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Seasonal variation of diet and time budget of Eastern hoolock gibbons (*Hoolock leuconedys*) living in a northern montane forest

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Abstract Most gibbons dwell in the tropical forests of Southeastern Asia, but eastern hoolock gibbons (*Hoolock leuconedys*) survive in high montane forest ranging from 1,600 to 2,700 m a.s.l. in Gaoligongshan (>24°30′N), Yunnan, China. To assess the behavioral adaptations of hoolock gibbons to the montane forest, we related temperature and food availability within the habitat to the seasonal behavioral patterns of a family group and a solitary female between August 2010 and September 2011 in Nankang, Gaoligongshan National Nature Reserve. The maximum temperature was 29.2 °C and the minimum temperature was −0.3 °C during the period. The monthly mean temperature was <10 °C between December and February, making Nankang the coldest gibbon habitat reported so far. Nonfig fruit and fig availability declined to nearly zero in cold months. The family group increased resting and decreased travel and social behaviors when the monthly mean temperature was low. Compared with other gibbon populations, the hoolock gibbons spent proportionally less time feeding on figs and other fruit than other gibbon populations except *Nomascus concolor* and *Symphalangus syndactylus*. Only 36 species of plants provided nonfig fruit or figs, which is less than the number of fruit species consumed by any other gibbon population observed during a similar period of time (about 1 year). Hoolock gibbons shifted their diet to leaves and increased feeding time when fruit was not available. We conclude that diet flexibility and an energy-conserving strategy during the cold season when fruit is scarce have enabled the hoolock gibbons to survive in a northern montane forest.

Keywords Eastern hoolock gibbon · Harsh habitat · Seasonal variation · Gaoligongshan · Temperate zone

Introduction

Most extant gibbons (Hylobatidae) dwell in tropical and subtropical forests in Southeastern Asia (Bartlett 2007) and are usually not considered “temperate primates” occurring mainly or exclusively north of 23.5° (Grueter et al. 2009). However, Chinese literature shows that gibbons used to range farther north to the area of the Yangtze River around 31°N before the 1960s (reviewed in Gao et al. 1981). The distributional range of gibbons in China has retreated southward to southern Yunnan, Guangxi, and Hainan, close to 25°N latitude (e.g., *Nomascus concolor* in Wuliang Mountain: Jiang et al. 2006; *Hoolock leuconedys* in Gaoligongshan: Fan et al. 2011a).

Fruit productivity decreases with increasing latitude and altitude (Hanya and Aiba 2010), and fruiting seasonality also increases with latitude, indicating that fruiting seasons are longer in the tropics and shorter toward the poles (Ting et al. 2008). In accordance with the high fruit productivity, gibbons living in tropical forest are more frugivorous except for the more folivorous siamang (*Symphalangus syndactylus*) (reviewed in Bartlett 2007) because of its relatively large body size and low metabolic rate (Palombit 1997). The tropical gibbons also show less seasonality in their monthly diet, which is dominated (>50 %) by fruits and figs in most months (*Hylobates agilis*: Gittins 1982;

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H. muelleri × *agilis*: McConkey et al. 2003; *H. lar*: Bartlett 2009). Like all other gibbons living in tropical forest, hoolock gibbons have been found to consume more fruit (>70 %) and less leaves (<15 %) in the warm lowland forests in Lawachara (24°30–32′N, altitude 10–25 m) and Chunati (22°8–53′N; altitude 15 m) in Bangladesh (Islam and Feeroz 1992; Ahsan 2001). Fruit dominated the monthly diet in all months in Lawachara (Islam and Feeroz 1992). In another lowland forest (26°70′N; altitude 119 m) in Hollongapa, Assam, India, hoolock gibbons spent 67 % of their feeding time on fruit during winter seasons (Tilson 1979). In contrast, *N. concolor* living in temperate montane forest (24°21′N; altitude 1,900–2,700 m) are more folivorous (fruit 44.1 %, leaves 46.5 %) and show extreme seasonal variation in diet in Wuliang Mountain (Fan et al. 2009). During the periods of fruit shortage, this group switched to a diet based mainly on leaves (Fan et al. 2009).

In temperate forests, fruits become scarce in cold winters (Hanya 2004a; Li 2006; Grueter et al. 2009), resulting in energetic challenges associated with food shortage and thermoregulatory costs (Tsuji et al. 2008). Japanese macaques (*Macaca fuscata*) reduce traveling and feeding when the temperature is low (Hanya 2004b). A group of *N. concolor* decreased time traveling and increased resting in response to low temperature on Wuliang Mountain (Fan et al. 2008).

Hoolock gibbons (genus *Hoolock*) are widely distributed in different forest types from the floodplains to the mountains in India (Das et al. 2003, 2009), Bangladesh (Islam and Feeroz 1992; Das et al. 2003), Myanmar (Brockelman et al. 2009), and South China (Fan et al. 2011a). Although hoolock gibbons have been recorded up to 2550 m in Manipur, northeast India (Choudhury 2001), 2,100–2,300 m on Victoria Mountain in Chin State, Myanmar (King et al. 1995), and 1,600–2,700 in Gaoligongshan Nature Reserve, Yunnan, China (Fan et al. 2011a), comparative information has not been reported from highland hoolock gibbons.

In this work, we studied how eastern hoolock gibbons allocate their time to different activities and their feeding time to various food items in response to seasonal variation of temperature and fruit abundance in a montane forest in Gaoligongshan (24°49′N; altitude 1,800–2,300 m). We also compared the results between this study and others conducted in lowland tropical forest to elucidate how hoolock gibbons adapt to their montane habitat.

Methods

Study site and study animals

We conducted this study in Nankang Park (1,330 ha; 24°49′N, 98°46′E), a forest corridor connecting the Gaoligongshan National Nature Reserve (120,000 ha) to the north and the Xiaoheishan Provincial Nature Reserve (6,293 ha) to the south. Nankang has been under management of Gaoligongshan National Nature Reserve since 1996. The forest is semihumid evergreen broadleaved forest, degraded by cardamom plantations, and dominated by trees of Lauraceae, Fagaceae, Theaceae, and Magnoliceae (Zhang et al. 2008; Fan et al. unpublished data). Cardamom plantations have been banned since 1996, and only pre-existing plantations can be maintained within the park. Based on interviews with local people, more than 5 gibbon groups lived in the corridor before 1985, but have declined to only 4 individuals (group A with 3 individuals and 1 solitary female B) in 2008, probably because of habitat degradation and hunting (Fan et al. 2011a). One small juvenile of group A died in March 2008, but the adult female gave birth again in November 2008. This infant was semidependant at the beginning of this research and became fully independent during daytime in October 2010. Both members of GA and the solitary female B were well habituated before our research.

Climate

A climate station was set up by the Meteorological Bureau of Baoshan City, 200 m from the boundary of the gibbon home range (24°49′N, 98°46′E; 2,190 m a.s.l.). 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 the highest was 20.3 °C in August 2010 (Fig. 1). The lowest recorded temperature was −0.3 °C on 16 January, and the forest was covered by snow on 16 and 17 January. The annual rainfall was 1,801 mm between October 2010 and September 2011. Rainfall exceeded 200 mm in each month of the rainy season from May to October, except in September 2011 (198 mm), but was less than 100 mm in each month of the dry season from November to April (Fig. 1).

Feeding behavior observation

Activity was recorded using scan sampling at 5-min intervals (Altmann 1974). For each observation sample, a 1-min scan was made, recording the behavior of all visible members. Each individual was observed for 5 s, and its predominant behavior recorded. We recorded activity as resting (sitting, lying, hanging, and autogrooming), traveling (bipedal walk, suspension, leap, bridge, and climb), feeding (picking, chewing, or swallowing), grooming, calling (solo or duet call), social playing, and “other.” We recorded conflict activity between groups, alarm calling, and unidentified behavior as “other.” When an individual

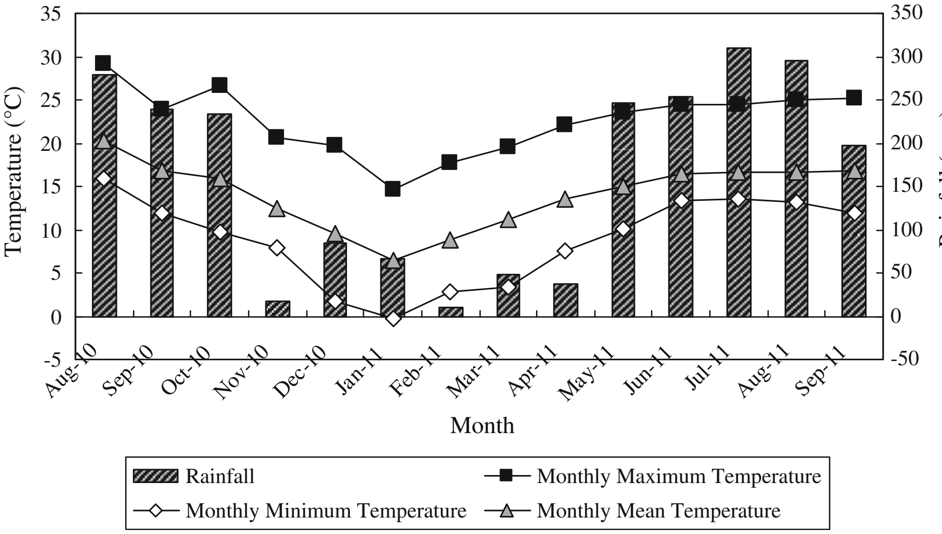

Fig. 1 Monthly mean, maximum, and minimum temperature (°C) and rainfall (mm) between August 2010 and September 2011 in Nankang, Gaoligongshan

was feeding, we recorded the food species and specific part eaten (nonfig fruit, fig, leaves, flower, animals, and others).

We tried to observe GA for 5 full days in each month, totaling 64 full days, from August 2010 to September 2011. Including half-day follows, we observed GA for 853 h on 103 days. We were unable to track female B successfully, but were able to observe her for at least 20 h in each of 9 months, and overall, for 464 h on 79 days (Table 3 in Appendix 2).

Fruit availability

Using a stratified random sampling design, we set 33 20 m × 20 m plots within the gibbons' home range in August and September 2010. The following data were collected in each plot: coordinates and altitude, plant species, tree heights, diameter at breast height (DBH), and the crown diameter of trees with DBH ≥10 cm. A total of 966 out of 1027 trees with DBH ≥10 cm were identified to 84 species in 43 genera and 25 families. All the 968 trees in 31 plots, plus lianas and epiphytes climbing on the trees, were monitored during 3 days per month in order to evaluate the seasonal availability of nonfig fruits and figs. We estimated abundance of ripe fruits using an index ranging from 0–4 (0 = <1 %; 1 = 1–25 %, 2 = 26–50 %, 3 = 51–75 %, 4 = 76–100 % of crown cover) (Poulsen et al. 2001). We used DBH as a proxy for tree crown volume (Chapman et al. 1992). We multiplied the abundance value by the DBH of each plant individual and then summed all these individual scores to yield a monthly abundance index for each food type. For lianas and epiphytes, we obtained the scores by multiplying the proportional volume (calculated as crown volume of liana/crown volume of host tree) by the DBH of the host trees. Plant species not eaten by the gibbons were not included in calculating the food abundance scores.

Data analysis

Gibbon diets and time budgets usually show diurnal variation (Raemaekers 1978; Fan et al. 2008, 2009). 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; Xiang et al. 2010). We then used the last 12 months from October 2010 to September 2011 to calculate the annual proportional time budget and diet of GA in order to obtain results comparable to other studies. We did not analyze the monthly diet and time budgets of female B in months with <20 observation hours. We combined social grooming, playing, and singing as social behavior in all analyses.

We combined the time that gibbons entered and left their sleeping trees of GA and B together to calculate the average active time for each month. Studies on temperate primate populations have found strong seasonal variation in the period of active time, as a consequence of the large variation in day length in these environments (Bartlett 2009; Xiang et al. 2010; present study). In comparing behavior budgets from different latitudes, therefore, one must consider the absolute amounts of time and not only the percentage of time in different activities (Xiang et al. 2010). We multiplied the monthly percentage time budget by the average active time to obtain the actual time per day (in hours) spent in different activities or feeding time on different food types (Hill et al. 2003; Hanya 2004b; Fan et al. 2012). We obtained resting time (in hours) by subtracting times for traveling, feeding, social, and other activities from 24.

Stepwise multiple regression was used to analyze the effects of temperature, rainfall, and food abundance (independent variables) on the feeding time allocated to different food types (dependent variables), and was used to assess the effects of temperature, rainfall, food abundance, and feeding time on different food types (independent variables) on the gibbons' time budget (dependent variables) (Table 1). SPSS 16.0 was used in all analyses.

Results

Fruit availability

Nonfig fruit production showed two peaks (Fig. 2). The first and smaller one was in March and April, mainly because a single species *Schefflera minutistellata* fruited in these months. The second peak occurred in September and October when 7 species fruited. Only 3 fig species were recorded in the site, and all were consumed by gibbons (Table 2 in Appendix 1). The densities of *Ficus sarmentosa* and *Ficus auriculata* were very low, and only one tree strangled by *Ficus sarmentosa* and no tree of *Ficus auriculata* was recorded in our plots. *Ficus neriifolia* was a common species, and 32 trees were recorded. Fig production also varied from month to month (Fig. 2). Most figs fruited between June and August, and none produced fruit in December, January, March, and April in our plots (Fig. 2).

Table 1 Dependent and independent variables used in stepwise multiple regression

	Dependent variables	Independent variables
Feeding behavior	Feeding time on leaves	Monthly mean temperature
	Feeding time on figs	Monthly rainfall
	Feeding time on nonfig fruit	Availability of figs
	Feeding time on flowers	Availability of nonfig fruit
	Feeding time on insects	
Time budget	Resting time	Monthly mean temperature
	Traveling time	Monthly rainfall
	Feeding time	Availability of figs
	Social behavior	Availability of nonfig fruit
		Feeding time on leaves
		Feeding time on figs
		Feeding time on nonfig fruit
		Feeding time on flowers
		Feeding time on insects

Annual time budget

Gibbons were active outside of the sleeping trees for a minimum of 6.3 h in February to 10.3 h in September (mean 9.1 h, $n = 14$ months). GA spent 36.7 % of their active time in resting, 31.6 % feeding, 25.1 % traveling, 6.3 % social behavior, and 0.4 % in other activities. During the 24 h cycle, GA spent 18.26 h in resting and sleeping, 2.81 h in feeding, 2.31 h in traveling, 0.59 h in social, and 0.03 h in other activities. Compared with GA, female B spent nearly equivalent time in feeding (29.3 %, 2.78 h), but it spent more time in resting (50.9 %, 19.3 h) and less time in traveling (15.6 %, 1.51 h) and social activities (1.3 %, 0.32 h).

Seasonal variation of time budget

Seasonal variation in the time budget was found in both GA and B (Fig. 3). Average daily feeding time of GA varied from 1.68 h in September 2010 to 3.52 h in April. Traveling of GA varied from 1.27 h in February to 3.40 h in June. Social time decreased from 0.99 h in October to 0.17 h in December. Mean monthly temperature was the most important factor influencing GA's time budget. GA increased resting ($F = 16.997, r_{\text{temperature}} = -0.793, t = -4.123, P = 0.002$) and decreased traveling ($F = 15.362$, $r_{\text{temperature}} = 0.778$,

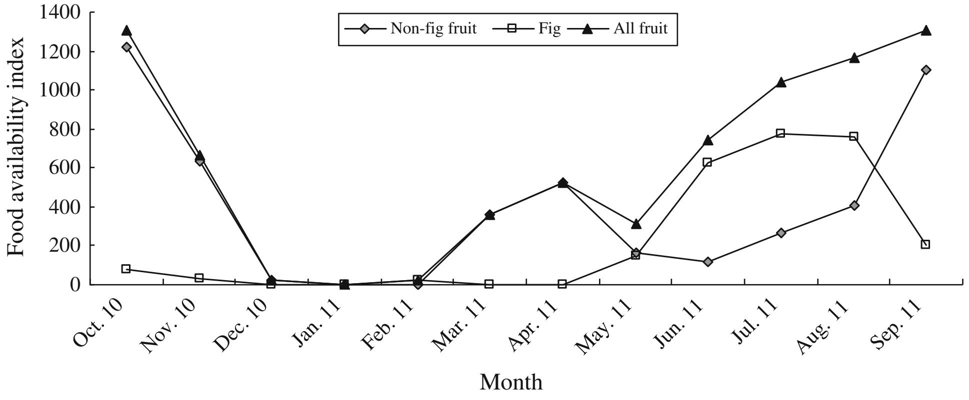

Fig. 2 Nonfig fruit and fig availability between October 2010 and September 2011 in Nankang, Gaoligongshan

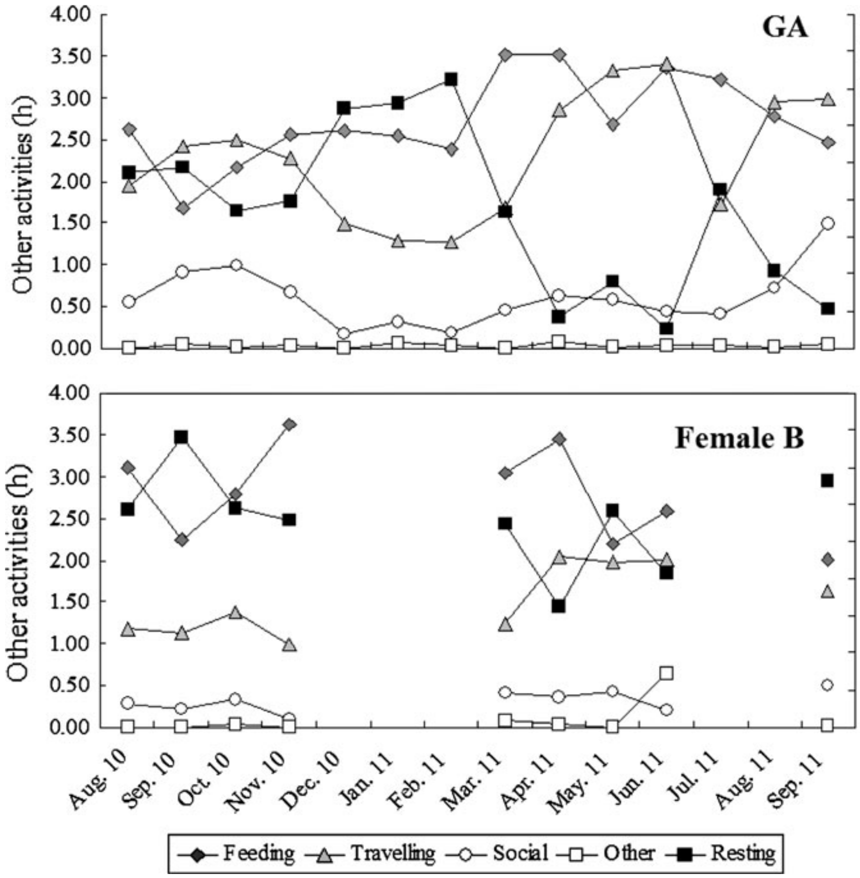

Fig. 3 Monthly time budget of GA and female B between August 2010 and September 2011 in Nankang

$t = 3.919, P = 0.003$) when mean monthly temperature was low. Members of GA allocated more time to social behaviors when they spent more time in searching for insects and mean monthly temperature was high ($F = 42.972, r_{\text{insects}} = 0.795, t = 6.882, P < 0.001; r_{\text{temperature}} = 0.273, t = 2.366, P = 0.042$). They spent more time feeding when they ate more leaves ($F = 5.580, r_{\text{leaves}} = 0.598, t = 2.362, P = 0.040$).

Overall diet

In total, 6,614 (GA: 5,384; B: 1,230) feeding records were made during the study period; 93 % records (5,005) were identified to species level for GA and 90.5 % (1,113) for female B. Combining the feeding records, the gibbons were observed to consume items from 66 plant species and several animal species, including cicadas, lepidopterous larvae, and bird chicks (Table 2 in Appendix 1). We observed that members of GA ate soil in five cases. Consumed items came from 34 species of trees, 20 species of lianas, 9 angiosperm epiphytes, 2 shrubs, and 1 bamboo species. We were able to identify all but 4 of the food plants to species level (Table 2 in Appendix 1). The top-ten consumed plant species accounted for 67.2 % of GA feeding records and 63.3 % of female B feeding records (Table 2 in Appendix 1).

GA's diet comprised 49.1 % fruit (nonfig fruit 35.6 %, fig 13.5 %), 43.3 % leaves (buds, young leaves, and mature leaves), 5.3 % invertebrates and bird chicks, 1.8 % flowers, and 0.6 % others. Female B spent somewhat more time feeding on fruit (nonfig fruit 40.1 %, fig 16.2 %) and invertebrates (10.7 %), and less time on leaves (30.4 %).

Seasonal variation of feeding behavior

Both GA and B showed obvious seasonal variation in feeding behavior (Fig. 4). They spent more time in searching for insects (GA: $F = 34.4792, r_{\text{fruit}} = 0.880, t = 5.872, P < 0.001$; B: $F = 9.341, r_{\text{fruit}} = 0.807, t = 3.056, P = 0.028$) and less time feeding on leaves (GA: $F = -12.512, r_{\text{fruit}} = -0.746, t = -3.537, P = -0.005$; B: $F = 10.755, r_{\text{fruit}} = -0.826, t = 3.280, P = 0.022$) when nonfig fruit was more available. Feeding time on leaves was negatively correlated with feeding time on insects, but the P value was only marginally significant for female B (Spearman correlation: GA: $r = -0.771, P = -0.001$; B: $r = -0.650, P = -0.058$). GA ate more figs when they were more available ($F = 10.802$,

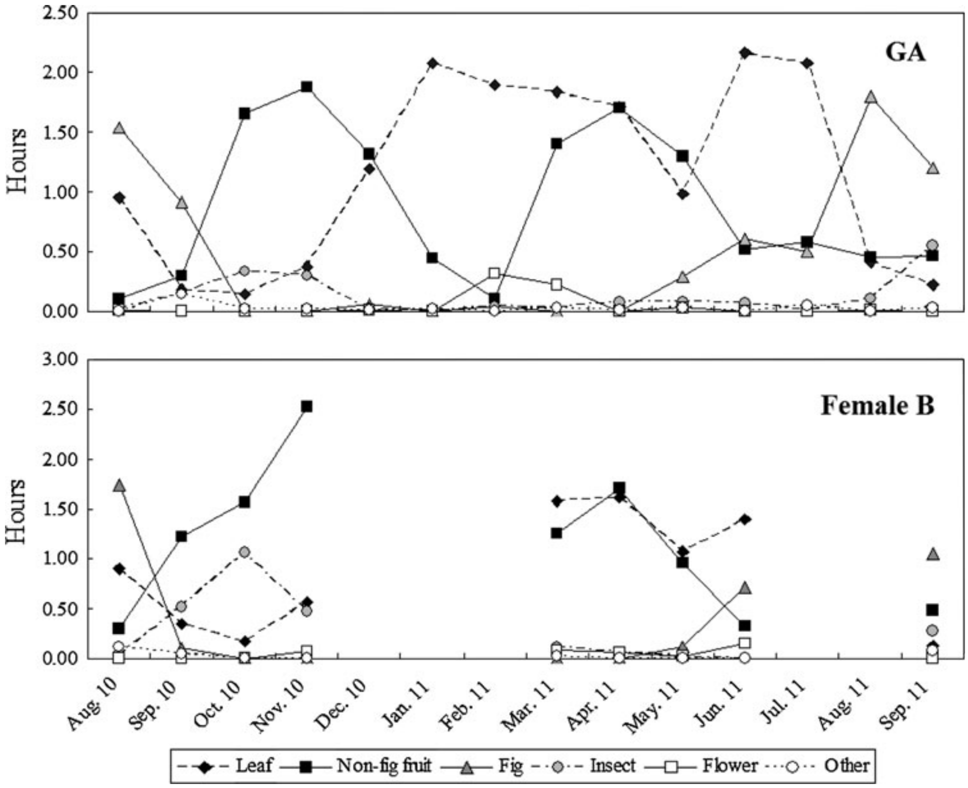

Fig. 4 Seasonal variation of feeding time allocated to different food types by GA and female B between August 2010 and September 2011 in Nankang

$r_{\text{fig}} = 0.721$, $t = 3.287$, $P = 0.008$). Surprisingly, both GA and B did not spend more time feeding on nonfig fruits when they were more abundant.

Discussion

We report on the feeding behavior of hoolock gibbons living in cold northern montane forest. The annual mean temperature was 13.3 °C and the monthly mean temperature was <10 °C between December and February in Nankang. The forest was covered by snow on two days in January 2011. Nankang is the coldest gibbon habitat ever reported and approximately as cold as the habitat of *Rhinopithecus bieti* (27°34′N; 2,448 m a.s.l.; annual mean temperature 14.3 °C), measured 800 m below the most frequently used altitude of the study group (Grueter et al. 2009). In this cold habitat, temperature was the most important factor influencing the gibbons' behavior budget. GA decreased time in traveling and social activities while increasing resting time when it was cold. Compared with *N. nasutus* (Fan et al. 2012) and *Hylobates lar* (Bartlett 2009), hoolock gibbons in this study did not increase the average amount of active time (*N. nasutus* 10.4 h, *H. lar* 8.7 h, present study 9.1 h) or feeding time (*N. nasutus* 2.48 h, *H. lar* 2.84 h, by multiplying the active time and proportional time budget; present study 2.81 h) to search for more food in the cold montane forest. These results indicate that hoolock gibbons adopt an energy-conserving strategy in montane habitat at high latitude.

Hoolock gibbons in our study spent proportionally less time feeding on figs and other fruit than other gibbon populations except for *N. concolor*, which also lives in montane forest (Fan et al. 2009), and *S. syndactylus* (reviewed in Bartlett 2007). This was mainly caused by the unavailability of nonfig fruit and figs during the coldest months (e.g., December to February, Fig. 1). Thirty-six species of plants provided nonfig fruits or figs to hoolock gibbons in Nankang (Table 2 in Appendix 1), which is in the lower range of that recorded for other gibbon species for which data were collected during a similar period (*N. concolor* 38, Fan et al. 2009; *H. lar* >39, Bartlett 2009; *H. agilis* 49, Gittins 1982; *N. nasutus* 50, Fan et al. 2011b; *N. leucogenys* 52, Hu et al. 1990; *H. klossii* 53, Whitten 1982; *H. muelleri* × *agilis* >167, McConkey et al. 2002). The nut of *Castanopsis hystrix* was among the top-ten most consumed species for both GA and female B. Except *N. leucogenys* in Xishuangbanna, China (Hu et al. 1990), no other studies have reported gibbons consuming nuts of family Fagaceae, even in the *N. concolor* habitat on Wuliang Mountain which was dominated by Fagaceae (Fan et al. 2009).

In our study we did not find a significant correlation between feeding time on nonfig fruits and their production.

This pattern was also reported by McConkey et al. (2003) and Lappan (2009), but was contrary to other gibbon studies (Bartlett 2009; Fan et al. 2012). Compared with leaves, fruits have a low content of indigestible fiber and high content of free sugars, which individuals can absorb directly and convert into energy (Raemaekers 1978). Hoolock gibbons might not need to increase feeding time when they eat nutritionally high-quality nonfig fruit. Furthermore, gibbons did not use all fruits equally (McConkey et al. 2002; Fan et al. 2011b). Therefore, it is likely to be the availability of specific fruits, rather than overall fruit availability, that influences feeding time on nonfig fruit.

Relative to their abundance, gibbons ate more *Ficus neriifolia* and less *Ficus sarmentosa* and *Ficus auriculata* (Table 2 in Appendix 1). Whenever figs of *Ficus neriifolia* ripened, gibbons fed on this single species heavily. Therefore, feeding time on figs was highly correlated with fig production.

When fruit was not available, hoolock gibbons shifted to a diet mainly of leaves and increased feeding time. Leaf feeding time was negatively correlated with fruit availability, which suggests that leaves are fallback foods, defined as foods whose use is negatively correlated with the availability of preferred food (Altmann 1998; Grueter et al. 2009). Hoolock gibbons consumed leaves from 42 species (Table 2 in Appendix 1), half of them (21) vines or epiphyte species which produced new leaves year-round.

Hoolock gibbons spent more time in searching for and feeding on insects when fruit was more available, and feeding time on insects was negatively correlated with feeding time on leaves. Insect feeding has been widely reported in different gibbon populations as an alternative source of protein (Bartlett 2007; Fan et al. 2012).

Four dominant families, Lauraceae, Fagaceae, Theaceae, and Magnoliceae, provided <10 % of food to hoolock gibbons in Nankang. The top-ten consumed species accounted for >60 % of the annual diet, and only one species (*Castanopsis hystrix*) belongs to these four dominant families, which suggests that gibbons relied on somewhat uncommon species in Nankang. In this harsh, marginal habitat, hoolock gibbons would face serious food shortage if the top-ten consumed species were destroyed. Forest degradation caused by cardamom plantation has been thought to be a major reason for gibbon population decline in recent history in Nankang (Fan et al. 2011a). Food shortage in winter between December and February might have caused the disappearance/death of the young juvenile of GA in March 2008.

In summary, temperature is the most important factor influencing the hoolock gibbon's time budget in this cold montane forest. Hoolock gibbons increased resting and decreased traveling in cold months. They consumed diverse food species and shifted to a diet mainly of leaves when fruits were not available. We conclude that diet flexibility and an energy-conserving strategy during the cold season when fruit is scarce have enabled the hoolock gibbons to survive in a northern montane forest. However, our study concerned only a small population living in a degraded forest; further studies are needed in more intact habitat.

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Appendix 1

See Table 2.

Table 2 Food species consumed by hoolock gibbons in Nankang, Gaoligongshan

Family	Species	Lifeform	Part(s) eaten	% of total records		Month(s) consumed
				A (5,384 records)	B (1,230 records)	
Actinidiaceae	*Saurauia polyneura*	T	L	1.1	0.1	Apr. to Aug.
Apocynaceae	*Melodinus khasianus*	V	Fr, L	0.1	0.3	Dec., Apr., May, and Sep.
Aquifoliaceae	*Ilex venulosa*	T	L	0.6		Jan.
Araceae	***Rhaphidophora decursiva***	V	Fr, L	**4.9**	**7.6**	Year-round
Araliaceae	*Trevesia palmata*	T	L	0.1		Jun.
Araliaceae	***Schefflera minutistellata***	T	Fr, L	**5.9**	**6.2**	Aug. to May
Berberidaceae	*Mahonia oiwakensis*	S	L	0.0		May and Jun.
Betulaceae	*Betula alnoides*	T	L	0.4		Mar.
Cucurbitaceae	*Zehneria maysorensis*	V	Fr, L	0.9	0.6	Jan. to Aug.
Elaeocarpaceae	*Elaeocarpus japonicus*	T	Fr, L	0.5	1.0	Oct. to Dec.
Elaeocarpaceae	*Elaeocarpus boreali*	T	Fr, L	0.5	1.1	May to Dec.
Elaeocarpaceae	***Elaeocarpus duclouxii***	T	Fr		**1.6**	Oct., Nov., and Apr.
Ericaceae	*Vaccinium duclouxii*	T	Fr, Fl	0.7	1.0	Feb., Mar., Aug., and Sep.
Ericaceae	*Rhododendron delavayi*	T	Fl, L	0.1	0.8	Feb. and Jun.
Ericaceae	*Rhododendron taronense*	E	Fl	0.1	0.2	Apr., May, and Aug.
Fagaceae	*Lithocarpus petelotii*	T	L	0.9	0.2	Apr.
Fagaceae	***Castanopsis hystrix***	T	Fr	**2.0**	**1.5**	Sep. to Dec.
Gesneriaceae	*Lysionotus wilsonii*	E	L	0.4	0.1	Aug., Sep., and Nov.
Gesneriaceae	*Aeschynanthus acuminatus*	E	Fl, L	0.1		Aug. and Sep.
Gramineae	*Fargesia contracta*	B	L	0.0		Aug.
Juglandaceae	*Engelhardtia spicata*	T	L	0.3	0.2	Nov. to May
Lardizabalaceae	*Holboellia latifolia*	V	Fr	0.1		Nov.
Lauraceae	*Neolitsea lunglingensis*	T	Fr	0.1	0.4	Oct. and Nov.
Lauraceae	*Litsea chinpingensis*	T	Fr		0.7	Nov. and Dec.
Lauraceae	*Litsea euosma*	T	Fr	0.1	1.4	Nov. and Dec.
Lauraceae	***Lindera foveolata***	T	Fl, L	**3.7**	0.4	Nov. to Jul.
Liliaceae	*Smilax lunglingensis*	V	Fr, L	0.4	0.4	Aug to Dec. and Mar. to May
Loranthaceae	***Scurrula philippensis***	E	Fr	**1.9**	1.1	Dec., Mar., Apr., Jun., and Sep.
Magnoliaceae	*Michelia floribunda*	T	L	0.0		Nov.
Magnoliaceae	*Alcimandra cathcartii*	T	L	0.0		Jul.
Menispermaceae	*Cyclea polypetala*	V	L	0.5	0.4	Aug., Nov., Dec., and Apr.
Menispermaceae	*Stephania japonica*	V	L	0.1		Jan.
Moraceae	***Ficus neriifolia***	T	Fr, L	**20.0**	**15.7**	Year-round except Oct., Nov., and Jan.
Moraceae	*Ficus sarmentosa*	S/E	Fr	0.4	0.3	Dec., Apr., May, and Sep.
Moraceae	*Ficus auriculata*	T	Fr		0.1	May
Myrsinaceae	***Embelia procumbens***	V	Fr, L	**10.7**	**8.8**	Year-round
Myrsinaceae	***Embelia floribunda***	V	Fr, L	**2.7**	1.2	Oct. to Mar.
Myrsinaceae	*Myrsine semiserrata*	T	Fr		0.4	Mar.
Nyssaceae	***Nyssa javanica***	T	Fr, L	**6.5**	**9.4**	Year-round
Orchidaceae	*Bulbophyllum striatum*	E	L	0.0		Aug. and Jan.
Orchidaceae	***Otochilus porrectus***	E	L	0.6	**2.0**	Jun. to Dec.
Polygonaceae	*Polygonum chinense*	V	L	0.3		Nov., Apr., and Sep.
Polypodiaceae	*Arthromeris lehmanni*	E	L	0.0		Aug.
Polypodiaceae	*Lepidogrammitis rostrata*	E	L	0.9		Jun. and Jul.
Rosaceae	*Sorbus ferruginea*	T/E	Fr		0.6	Sep. and Nov.
Rosaceae	*Rubus xanthoneurus*	V	Fr	0.4	0.1	Aug.
Rosaceae	*Cerasus trichostoma*	T	Fr	1.1		Oct. and May
Rosaceae	*Rosa soulieana*	V	Fr	0.2		Dec.

Table 2 continued

Family	Species	Lifeform	Part(s) eaten	% of total records		Month(s) consumed
				A (5,384 records)	B (1,230 records)	
Rubiaceae	*Aidia cochinchinensis*	T	Fr	1.6		Apr. to Jun.
Rutaceae	*Zanthoxylum scandens*	V	L	0.3		Jun.
Rutaceae	*Evodia fargesii*	T	L	0.2		Nov. and Apr.
Rutaceae	*Toddalia asiatica*	V	Fr, L	0.7	0.4	Sep. to Jan.
Schisandraceae	*Schisandra micrantha*	V	L	1.1		May and Jun.
Schisandraceae	*Schisandra propinqua*	V	Fr	0.2		Oct. to Dec.
Staphyleaceae	*Turpinia macrosperma*	T	Fr	1.1	0.2	Oct., Nov., Apr., and Aug.
Sterculiaceae	*Sterculia principis*	T	L	0.8		May and Jun.
Sterculiaceae	*Sterculia euosma*	T	L	0.2		May
Styracaceae	*Parastyrax lacei*	T	Fr	0.0	0.2	Nov.
Theaceae	*Schima khasiana*	T	L	0.3		Mar. and Jun.
Theaceae	***Eurya pseudocerasifera***	T	Fr, L	0.5	**1.8**	Oct. to Mar.
Vitaceae	***Cayratia japonica***	V	Fr, L	**8.9**	**8.7**	Jul. to Jan.
Vitaceae	*Tetrastigma delavayi*	V	L	0.1		Feb.
	Unidentified 1	E	L	0.1	0.4	Jul. and Sep.
	Unidentified 2	T	Fr	0.4	0.9	Oct. and Nov.
	Unidentified 3	V	Fr	0.1	0.2	Sep.
	Unidentified 4	V	Fr	0.1	0.1	May and Sep.
	Invertebrates			5.5	10.7	Year-round
	Soil			0.1		Oct. and Apr.
	Bird chick			0.0		May

Species in bold face were top-ten consumed food species

Appendix 2

See Table 3.

Table 3 Observation time and feeding records for 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
10-Aug	12	87	805	1,873	8	70	669	669
10-Sep	6	63	619	1,600	13	67	567	567
10-Oct	7	59	603	1,429	8	57	512	512
10-Nov	8	71	701	1,791	6	42	390	390
10-Dec	7	55	514	1,182	4	18	150	150
11-Jan	7	57	495	1,055	1	5	34	34
11-Feb	4	33	290	579	2	8	71	71
11-Mar	7	47	433	1,008	7	47	472	472
11-Apr	6	59	635	1,276	6	34	313	313
11-May	6	56	590	1,253	8	38	358	358
11-Jun	6	55	572	1,068	5	28	268	268
11-Jul	8	52	489	954	1	2	15	15
11-Aug	9	71	693	1,489	2	2	13	13
11-Sep	10	88	846	1,935	8	46	406	406
Total	103	853	8,285	18,492	79	464	4,238	4,238

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