

Feeding ecology of eastern hoolock gibbons in Nankang, Gaoligongshan

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Background

Supported by RSG fund, my research team had conducted a survey of the population and distribution of hoolock gibbons in China between March 2008 and August 2009 (Fan et al., 2011). The survey results showed a rapid decline in both population and sites. Tsaoko cardamom (*Fructus tsaoko*) cultivation was thought to be one of the main threats to the gibbon population, currently with less than 200 individuals in China. Tsaoko cardamom is a spicy and medicinal herb, and provides the main income for the local people. Cardamom plantations occur throughout the gibbons' habitat, between 1,800 and 2,200 m asl. To plant cardamom, local people cut down trees in the moist valley to reduce the canopy density to 50-70%. They also clear out small trees and lianas. It reduces gibbons' food tree densities and may increase gibbon's foraging efforts because of the discontinuous canopy. There is need to study the impacts of cardamom plantation on the feeding ecology of gibbons.

Two sites inside Gaoligongshan have been chosen for the comparative research. A family group and a solitary adult female already habituated to observers in Nankang, the habitat with cardamom plantation and more human disturbances. Another site is Datang where the forest has been well protected. However, the field research in Datang was aborted in July 2010 after 10 months work because one of the study groups disappeared and one local guide died during the research. Therefore, this project focused only on the feeding ecology of gibbons in Nankang. I am going to start a new research in Banchang where no cardamom occurs in March 2012. Because we do not have the comparative data from gibbon groups living in primary forest, we can not get any conclusions of how cardamom planting affect hoolock gibbon's feeding behavior. I just report the novel basic information in feeding behavior of eastern hoolock gibbon here. I would like to emphasize that this is the first long-term research of eastern hoolock gibbons around the world.

Study site

Nankang Park is a forest corridor connecting the Gaoligongshan National Nature Reserve in north and the Xiaoheishan Provincial Nature Reserve in south. This park is located along three county boundaries (Tengchong, Baoshan, and Longling). The forest belongs to the central government but can be used by the local villages. Local people started to plant cardamom in the forest in 1985 (Fan et al., 2011). It has been under management of Gaoligongshan National Nature Reserve since 1996. Since then, cardamom expansion was exhibited but local people could manage their existed cardamom field. Based on interview information, more than 5 groups lived in the corridor before 1985 but declined to only 4 individuals (one family group with 3 individuals and 1 solitary female) in 2008 (Fan et al., 2011). Currently, this is the south most hoolock gibbon population (N24°49', E98°46') in China (Fig. 1). The forest is semi-humid evergreen broadleaved forest, dominated by Lauraceae, Fagaceae, Theaceae, and Magnoliaceae (Zhang et al., 2008, this research).

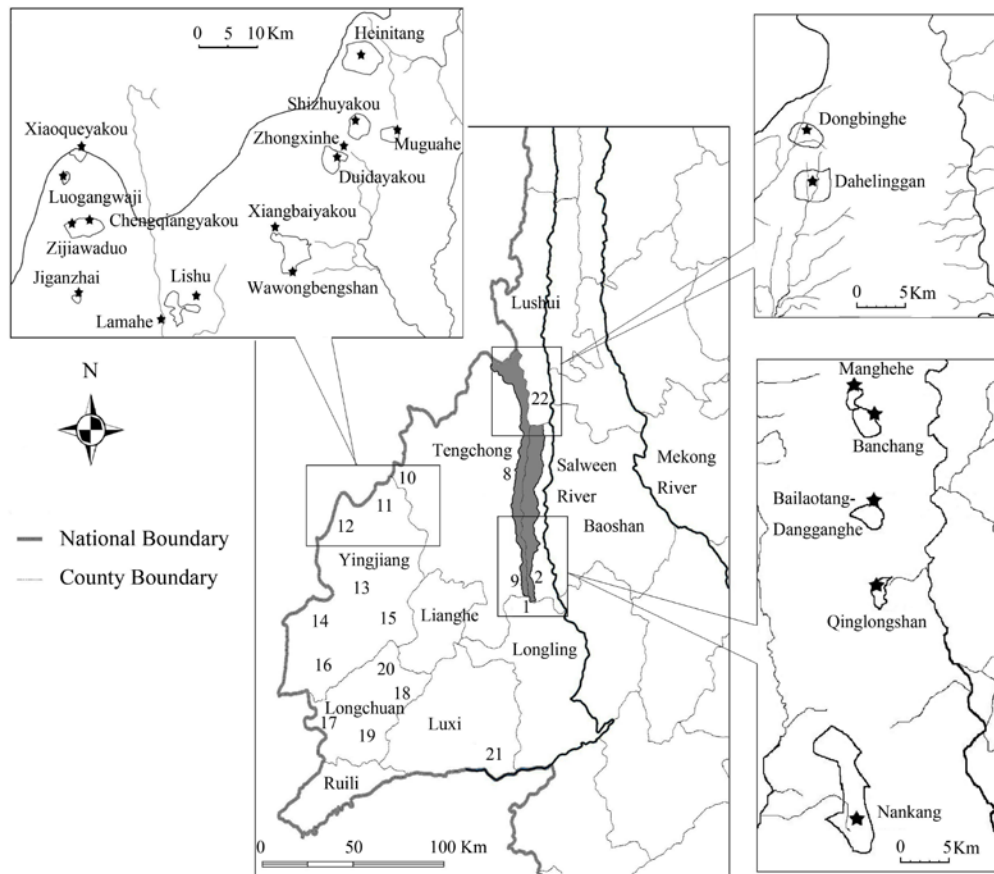


Fig.1 Distribution of eastern hoolock gibbons in China, from the 2008-2009 survey (Fan et al., 2011).
Climate

There is a climate station set by the Meteorological Bureau of Baoshan City in the site, 200 m from the boundary of the gibbon home range (N24°49', E98°46', H2190m). The annual mean temperature was 13.3°C between October 2010 and September 2011. The lowest monthly mean temperature was 6.4°C in January and highest 20.3°C in August 2010 (Table 1). The annual rainfall was 1801.4 mm between October 2010 and September 2011. Rainfall was > 200 mm in each month of rainy season from May to October, except in September 2011, while < 100 mm in each month of dry season from November to April (Table 1).

Table 1. Rainfall (mm) and temperature (°C) between August 2010 and September 2011 in Nankang, Gaoligongshan. Annual mean was calculated from data between October 2010 and September 2011.

| Month | Rainfall | Monthly Maximum Temperature | Monthly Minimum Temperature | Monthly Mean Temperature | Mean of Daily Maximum Temperature | Mean of Daily Minimum Temperature |
|--------|----------|-----------------------------|-----------------------------|--------------------------|-----------------------------------|-----------------------------------|
| 10-Aug | 279.6 | 29.2 | 16.0 | 20.3 | 24.2 | 18.0 |
| 10-Sep | 239.4 | 23.9 | 12.0 | 16.9 | 21.0 | 15.0 |
| 10-Oct | 233.4 | 26.6 | 9.7 | 16.0 | 19.9 | 13.6 |

| | | | | | | |
|--------|--------|------|------|------|------|------|
| 10-Nov | 17.9 | 20.6 | 7.9 | 12.5 | 16.8 | 10.2 |
| 10-Dec | 83.9 | 19.8 | 1.8 | 9.5 | 14.5 | 6.3 |
| 11-Jan | 66.3 | 14.7 | -0.3 | 6.4 | 11.1 | 3.7 |
| 11-Feb | 9.4 | 17.8 | 2.9 | 8.8 | 14.2 | 5.3 |
| 11-Mar | 48.7 | 19.5 | 3.4 | 11.1 | 15.4 | 8.2 |
| 11-Apr | 38.1 | 22.1 | 7.5 | 13.5 | 18.6 | 10.3 |
| 11-May | 247.0 | 23.6 | 10.1 | 15.0 | 19.1 | 12.7 |
| 11-Jun | 254.1 | 24.4 | 13.3 | 16.4 | 19.4 | 15.0 |
| 11-Jul | 309.5 | 24.5 | 13.5 | 16.6 | 20.1 | 15.1 |
| 11-Aug | 295.0 | 25.0 | 13.2 | 16.6 | 20.1 | 14.8 |
| 11-Sep | 198.1 | 25.2 | 11.9 | 16.9 | 21.2 | 14.7 |
| Annual | 1801.4 | 22.0 | 7.9 | 13.3 | 17.5 | 10.8 |

Feeding behavior observation

A scan sampling method at 5-min intervals was used to record the activity of gibbons (Altmann, 1974). For each observation sample, a 1-min scan was made recording the behaviour of all visible members. Each individual was observed for 5 sec and its predominant behaviour recorded. 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 solo/duet calling at the time of the 5-min scan. Playing refers to social play between ≥ 2 individuals. 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, flower, animals, and other).

This research was started in July 2010 and the first month was used to train students, therefore, the data collected in July 2010 was not included in this report. Both the members in the family group (GA) and the solitary female (B) were habituated before this research. We tried to observed the GA 5 full days in each month, totally 64 full days, from August 2010 to September 2011. Including the half-day follows, we observed GA 853 hours in 103 days. Tracking of female B was not very successful and we observed this female for more than 20 h in 9 months (Table 2). Finally, we observed B 464 hours in 79 days.

Table 2. Sample size of a family group (GA) and a solitary female (B) between August 2010 and September 2011 in Nankang, Gaoligongshan.

| | GA | | | | B | | | |
|---------|------|-------|-------|---------|------|-------|-------|---------|
| | Days | Hours | Scans | Records | Days | Hours | Scans | Records |
| Aug. 10 | 12 | 87 | 805 | 1873 | 8 | 70 | 669 | 669 |
| Sep. 10 | 6 | 63 | 619 | 1600 | 13 | 67 | 567 | 567 |
| Oct. 10 | 7 | 59 | 603 | 1429 | 8 | 57 | 512 | 512 |
| Nov. 10 | 8 | 71 | 701 | 1791 | 6 | 42 | 390 | 390 |
| Dec. 10 | 7 | 55 | 514 | 1182 | 4 | 18 | 150 | 150 |
| Jan. 11 | 7 | 57 | 495 | 1055 | 1 | 5 | 34 | 34 |

| | | | | | | | | |
|---------|-----|-----|------|-------|----|-----|------|------|
| Feb. 11 | 4 | 33 | 290 | 579 | 2 | 8 | 71 | 71 |
| Mar. 11 | 7 | 47 | 433 | 1008 | 7 | 47 | 472 | 472 |
| Apr. 11 | 6 | 59 | 635 | 1276 | 6 | 34 | 313 | 313 |
| May. 11 | 6 | 56 | 590 | 1253 | 8 | 38 | 358 | 358 |
| Jun. 11 | 6 | 55 | 572 | 1068 | 5 | 28 | 268 | 268 |
| Jul. 11 | 8 | 52 | 489 | 954 | 1 | 2 | 15 | 15 |
| Aug. 11 | 9 | 71 | 693 | 1489 | 2 | 2 | 13 | 13 |
| Sep. 11 | 10 | 88 | 846 | 1935 | 8 | 46 | 406 | 406 |
| Total | 103 | 853 | 8285 | 18492 | 79 | 464 | 4238 | 4238 |

Food availability

We set 33 20×20m plots in different altitude within the gibbon's home range in August and September 2010. In each plot, the following data has been collected: the coordinate and altitude of each plot, plant species, tree height, DBH, the crown diameter of trees (DBH ≥ 10cm). **Nine hundred and sixty six of 1027 trees with DBH ≥ 10cm were identified to ≥ 43 genera in 25 families.** Except two plots, all the 968 tree individuals in 31 plots, lianas and epiphytes climbed on the trees in the plots have been monitored for the seasonal availability of food parts (fruit, figs, leaves, buds, and flowers) between 14-17th every month. An abundance value was assessed for each plant parts ranging from 0–4 (0 < 1%; 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 relationships between the gibbon 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 **little** time feeding **on** flowers (Fan et al., in press), we did not calculate the abundance for flowers.

Data analysis

Gibbons' diet and time budget usually showed diet variation (Fan et al., 2008, 2009; Raemaekers, 1978). In order to ensure that diet and time budget were not biased by uneven data collection across the day, data were averaged for each hour before mean monthly diet and time budgets were computed (Hill et al., 2003). We did not analyze the monthly diet and time budgets of female B in those months with < 20 observation hours. We integrated grooming, playing and singing as social behaviour in all analysis.

Results

Food diversity

In total, 6614 (GA: 5384; B: 1230) feeding records were made during the research period. Of

them, 93% records (5005) were identified to species-level for GA and 90.5% (1113) for female B. Eastern hoolock gibbons were observed to consume material from 66 plant species and several animal species, including cicadas, worms and bird chicks. We were surprised that member of GA ate soil in 5 cases. Consumed plant and plant parts came from 34 tree, 20 liana, nine angiosperm epiphyte, two scrubs and one bamboo species. All but four of the food plants were able to be identified to species (Appendix I), belongs to 53 genus in 34 families. The ten most consumed plant species accounted for 67.2% of GA feeding records, 63.3% of female B feeding records (Appendix I).

Annual diet

We used the last 12 month from October 2010 to September 2011 to calculate the annual diet of GA. GA diet comprised of 49.1% fruit (non-fig fruit: 35.6%, fig: 13.5%), 43.3% leaves (buds, young leaves and mature leaves), 5.3% invertebrate animals and bird chicks, 1.8% flower, and 0.6% others. We did not analyze the annual diet of female B because we did not have the year-round data for this female.

Seasonal variation of diet

Both GA and B showed obvious seasonal variation of monthly diet (Fig. 2 and Fig. 3). Leaves accounted for 81.9% of the GA monthly diet in January and decreased to 6.8% in October 2010. Non-fig fruit accounted for 76.7% of GA monthly diet in October 2010 but only accounted 4.0% in August 2010. Figs accounted around 50% of the GA monthly diet in August and September in both 2010 and 2011 but accounted <20% in all other months. GA spent more time in searching for invertebrate animals between September and November.

Although sample size for female B was not as good as GA, we could find the similar pattern from the 9 month samples with >20 observation hours. B ate more leaves between March and June while ate more non-fig fruit between September and November. Figs were the most important food items in August and September.

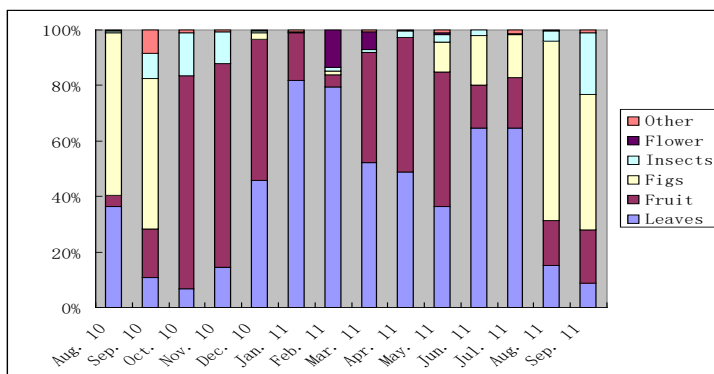


Fig. 2. Monthly diet of GA between August 2010 and September 2011 in Nankang.

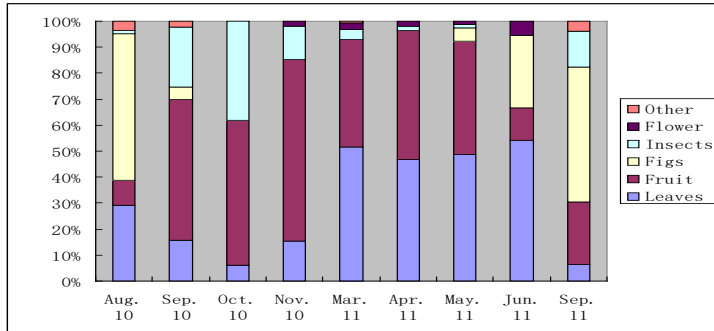


Fig. 3. Monthly diet of female B in 9 months with > 20 observation hours between August 2010 and September 2011 in Nankang.

Annual time budget

We used the last 12 months to analyze the annual time budget of GA. GA spent 36.7% of their active time in resting, 31.6% feeding, 25.1% travelling, 6.3% social behaviour and 0.4% in other activities. We did not analyze the annual time budget for female B because of inadequate sample size. Compared with GA, B spent more time in resting and less time in travelling and feeding base on the 9 months samples.

Seasonal variation of time budget

Seasonal variation of time budget was found in both GA and B (Fig. 5 and Fig. 6). Feeding time of GA varied from 17.1% in September 2010 to 37.3% in March. Resting of GA varied from 24.6% in June to 48.6% in September 2010. Travelling of GA varied from 17.1% to 35.4% in June.

Female B spent 41.3% time in feeding in November and feeding time decreased to 19.5% in September 2011. Resting time varied from 63.4% in September 2010 to 38.3% in April. Travelling accounted for 11.3% in November and 21.4% in April.

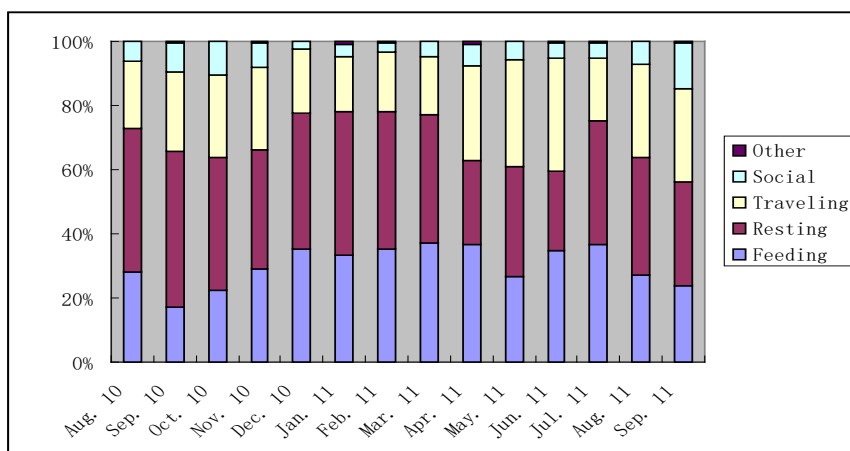


Fig. 5. Monthly time budget of GA between August 2010 and September 2011 in Nankang.

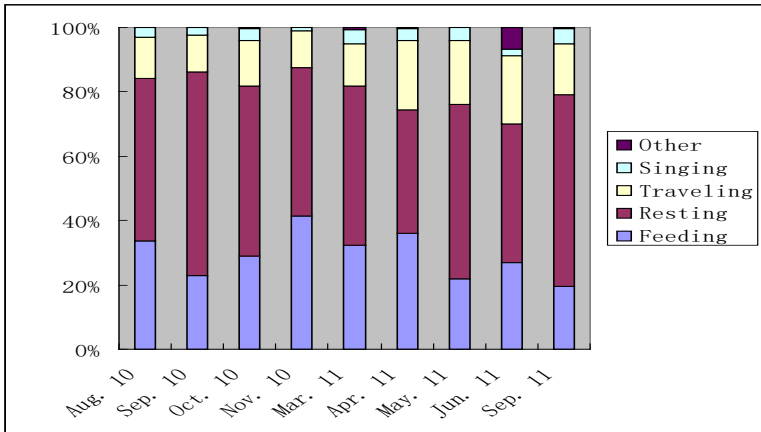


Fig. 5. Monthly time budget of female B in 9 months with > 20 observation hours between August 2010 and September 2011 in Nankang.