠李科 Rhamnaceae

梗花雀梅藤 *Sageretia henryi*

山腰物种 (Slope of the hill)：

193 葡萄科 Vitaceae

扁担藤 *Tetrastigma planicaule*

毛脉崖爬藤 *Tetrastigma pubinerve*

崖爬藤 *Tetrastigma obtectum*

广西崖爬藤 *Tetrastigma kwangsiense*

103 葫芦科 Cucurbitaceae

栝楼 *Trichosanthea kirilowii*

148 蝶形花科 Papilionaceae

藤黄檀 *Dalbergia hancei*

滇黔黄檀 *Dalbergia yunnanensis*

藤槐 *Bowringia callicarpa*

147 苏木科 Caesalpiniaceae

红背叶羊蹄甲 *Bauhinia rubro-villosa*

老虎刺 *Pterolobium punctatum*

179 茶茱萸科 Icacinaceae

小果微花藤 *Iodes vitiginea*

332 禾本科 Gramineae

蓬叶竹 *Indocalamus calcicolus*

185 桑寄生科 Loranthaceae

红花寄生 *Scurrula parasitica*

223 紫金牛科 Myrsinaceae

厚叶酸藤子 *Embelia subcoriacea*

皱果崖豆藤 *Millettia oosperma*

猪腰豆 *Whitfordiodendron filipes*

23 防己科 Menispermaceae

苍白秤勾枫 *Diploclisia glaucescens*

179 茶茱萸科 Icacinaceae

大果微花藤 *Iodes balansae*

302 天南星科 Araceae

地苷 *Pothos pilulifer*

麒麟尾 *Epipremnum pinnatum*

28 胡椒科 Piperaceae

8 番荔枝科 Annonaceae

香港鹰爪 *Artabotrys hongkongensis*

垭口物种 (Col of the hill)：

193 葡萄科 Vitaceae

扁担藤 *Tetrastigma planicaule*

广西崖爬藤 *Tetrastigma kwangsiense*

七小叶崖爬藤 *Tetrastigma delavayi*

崖爬藤 *Tetrastigma obtectum*

柔毛网脉崖爬藤 *Tetrastigma retinervium var. pubescens*

毛脉崖爬藤 *Tetrastigma pubinerve*

乌敛梅 *Cayratia japonica*

103 葫芦科 Cucurbitaceae

栝楼 *Trichosanthea kirilowii*

231 萝藦科 Asclepiadaceae

凸脉球兰 *Hoya nervosa*

232 茜草科 Rubiaceae

鸡眼藤 *Morinda umbellata*

251 旋花科 Convolvulaceae

菟丝子 *Cuscuta chinensis*

233 忍冬科 Caprifoliaceae

腺背忍冬 *Lonicera hypoglauca*

179 茶茱萸科 Icacinaceae

小果微花藤 *Iodes vitiginea*

223 紫金牛科 Myrsinaceae

厚叶酸藤子 *Embelia subcoriacea*

302 天南星科 Araceae

麒麟尾 *Epipremnum pinnatum*

230 夹竹桃科 Apocynaceae

山橙 *Melodinus suaveolens*

251 旋花科 Convolvulaceae

190 鼠李科 Rhamnaceae

复鼠翼核果 *Ventilago calyculata*

146 含羞草科 Mimosaceae

腾金合欢 *Acacia sinuata*

147 苏木科 Caesalpiniaceae

红背叶羊蹄甲 *Bauhinia rubro-villosa*

老虎刺 *Pterolobium punctatum*

212 五加科 Araliaceae

球序鸭脚木 *Schefflera glomerulata*

28 胡椒科 Piperaceae

复毛胡椒 *Piper bonii*

231 萝藦科 Asclepiadaceae

凌云弓果藤 *Toxocarpus paucinervius*

凸脉球兰 *Hoya nervosa*

菟丝子 *Cuscuta chinensis*

133 金虎尾科 Malpighiaceae

贵州盾翅藤 *Aspidopterys*

311 薯蓣科 Dioscoreaceae

五叶薯蓣 *Dioscorea pentaphylla*