Primate Conservation 2017 (31): 107-113

Population, Distribution, Vocalization and Conservation of the Gaoligong Hoolock Gibbon (*Hoolock tianxing*) in the Tengchong Section of the Gaoligongshan National Nature Reserve, China

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Abstract: We conducted surveys to estimate the current population and distribution of the recently described Gaoligong hoolock gibbon (*Hoolock tianxing*) in Yunnan Gaoligongshan National Nature Reserve Tengchong Bureau (TC-GLGS). The reserve supports the northernmost known population of the species in China. A total of 17–20 gibbons in 6–7 family groups were recorded in TC-GLGS in a population census conducted in 2016. The mean group size was 2.8–2.9 individuals (range 2–4) with a population density of 0.18–0.21 groups/km^2. All groups contained a single adult pair, and juveniles and/or infants were observed in all but two. Mean dawn time was 07:26 h during the survey, and vocalizations were concentrated in the first hour after dawn (57.9% of total song bouts), with an average song bout duration of 25.7 min (n = 19). Four other primate species occurred in sympatry with the gibbons in the study area, with *Macaca arctoides* and *M. assamensis* being the most abundant. TC-GLGS appears to support the single largest subpopulation of *H. tianxing* in China, but the population density was very low, despite the presence of large areas of healthy, closed-canopy forest, suggesting that the population may have been well below carrying capacity. The suppressed population size is a combined result of rampant hunting in the past, loss of lower elevation forest, and ongoing disturbance by cattle grazing in the remaining gibbon habitat. Long-term conservation challenges facing the Gaoligong hoolock gibbon in China include the prevention of poaching and disturbance, restoration of deforested areas <2,000 m asl, and the establishment of biological corridors between forest fragments. Translocation to areas contiguous with larger subpopulations should be considered for single groups in isolated forest fragments.

Key words: Skywalker gibbon, population surveys, group, density, Yunnan

Introduction

The hoolock gibbons, genus *Hoolock*, are restricted to moist broad-leaved forests of the Eastern Himalaya, and are the northernmost of the four extant gibbon genera (*Hoolock*, *Hylobates*, *Nomascus*, and *Symphalangus*) (Chivers 2013). Since the majority of hoolock gibbon populations occur in remote and often inaccessible mountain ranges, their taxonomy, distribution and status are not clearly known (Geissmann *et al*. 2013; Fan *et al.* 2017). At the end of 2016, there were two widely-accepted species, namely the western hoolock gibbon *(Hoolock hoolock*) and the eastern hoolock gibbon (*H. leuconedys*), with the Chindwin tributary of the Irrawaddy in Myanmar delimiting their ranges (Geissmann *et al*. 2013; Fan *et al*. 2017). A population of the eastern hoolock gibbon living between Myanmar's Nmai Hka tributary of the Irrawaddy and the Salween (Nujiang in Chinese) of China's Yunnan Province was recently described as a new species: *Hoolock tianxing* Fan *et al*., 2017, the Gaoligong hoolock gibbon or Skywalker hoolock gibbon. The authors proposed that it should be categorized as Endangered under the IUCN Red List criteria.

A number of behavioral and ecological studies have been conducted on *H. tianxing* in Yunnan; they include calling (Lan *et al.* 1999; Zhang *et al*. 2011; Yin *et al.* 2016), ranging behaviour (for example, Zhang *et al*. 2013; Yuan *et al.* 2014), diet and activity budget (Fan *et al.* 2013), and habitat use (for example, Bai *et al*. 2011). The distribution and status of *H. tianxing* in Gaoligongshan and China have been summarized by Lan *et al.* (1995), Zhang *et al*. (2007) and Fan *et al.* (2011).

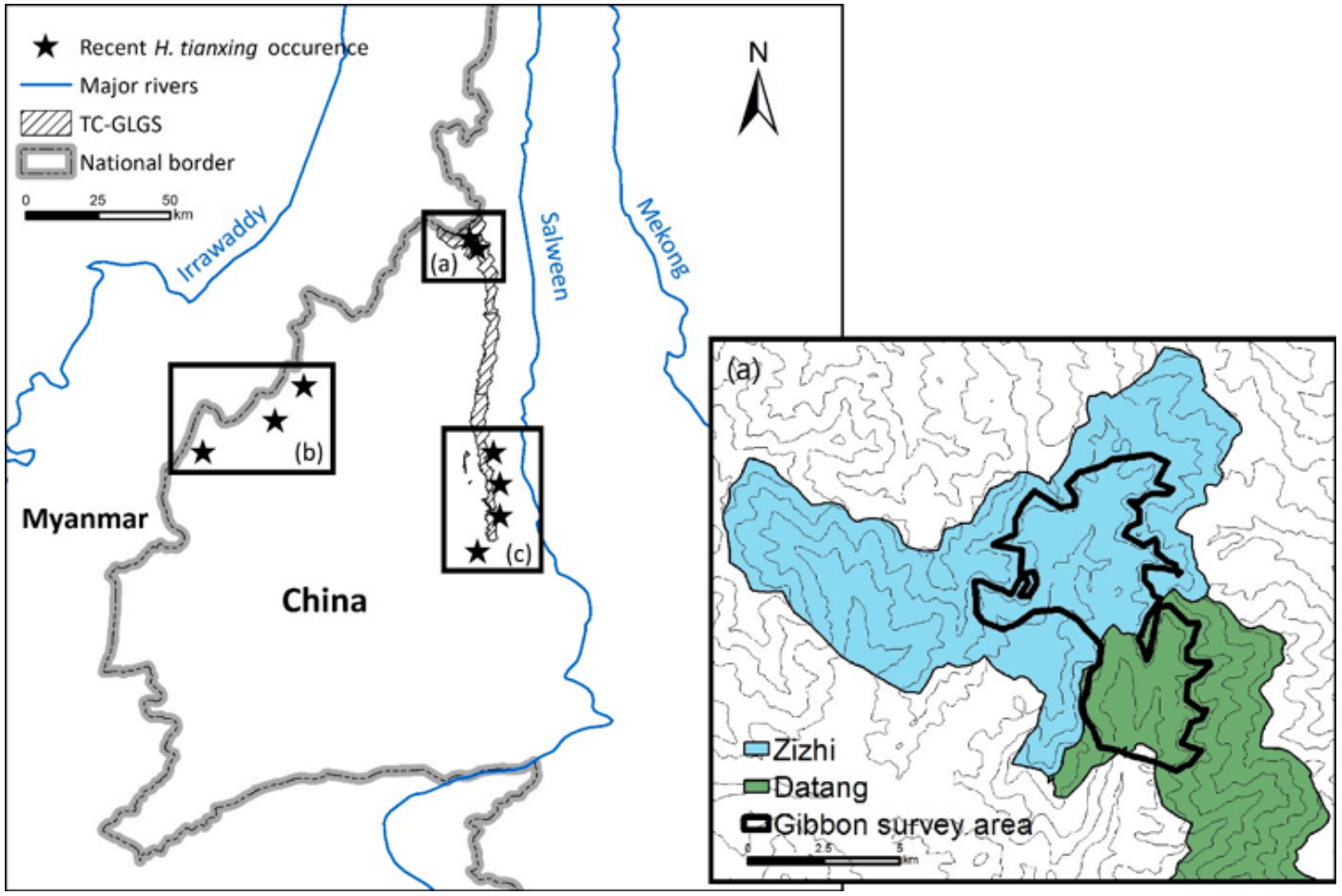

Figure 1. Geographic location and the gibbon survey area of Yunnan Gaoligongshan National Nature Reserve Tengchong Bureau (TC-GLGS), and the current distribution of *Hoolock tianxing* in China in three major clusters.

Figure 2. Adult male *Hoolock tianxing* of DT-A group, taken on 24 November 2016 during the gibbon population census. Photo by Chi Fung Mak.

The latest survey was that of Fan *et al.* (2011) in 2008–2009. They estimated less than 200 individuals in no more than 43 groups in 17 isolated locations, with the biggest subpopulation containing only five groups. Some of these groups live outside protected areas and are threatened by poaching and habitat loss, and most are not regularly monitored (Fan 2016). Although the largest population of eastern hoolock gibbon *sensu lato* is in Myanmar, there is still a lack of reliable and up-to-date information on their distribution and population sizes there (Geissmann *et al.* 2013). *Hoolock tianxing* occurs east of the Nmai Hka River, and its geographic range and conservation status in Myanmar is unknown (Fan *et al*. 2017). More robust data on the sizes and conservation status of the different subpopulations of *H. tianxing* are needed to guide conservation efforts on its behalf.

The Hong Kong-based NGO Kadoorie Farm & Botanic Garden (KFBG) has been collaborating with the Gaoligongshan National Nature Reserve Tengchong Bureau (TC-GLGS) on biodiversity surveys and conservation initiatives since 2014. In 2016, we launched a project to protect and study the resident gibbon population, and organized a gibbon population census in order to clarify the current population size, distribution and status of *H. tianxing*. The TC-GLGS gibbon population is of particular interest to enhance our understanding of the species as it is the northernmost subpopulation of the species in China, and comparative historical data are available, creating an opportunity to examine the population trend of the species there. Here we report on the results of our survey.

Methods

Study area

Gaoligongshan, a rugged, north-south running mountain range in southwestern Yunnan, stretches about 600 km from the Tibetan Plateau to Myanmar. It is the watershed of the Salween and Irrawaddy basins in China, and the southwest monsoon from the Indian Ocean brings plentiful rainfall to this low-latitude, high-altitude massif, making it a hotspot for biological discovery (Yang *et al*. 2016; Fan *et al*. 2017). Chaplin (2005) considered it to be "one of the world's most significant biodiversity hotspots outside of the tropics", and provided detailed analysis of its geography in relation to its rich and unique biodiversity. The administration of the Gaoligongshan National Nature Reserve (405,500 ha) is divided into four management sections under three distinct administrative bureaus. *Hoolock tianxing* is restricted to the southern portion (81,443 ha) that is managed by the Baoshan Administrative Bureau. The Baoshan Administrative Bureau manages TC-GLGS that covers 42,418 ha of the western slope of Gaoligongshan, and 90% of TC-GLGS is under well-preserved forest cover. The highest peak in TC-GLGS reaches 3780 m asl, but the elevation drops abruptly to 1800 m in the river valley. Elevational vegetation zonation is well-defined. From the summit to the river valley, one can find sub-alpine bamboo-rhododendron dwarf forest interspersed with mixed coniferous forest at 2700–3200 m, humid evergreen broad-leaved forest at 1800–2800 m, and monsoon humid evergreen broad-leaved forest below 1800 m. Old-growth forest outside the reserve below about 2000 m has, however, been cleared over generations of human settlement, and gibbons are restricted to the lower belt of the protected humid evergreen broad-leaved forest. The tree canopy there averages 25 m.

The survey area was in the northern portion of TC-GLGS, directly adjoining Myanmar's Kachin State. It was divided into two management units; namely Zizhi on the west and Datang on the east (Fig. 1). The forest of Datang and Zizhi is well-protected and contiguous, so the gibbons can be considered as a single population. The gibbon population of TC-GLGS declined dramatically during the 1990s, and they appear to have been extirpated from the southern portion of the reserve (Fan *et al*. 2011). Fan *et al*. (2011) reported 3–4 groups in Datang and two groups in Zizhi in 2009, but were unable to provide detailed population numbers. Since the upper altitudinal limit of *H. tianxing* is 2600 m, we focused our survey effort between 2100 and 2600 m asl. The forest there was old-growth humid evergreen broad-leaved forest dominated by Fagaceae, Lauraceae and Theaceae.

Gibbon survey

We have been monitoring the gibbon groups in the Zizhi and Datang survey areas (Fig. 1) every month since April 2016. We selected and trained 10 reserve wardens to form a gibbon monitoring team. They spent the first few months exploring the forest and familiarizing themselves with the gibbons' ranging patterns. We visited the reserve several times to train the wardens and determine the best listening posts for the population censuses.

A full gibbon population census was conducted from 23 to 27 November 2016. Forty-six people participated. All received training in identifying gibbons and their calls, and in the use of standardized record sheets provided prior to the survey. Most teams had at least one member with experience in surveying wild gibbons. We followed the survey method of Fan *et al*. (2011) that is otherwise widely used in hoolock gibbon surveys (Brockelman *et al*. 2009; Geissmann *et al*. 2013). There were 22 listening posts on hilltops and ridges, each separated by at least 450 m. The time, type, and duration of all gibbon vocalizations were recorded from pre-dawn (i.e. *c*. 07:00 h) to 12:00 h on four consecutive mornings (24–27 November). When gibbons were close to the listening posts, the team would track and directly observe the gibbons to record group size and composition. One team member would remain to continue obtaining vocalization data. All teams also conducted biodiversity fieldwork each afternoon in the gibbon forest during the survey period, our survey therefore covered the full active hours of gibbons. Minimum population size and density were estimated by triangulation of the vocalization data and confirmed with direct observation (Brockelman and Ali 1987; Brockelman and Srikosamatara

Table 1. Observation records of *Hoolock tianxing* during the present survey, Yunnan Gaoligongshan National Nature Reserve Tengchong Bureau, China. Group composition: AM = Adult male; AF = Adult female; SJ =Subadult/juvenile; IN = Infant. Coordinates were recorded using hand-held GPS.

Date 2016	Time and duration	Distance between observers and gibbons	Group composition (number of individuals)	Coordinates
24 November	08:05–08:13	40 m	AM (1)	25°45’03.49”N 98°42’05.98”E
24 November	09:36–09:54	300 m	AM (1)	25°47’51.65”N 98°41’41.31”E
25 November	9:37	30 m	AM (1), AF (1)	25°48’12.22”N 98°40’07.66”E
25 November	10:14–10:23	30 m	AM (1)	25°45’03.49”N 98°42’05.98”E
26 November	08:39–09:28	480 m	AM (1), AF (1)	25°47’28.67”N 98°40’56.30”E
26 November	08:41–09:28	500 m	AM (1), AF (1), SJ (1)	25°47’28.67”N 98°40’56.30”E
26 November	10:15–10:34	15 m	AM (1), AF (1), SJ (2)	25°45’92.05”N 98°41’27.18”E
26 November	08:21–08:55	200 m	AM (1), AF (1), SJ (1)	25°44’13.68”N 98°42’04.04”E

Table 2. Group composition of *Hoolock tianxing* recorded in the present survey, Yunnan Gaoligongshan National Nature Reserve Tengchong Bureau, China. * = group could be a double-count of DT-B and result is preliminary.

Group	Group composition				Total
	Adult male	Adult female	Subadult/ Juvenile	Infant	
DT-A	1	1	1	0	3
DT-B	1	1	1	0	3
DT-C	1	1	1	0	3
ZZ-A	1	1	0	0	2
ZZ-B	1	1	2	0	4
ZZ-C*	1	1	1	0	3
ZZ-D	1	1	0	0	2
Total	6–7	6–7	5–6	0	17–20

1993). The area covered by our survey was 3,320 ha, covering the potential gibbon habitat between 2100 and 2600 m (Fig. 1).

Results

The weather was sunny but cold during the survey period, with night time temperatures dropping below freezing. Gibbons were observed directly on eight occasions, the earliest contact time was 08:05 h on 24 November, and the latest was 10:15 h on 26 November (Fig. 2). We observed the gibbons from as close as 15 m on 26 November, but had no direct contact with gibbons on 27 November (Table 1).

Vocalizations

During the survey, mean dawn time was 07:26 h. *Hoolock tianxing* duet, and a total of 19 song bouts were heard. The gibbon groups produced morning song bouts on all four days of the survey. Calls were most frequently heard within the first hour after dawn (57.9% of total song bouts), and we recorded 73.7% of all song bouts within 1.5 h after dawn. The earliest song bout started at 07:44 h on 25 November, and the latest one at 10:15 h on 26 November (Fig. 3). Average song bout duration was 25.7 min (n = 19), and varied from 4 min (between 08:08–08:12 on 26 November) to an exceptionally extended bout of 63 min (between 08:20–09:23 on 26 November). One of the gibbon groups called up to 3 times a day (24 and 26 November, respectively).

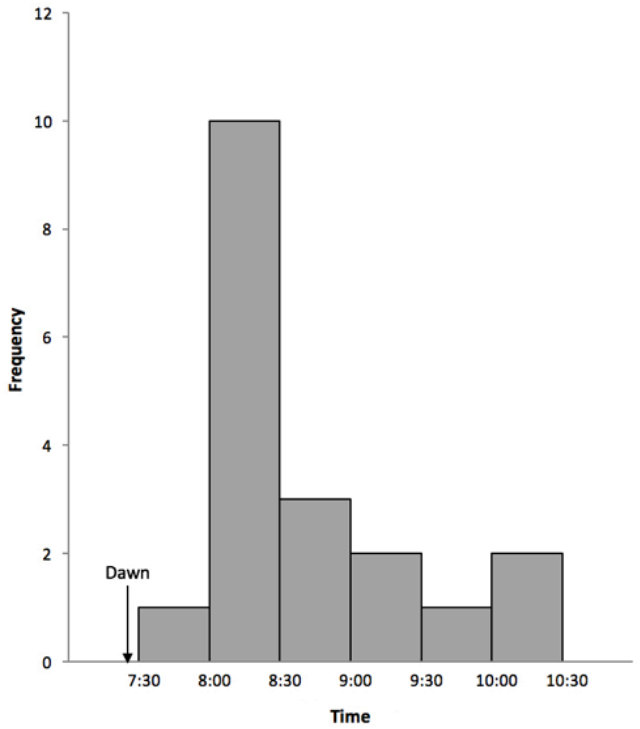

Figure 3. Frequency distribution of the onset of vocalization for *Hoolock tianxing*, Yunnan Gaoligongshan National Nature Reserve Tengchong Bureau, China. N = 19 song bouts.

Population and group size

Based on locations of observation and vocalization, timing of song bouts, and group composition observed, we confirmed there were 6–7 gibbon groups with a total of 17–20 gibbons in TC-GLGS, including three or four groups of three individuals, two groups of two individuals, and one group of four individuals. The mean group size was 2.8–2.9 with a population density of 0.18–0.21 groups/km^2. Three of the groups live in the Datang unit (groups prefixed with "DT-") and the other three groups in the Zizhi unit (groups prefixed with "ZZ-"). All groups observed were socially monogamous, with four of the six groups having immatures (Table 2). A fourth gibbon group, consisting of a breeding pair and a juvenile, was detected in the Zizhi unit on 25 November, close to the home range of DT-B which had the same group composition; unfortunately, DT-B was not detected on the same date. Subsequent regular monitoring also detected the same gibbon group in Zizhi, but never in the same time span when DT-B was detected, and therefore we cannot discount the possibility that DT-B either shifted its home range or has a particularly large home range.

Sympatric primates

The primate community sympatric with *H. tianxing* has rarely been reported. Four other primates—*Macaca arctoides*, *M. assamensis*, *M. mulatta*, and *Trachypithecus phayrei*—were identified on camera traps or recorded during casual encounters in the survey area. *Trachypithecus phayrei* was the rarest amongst the four, and has probably been extirpated in the Datang unit. *Macaca arctoides* and *M. assamensis* are widespread and common. *Macaca mulatta* largely occurs at lower elevations, and is more frequently encountered in rocky forest near human habitation.

Discussion

As far as we are aware, our population census was the most intensive field survey ever conducted for *H. tianxing*. We recorded 17–20 individuals in 6–7 family groups of *H. tianxing* in TC-GLGS. Comparing our findings with those of Fan *et al.* (2011), the Datang population remained stable, while the population in Zizhi increased. The population of *H. tianxing* in TC-GLGS is of particular research and conservation importance because it is both the northernmost (up to c. 25°48'13"N), and the largest subpopulation known in China (see Fan *et al.* 2011).

The mean group size in TC-GLGS was 2.8–2.9 individuals (range 2–4), which is lower than the national estimate of 3.9 reported by Fan *et al*. (2011). Average group sizes for eastern hoolock gibbon *sensu lato* in Myanmar is 2.4 (Geissmann *et al*. 2013). The population density in TC-GLGS was 0.18–0.21 groups/km^2, which is substantially lower than values reported for the Gaoligong hoolock gibbon from the eastern slopes of Gaoligongshan (0.5 groups/km^2; Yin *et al*. 2016) or eastern hoolock gibbon *sensu lato* in Myanmar (>1 to 2.3 groups/km^2; Geissmann *et al*. 2013). The average gibbon