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Two Endemic Primates' Species in China: Hainan Gibbon and Guizhou Snub-Nosed Monkey

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Abstract

Hainan gibbon (*Nomascus hainanus*) is the most threatened species of gibbon, the endemic primates of China. Currently, there were only 4 groups no more than 30 individuals left, which is only distributed in a 16 km² area (H: 800–1280 m) of Bawangling National Nature Reserve of Hainan island in China. The social structure of the Hainan gibbon is polygynous, with one adult male pairing with two adult females. Hainan gibbon research has always been one of the hot spots of primate research, mainly concentrated in ecology, behavior, and genetic research. Here, we mainly reported the classification, historical population changes, community structure, dietary, reproductive and song behavior of Hainan gibbon. We also reported the other unique primate of China: Guizhou snub-nosed monkey.

Keywords: primate, species, China, Hainan gibbon, Guizhou snub-nosed monkey classification

1. Introduction

Hainan gibbon (*Nomascus hainanus*) is the most threatened species of gibbon, the endemic primates of China. Currently, there were only 4 groups no more than 30 individuals left, which is only distributed in a 16 km² area (H: 800–1280 m) of Bawangling National Nature Reserve of Hainan island in China [1]. The social structure of the Hainan gibbon is polygynous, with one adult male pairing with two adult females [2]. Hainan gibbon research has always been one of the hot spots of primate research, mainly concentrated in ecology, behavior, and genetic research.

Guizhou snub-nosed monkey (*Rhinopithecus brelichi*) belong to the primates, Cercopithecidae, Colobinae, *Rhinopithecus*, is one of the most endangered (En) species and first-class protected animals in China, according to the International Union for the Conservation of Nature and Natural Resources [3]. These monkeys reside only at the Fanjingshan National Nature Reserve (FNNR) in a narrow habitat that can fragment severely under risky survival conditions [4]. Similar to other Chinese snub-nosed monkey species, habitat destruction is a potential threat to the survival of the Guizhou snub-nosed monkey [5, 6], and suitable habitat at low altitudes has come under increased pressure in the FNNR. Due to the development of tourism at both FNNR and Mt Fanjingshan, the habitat of the monkey has become severely disturbed.

We summarized these two primates species research results in recent years as follows.

2. Methodology

2.1 Literature collection

By searching for the historical documents, to understand the Hainan gibbon name origin and classification changes. Hainan gibbon and Guizhou snub-nosed monkey ecological characteristics such as population change, population structure and distribution.

2.2 Wild survey

We have 18 years of wild survey for Hainan gibbon in Bawangling nature reserve since 2002. We also interviewed residents to understand the history of Hainan gibbon distribution and the current status. Hainan gibbon has the characteristics of aloud singing in the morning. So, we can determine the location of Hainan gibbon according to singing and track observation. We used a recorder to record the Hainan gibbons' songs behavior and alarm calls. We also observed the reproductive behavior, feeding behavior and other behaviors. To understand the Hainan gibbon habitat for plants, we set up 85 quadrants (30 × 30 m) of plants according to the elevation gradient at an altitude of 600–1200 m in Bawangling nature reserve.

Guizhou snub-nosed monkey is only distributed in Fanjingshan National Nature Reserve, Guizhou, China. The area of this reserve is 567 km² (27°46'50"–28°1'30"N, 108°45'55"–108°48'30"E). We used telescope to observe the behavior of monkeys, such as feeding behavior, breeding behavior, resting and playing behavior. At the same time, we used GPS to record the location of behavior. We collected the plant specimens of the monkeys feeding for species identification, and record the part of the plant was consumed by the monkeys.

To understand the habitat conditions of Guizhou snub-nosed monkey, we set up 100 botanical plots at different altitude in the Fanjingshan National Nature Reserve. The area of each plot was 500 m². The plant species name and number of the botanical plots were recorded. The species of relative base coverage, relative frequency and relative density were analyzed.

3. Results

3.1 Species description of the two primates

3.1.1 Classification of the Hainan gibbon

Hainan gibbon (*Nomascus hainanus*) (**Figure 1**) is the earliest named for the first time as a new species of *Hylobates hainanus* by Thomas [7] according to a specimen of the Hainan gibbon stored in the British natural history museum. Since then, the classification status of the Hainan gibbon has gone through several changes; first Pocock [8] put it as the *Hylobates nasutus* species; then Delacour [9] argued that the Hainan is supposed to be a subspecies of black gibbons (*H. naustus*) from Tonkin regions, and named *H. concolor hainanus*. But later, researchers found that they are significantly different in shape, color and other characteristics between them; so, the Hainan gibbon is taken as an independent subspecies [10–14]. Chinese scholars

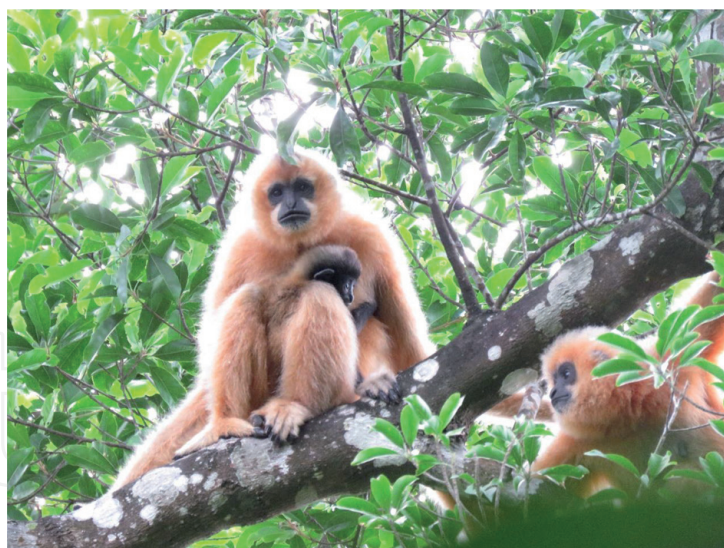


Figure 1.
 The adult female of the Hainan gibbon with infant.

Su Bing et al. [15] by molecular genetic evidence proved the Hainan gibbon and other black gibbons have bigger difference in molecular level , and it should be an independent species. Geissmann [16] classified the Hainan gibbon as Hainan subspecies (*Nomascus sp. cf. Nasutus hainanus*) of East black gibbons, according to the differences in color and singing behavior; after that Brandon-Jones et al. [17] proved Hainan gibbons and East black gibbon are supposed to be two different subspecies by the evidence of molecular biology. Recent research results show the Hainan gibbon is an independent gibbon species based on morphology and singing behavior [18–21].

3.1.2 Morphological features of *Rhinopithecus brelichi*

In 1903, the British biologist Thomas visited Fanjingshan and named the Fanjingshan snub-nosed monkey as Guizhou snub-nosed monkey (*Rhinopithecus brelichi*) (**Figure 2**).

Guizhou snub-nosed monkey is smaller as Sichuan snub-nosed monkey morphologically, but the tail is longer than Sichuan snub-nosed monkey. Body length of Guizhou snub-nosed monkey is 637–690 mm and tail length is 846–905 mm. The



Figure 2.
 Wild Guizhou snub-nosed monkey in Fanjingshan National Nature reserve.

nose of the monkeys is slightly concave downward. The color of face is gray or pale blue. The body of Guizhou snub-nosed monkey is gray in color, with clear white patch between the shoulders. From the shoulders down the upper lateral to the back of hand, the color changes from light gray gradient in brown to black. Under the neck, armpit and upper limb inside are gold, sharing yellowish gray color. Tail base is dark gray, to the end changes to black or yellowish-white, black around the callosity. Juveniles color were pale, perfect silver gray. The tail was dark gray end of yellow-white.

3.2 Historical population of the two primates

3.2.1 Historical population changes in Hainan gibbons

Hainan gibbons were widely distributed in Hainan province until the 1960s. In the early 1950 s, there were still about 2000 individuals of Hainan Gibbons in Hainan Island. In 1978, the Hainan gibbon has narrowed the range of the Baisha County, Qiongzong County and Limushan Mountain, population has dropped to only 450–500 individuals. But by the early 1990s, they were distributed only in Bawangling National Nature Reserve. The other sub-populations were extirpated during a period of logging and hunting between 1960 and 1980. The current population increased from a total of 10 individuals in 2–3 groups in 1978 to 21 individuals in 4 groups in 1988 [2]. The population decreased to 15 in 1993 as a result of hunting [22]. There were only 13 individuals remaining in 2002, including 6 in group A (including 2 infants), 5 in group B (including 1 infant) and 2 solitary individuals. Population changes in recent years is shown in **Figure 3**. The rate of population recovery has increased progressively since then and increasing up to 26 in 2013 [23]. A new family group C is formed in the summer of 2011, later the group D is formed in 2016. As a result of male and female sex ratio, the female is less, so the newly formed group D has only one adult female. An infant was born in group C in 2018, now there were 4 groups of Hainan gibbon and 28 individuals distributed in Bawangling National Nature Reserve.

3.2.2 Historical population and distribution changes of Guizhou snub-nosed monkeys

Quan and Xie [24] first reported that Guizhou snub-nosed monkey population is about 200 individuals, Tan [25] conducted preliminary investigation, and estimated its population to be 300–500. Eudey [26] reported that Guizhou snub-nosed

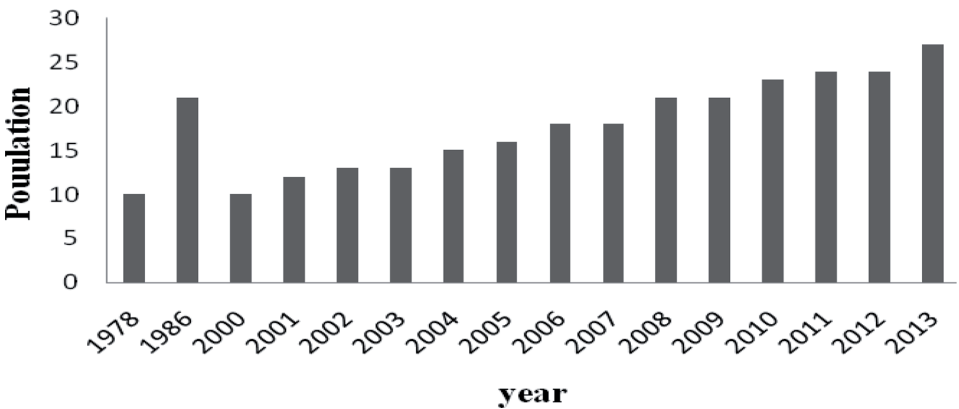


Figure 3.
The changing number of the Hainan gibbon population in the Bawangling natural reserve.

monkeys do not exceed the total number of 500–670. In 1993, the Fanjingshan National Nature Reserve reported that the population of Guizhou snub-nosed monkeys was estimated at 764 individuals [27]. Bleisch [28] reported there are 800 individuals, Quan and Xie [29] think the population is about 500 individuals. Yang et al. [27] identified the wild populations as 750–764 after years of investigation. Then the survey indicates that the population size is approximately 750 monkeys [30]. A recent population survey shows that the Guizhou snub-nosed monkeys is 661–710, belonging to 94 “family groups” [31], almost unchanged from 1993. The *Rhinopithecus brelichi* acts as a group structure, mainly active in four regions in the Fanjingshan National Nature Reserve. Each group consists of 2–10 family groups with the smallest family size consisting of 1 male and 1 female. The common family group consists of 1 adult male and 2–4 adult female individuals, and sub-adult individuals, young individuals and infants. Compared with *R. bieti* and *R. roxellana*, the Guizhou snub-nosed monkeys have a lower diversity of mitochondria DNA, which is vulnerable to environmental changes or climate oscillations [32–34].

However, the range of habitats available to the Guizhou snub-nosed monkey has changed dramatically. In the 1960s, Guizhou snub-nosed monkeys were often observed at an elevation of 500 m [29]. In the 1980s, they were commonly observed at 800 m and above [29]. Studies conducted in 1990s and between 2000 and 2009 showed an elevation range 1400–2100 m [4, 29, 30]. Now they are distributed in the nature reserve with the altitude 900–2180 m [31].

3.2.3 Artificial breeding of Guizhou snub-nosed monkey

In 1992, the state forestry administration approved Fanjingshan national nature reserve captured seven individuals from wild to conduct breeding research in view of Guizhou snub-nosed monkey fewer wild populations, small range of habitats and particularly high extinction coefficient. After 3 years of hard work, the first artificial breeding of Guizhou snub-nosed monkey was born in 1995. In 2005, the scientific research personnel of Fanjingshan national nature reserve administration succeeded in breeding the second generation of Guizhou snub-nosed monkey.

Generally speaking, the wild animals captive breeding reach the second generation and reach a certain amount, the animal's growth is good, it marked the artificial breeding technology is complete maturity. But by the end of 2015, Fanjingshan national nature reserve administration only had five individuals of Guizhou snub-nosed monkey. In 2007, Fanjingshan national nature reserve gave one male and one female captivity Guizhou snub-nosed monkey to the state forestry administration in Beijing Daxing wildlife rescue center, later transferred to Beijing Zoo breeding, just one infant was born in 2013. The captive populations of Guizhou snub-nosed monkey also have a lot of problems in terms of breeding.

3.3 Ecology research of the two primates

3.3.1 Hainan gibbon community structure

Gibbon's main social organization is monogamy, the average group size of four individuals [35], but in the black gibbon is polygamy [36]. While Hainan gibbon group size is commonly four to nine individuals, each group including one adult male, two adult females and their offspring [2, 37]. Jiang et al. [38] research results show that the two groups of Hainan Gibbon, which is distributed in Bawangling National Nature Reserve gibbon began in 1986, each family group has an adult male and two adult females. In 1994, a new family group formed its social structure is monogamy, but the original two family group still has one adult male and two

adult females. By 1997, the newly formed family group becomes the second wife of the social structure, protection zones of all three group of gibbon to form the two adult females social structure. During 2002–2015, when we are doing research in Bawangling National Nature Reserve of Hainan province, we found that one newly family group was formed in 2011, the new group social structure also has one adult male and two adult females. We also found in the process of investigation and research of Hainan gibbon, the biggest extended family group size is nine individuals; when the males of family group are about to reach sexual maturity, they are automatically expelled by adult male of family group leaving birth group, generally in independent living surrounding the family unit.

3.3.2 Habitat and the home range of Hainan gibbon

Chivers [39] reported that the gibbons generally live in tropical lowland rain-forest or subtropical mountain evergreen broad-leaved forest, occasionally some species will be distributed in evergreen forest and half deciduous forest near the northern mixed environment. Hainan gibbon research started relatively late, the first habitat research was completed by Liu et al. [40], in their study they showed that in Bawangling nature reserve, the Hainan gibbon's general activities were at an altitude of 800–1200 m, home range area is larger.

The early results of Hainan gibbon's home range is 3.05–5.0 km² [41], the later scholars used GIS system to calculate the home range is 5.48–9.87 km² [42, 43]. Hainan gibbon's home range is far greater than other species of gibbon family groups, such as living in Thailand region of white palm gibbon and Java moloch gibbons domain area of only 0.16 and 0.17 km², life in Bangladesh hoolock gibbons and Malaya area of lar gibbons has larger home range area of only 0.45–0.56 km² [44].

3.3.3 Temporal habitat utilization of Guizhou snub-nosed monkey

To investigate the vegetation distribution of Guizhou snub-nosed monkey habitat, botanical plots were set up at 1500, 1700, 1900, and 2100 m in the FNNR. This is the altitudinal range the monkeys exploited. Each plot was 50 m (altitude) × 10 m (width) or 500 m². Plot size was based on the steeply sloped nature of the landscape of the Fanjingshan Mountain. The total number of botanical plots constructed and monitored was 100. We identified 236 species from 125 genera and 72 families in the 100 botanical plots, which included 183 tree species (75 genera and 42 families) and 53 vine species from 26 genera and 16 families. The Shannon-Wiener diversity and evenness indices for each vegetation community were higher at elevations 1700 m and 1900 m ($H = 5.97$ nit, $E = 0.85$, $H = 5.70$ nit, $E = 0.87$) and lower at elevations of 1500 m and 2100 m ($H = 5.24$ nit, $E = 0.82$; $H = 4.64$ nit, $E = 0.83$).

The exploitation of resources used by Guizhou snub-nosed monkey varied significantly by elevation among seasons (Kruskal-Wallis, $X^2 = 9.746$, $df = 3$, $p < 0.05$). From January to March (Spring), the elevational range (537–668 m) and daily distance travel (5200–7000 m) was greatest. In contrast during the summer and fall (April–September), the two seasons had the lowest elevational range of 144 m and the lowest daily distance travel of 550 m. From October to December (winter), the elevational range and daily distance travel gradually increased (**Table 1**).

3.3.4 Dietary of Hainan gibbons

We conducted dietary composition study of Hainan gibbons in Bawangling National Nature Reserve in China from August 2002 to August 2014. Total field observation days of all groups were up to 584, and accumulated 3400 h. The results

| Month | Frequency of monkey activity | Mean elevation (m) | SD ^a | Minimum elevation (m) | Maximum elevation (m) | Elevational range(m) ^b | Maximum daily move distance(m) | Minimum daily move distance(m) | SD ^c |
|--------|------------------------------|--------------------|-----------------|-----------------------|-----------------------|-----------------------------------|--------------------------------|--------------------------------|-----------------|
| 1 | 24 | 1730 | 210 | 1432 | 2100 | 668 | 6000 | 5400 | 147 |
| 2 | 25 | 1680 | 173 | 1560 | 2100 | 540 | 6200 | 5200 | 369 |
| 3 | 29 | 1799 | 161 | 1503 | 2040 | 537 | 7000 | 6100 | 242 |
| 4 | 31 | 1645 | 113 | 1510 | 1876 | 366 | 1800 | 1000 | 226 |
| 5 | 24 | 1764 | 109 | 1543 | 1887 | 344 | 1000 | 550 | 119 |
| 6 | 21 | 1812 | 44 | 1756 | 1900 | 144 | 2000 | 1200 | 229 |
| 7 | 18 | 1790 | 80 | 1654 | 1912 | 258 | 2000 | 1100 | 257 |
| 8 | 28 | 1757 | 106 | 1507 | 1805 | 298 | 3200 | 2600 | 160 |
| 9 | 29 | 1780 | 145 | 1524 | 1921 | 397 | 4000 | 3200 | 233 |
| 10 | 26 | 1824 | 156 | 1513 | 1979 | 466 | 4000 | 3500 | 146 |
| 11 | 31 | 1810 | 144 | 1590 | 2100 | 510 | 5200 | 4300 | 315 |
| 12 | 37 | 1773 | 140 | 1546 | 2000 | 454 | 6000 | 5100 | 274 |
| Spring | 78 | 1736 | 176 | 1432 | 2100 | 668 | 7000 | 5200 | 493 |
| Summer | 76 | 1744 | 122 | 1510 | 1900 | 390 | 2000 | 550 | 426 |
| Fall | 75 | 1764 | 121 | 1507 | 1921 | 414 | 4000 | 1100 | 820 |
| Winter | 94 | 1800 | 147 | 1513 | 2100 | 587 | 6000 | 3500 | 739 |

^aStandard deviation.
^bHighest elevation minus lowest elevation in any month.

Table 1.
Monthly variation in elevational range and maximum daily move distance, September 2011 to August 2013 [45].

show that Hainan gibbons consumed 133 plant species [46]. Of the plant species eaten, 81.1% were trees, 15.9% were lianas and 3.0% were herbs. Hainan gibbon spent 64.8% of feeding time on fruits, followed by on leaves (28.8%), buds (5.5%), flowers (0.6%) and animals feed (0.3%). The Hainan gibbon consumed fruits from 14 *Ficus* species, whereas it only accounts for 7.2% of the feeding time. The most commonly used part of a plant was ripe fruit in general. Five kinds of animal feed were eaten including young birds, bird eggs, spiders, termites and pupae.

| Family | Species | Feeding part |
|----------------|--------------------------------------|--------------|
| Anacardiaceae | <i>Choerospondias axillaris</i> | Fr |
| Annonaceae | <i>Oncodostigma hainanense</i> | Fr |
| | <i>Pouteria hainanense</i> | Fr |
| | <i>Polyalthia laui</i> | Fr |
| Apocynaceae | <i>Melodinus suaveolens</i> | Fr |
| Araliaceae | <i>Schefflera octophylla</i> | Fr, L |
| Burseraceae | <i>Canarium album</i> | Fr |
| Elaeocarpaceae | <i>Elaeocarpus apiculatus</i> | Fr |
| | <i>Elaeocarpus sylvestris</i> | Fr |
| Euphorbiaceae | <i>Baccaurea ramiflora</i> | Fr |
| | <i>Bischofia javanica</i> | Fr |
| | <i>Endospermum chinense</i> | Fr, L |
| Guttiferae | <i>Garcinia multiflora</i> | Fr |
| | <i>Garcinia oblongifolia</i> | Fr |
| Lauraceae | <i>Litsea baviensis</i> | Fr |
| | <i>Machilus chinensis</i> | Fr |
| Moraceae | <i>Artocarpus styracifolius</i> | Fr |
| | <i>Ficus esquiroliana</i> | Fr |
| | <i>Ficus harmandi</i> | Fr |
| | <i>Ficus tinctoria</i> | Fr |
| | <i>Ficus variegata</i> | Fr |
| | <i>Ficus virens</i> | Fr, L |
| Myrtaceae | <i>Acmena acuminatissima</i> | Fr |
| Papilionaceae | <i>Derris trifoliata</i> | L |
| Polygalaceae | <i>Xanthophyllum hainanense</i> | L |
| Proteaceae | <i>Helicia kwangtungensis</i> | Fr |
| Rubiaceae | <i>Mussaenda hainanensis</i> | L |
| | <i>Nephelium lappaceum</i> | Fr |
| Tiliaceae | <i>Microcos paniculata</i> | Fr |
| Ulmaceae | <i>Gironniera subaequalis planch</i> | Fr |
| Vitaceae | <i>Tetrastigma cauliflorum</i> | Fr |

Note: Part(s) eaten: L, leaves, Fr, fruit, Fl, flowers.

Table 2.
Plant species that can be used by Hainan gibbons per year at Bawangling National Nature Reserve.

The dominant plant families were Moraceae, Annonaceae, Lauraceae and Myrtaceae, with more than seven species. Hainan gibbons feed on two kinds of Leguminosae plants, *Derris trifoliata* and *Millettia pachyloba*, consuming their tender leaves during dry season, when other food is scarce. Plant family and species such as Moraceae, *Pouteria hainanense*, *Canarium album* and *Gnetum montanum* are the major food sources of Hainan gibbon, but during the dry season they bear only a few fruits.

There were only 32 food species repeatedly used by Hainan gibbons each year (Table 2), and 18.7% of species leaves were eaten [46]. There are few fig species available as foods especially in the dry season. In this season, due to less precipitation, Ficus fruit and non-figs become scarce and less available. Hainan Gibbons eat more tender leaves and increase their feeding time to live through this period.

3.3.5 Food resource distribution and availability of Guizhou snub-nosed monkey

The Guizhou snub-nosed monkeys were observed to feed on a total of 104 species from 51 genera and 31 families. These included 84 tree species from 41 genera and 26 families, representing 45.9% of the total number of tree species, and 20 vine species from 10 genera and 7 families, representing 37.7% of the total vine species. The IVI percentages of the feeding trees species at various elevations were: 65.5% at 1500 m, 65.6% at 1700 m, 72.9% at 1900 m and 58.7% at 2100 m. The IVI percentage of feeding trees accounted for 66.4% of the total number of records in the plots.

The plant species consumed by the Guizhou snub-nosed monkey varied significantly among seasons. (Kruskal-Wallis, $X^2 = 8.897$, $df = 3$, $p < 0.05$). From January to March, 34 feeding trees species accounting for 32.7% of the diet were consumed, mainly the buds of *Pterostyrax psilophyllus*, *Prunus grayana*, *Carpinus kweichowensis*, *Betula austrosinensis*, *Styrax japonica*, *Sassafras tzumu* and *Acer flabellatum*. From April to June, 64 feeding trees species accounting for 61.5% of the diet were consumed, mainly the leaves of *Tilia tuan*, *Prunus grayana*, *Styrax faber*, *Cyclobalanopsis gracilis*, *Cladrastis sinensi* and *Sorbus wilsoniana* and fruits of *Prunus grayana*. From July to September, 81 feeding trees species accounting for 77.9% of the diet were consumed, mainly the leaves of *Prunus grayana*, *Tilia*, *Litsea cubeba* and *Styrax japonica* and the fruits of *Dendrobenthamia* and *Acer davidii*. Finally, from October to December, 52 feeding trees species accounting for 50% of the diet were consumed, mainly the fruits and seeds of *Dendrobenthamia*, *Cerasus serrulata*, *Sorbus megalocarpa* and *Camellia* and the buds of *Magnolia sprengeri*. The monkeys fed on a core set of 28 species during all seasons the year, which accounted for 15.3% of the total number of species consumed. In addition, 48 species were consumed during at least 2 seasons of the year.

3.4 Behavioral ecology research of Hainan gibbon

3.4.1 Reproductive behavior

Hainan gibbon sexual maturity relatively late (generally around 7–8 years), generally produce one infant every 2 year [47]. The mating behavior of Hainan gibbon generally initiated by the female adult individuals, each mating duration is very short, and mate can range from 1 to 9 times. Posture is pushing type mating, pregnancy for 173 days. The infants can completely leave maternal independent activities that are needed 1.5 years after birth [1].

3.4.2 Song behavior

All gibbons have loud, complex, stably structured songs [48]. Gibbon songs occur frequently and regularly, usually beginning shortly before or after sunrise,

with a usual duration of 10–30 min [49]. Gibbon song sound frequency varies among species, with a general fundamental frequency in the 0.2–5 kHz range [50], and male song reaching up to 4 kHz, such as in *Nomascus leucogenys* [51]. We recorded the songs of three Hainan gibbon groups and seven solitary Hainan gibbons in Bawangling National Nature Reserve, Hainan Province, China. In total, we recorded 184 segments of Hainan gibbon song over 129 days. Recordings from group B were conducted in 2002–2003 and the quality was too poor for analysis, so we concentrated on songs recorded in 2011–2013 from groups A and C.

The first song of Hainan gibbon started within 20 min (before or after) of sunrise, and the second 4 h after sunrise, during which time there were occasionally a third and fourth song event. We found that Hainan gibbons' song includes female–male chorus and male solos, no female solos. A typical chorus is usually initiated and dominated by the adult male in *Nomascus*. Females add a great call and the chorus ends with male song [48, 51]. There was no significant difference in song duration between solitary gibbons and group C (single-factor analysis of variance and LSD multiple comparisons: $F = 5.13$, $df_1 = 2$, $df_2 = 14$, $P = 0.26$), but both differed significantly from group A (solitary: $P_2 = 0.016$, group C = 0.008) [18].

3.4.2.1 Male song

Male song in groups was composed mainly of two types of sounds: simple repetition of one note and frequency-modulated (FM) notes. Simple repeated notes consisted of one to three similar, short notes. FM notes consisted of one to five long notes (**Figure 4**). Solitary adult male song sound spectrum characteristics were simple, consisting only of three to five long FM notes and no short or single notes. The long-note frequency of solitary gibbons was similar to that of group song, but the durations of each note and complete song were shorter than in the family groups.

3.4.2.2 Chorus

The Hainan gibbon chorus is usually initiated and dominated by an adult male. The females issue a simple great call at the climax of the male's song, and then the male contributes to the chorus with complex FM notes, and finally the chorus ends with a simple FM note sung by the adult male (**Figure 5**). Subadults and juveniles did not sing alone and were involved only in chorus song.

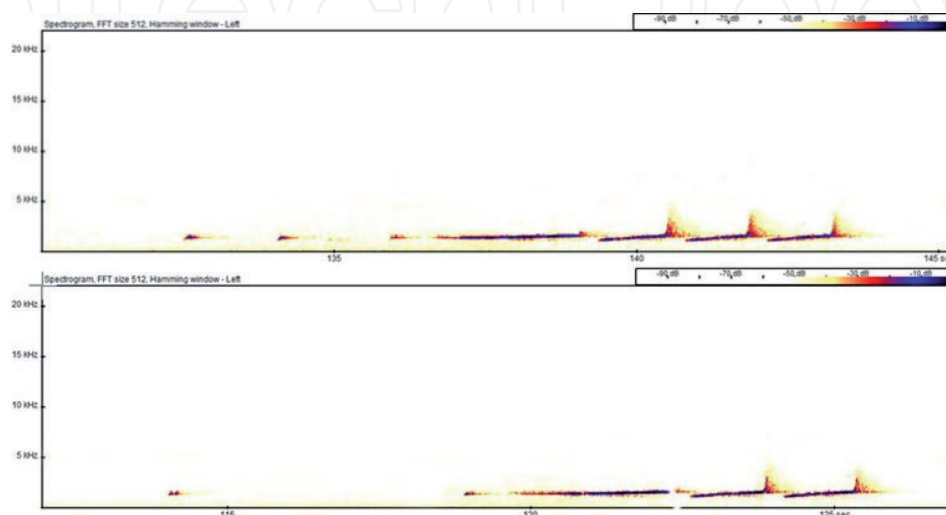


Figure 4. Song spectra of Hainan gibbons in group A at Bawangling nature Reserve in September 2012 (Reference from [18]). (Note: The songs consist of two or three short syllables and three or four long syllables.)

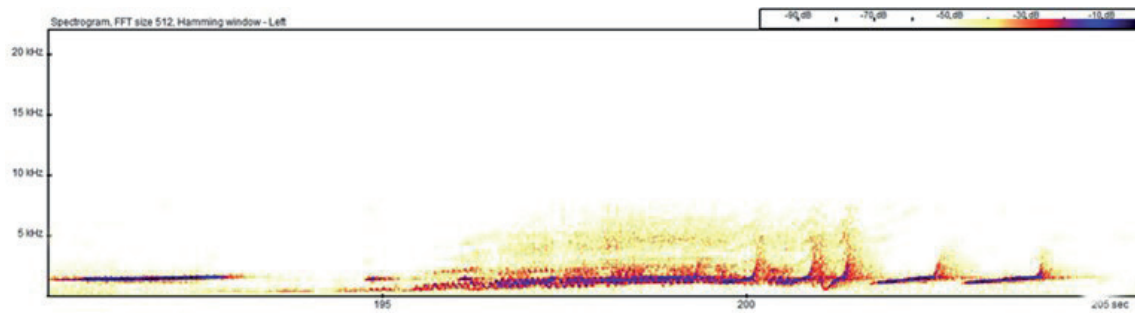


Figure 5.
 Song spectra of duetting gibbons in group A at Bawangling nature Reserve in March 2013 (Reference from [18]).

In a full chorus, the male gibbon begins with a song consisting of two short notes and a long note: the male's song lasts 2–3 s. The start of the female's song is also a single, short note, followed by a loud call. The duration of choruses is ca. 7.5 s. Finally, the adult males sing an accompaniment, which also consists of very simple FM notes. In choruses, the song of male usually comprises two short notes and five to six relatively stable long notes. Compared with solo song, there is one additional long note. Male chorus and solo song did not differ significantly between groups A and C in frequency ($F = 1.417$, $df\ 1 = 3$, $df\ 2 = 35$, $P = 0.25$). Once the male Hainan gibbon has sung a FM note in chorus, it then sings songs that combine a short note with along FM note. After the first FM note, males continue with one to three short single notes and the sonic frequency shifts higher and higher. The next stage is loud song by two adult females, which then give two to four simple FM notes. The mean \pm SD FM note duration was 5.20 ± 1.43 s (range 2.28–11.1 s); the starting frequency of the first FM note was 1.38 ± 0.06 kHz; it then rose to 1.64 ± 0.05 kHz ($N = 59$), with a duration of 2.67 ± 0.80 s ($N = 59$); the starting frequency of the second FM note was 1.19 ± 0.06 kHz; it then rose to 1.65 ± 0.035 kHz, with a duration of 1.40 ± 0.03 s ($N = 59$). A complete female great call in chorus includes seven to nine notes. Female great call sound spectrum characteristics were very similar between groups A and C. Excepting the first two notes, the great call consists of rising fast trill notes. In the great call, the first note's duration is longer than that of subsequent notes (length 0.86 ± 0.40 s, $N = 14$) and its frequency is lower (0.62 ± 0.01 kHz, $N = 14$). The note of the great call then becomes shorter and the frequency increases until it reaches the highest frequency at the end. The frequency of the highest note made by adult females is at least 1.70 kHz, the highest frequency being no more than 2.0 kHz, with a mean of 1.78 ± 0.06 kHz ($N = 13$), the mean duration was 4.71 ± 1.23 s.

3.4.2.3 Alarm calls

Alarm calls are important defensive behaviors. We have reported the acoustic spectrum characteristics of alarm calls produced by Hainan gibbons (*Nomascus hainanus*) inhabiting Bawangling National Nature Reserve in Hainan, China [52].

Alarm calls of Hainan gibbon were emitted by family groups only and not solitary animals. Hainan gibbons produce two types of alarm call. Hainan gibbons emitted the same alarm call across different threats (raptor, snake or people). Male and female adult gibbons emitted “gou-gou-gou” to alert group members of a danger when they encountered a potential predator, hereafter termed an alarming call (**Figure 6**). Following the alarming call, individuals in the family group gather, young gibbons move rapidly towards females, adult males conceal themselves in a location convenient for further vigilance, and all members (except infants) produce “jier- jier-jier” sounds, occasionally accompanied by jumping in a tree or flapping

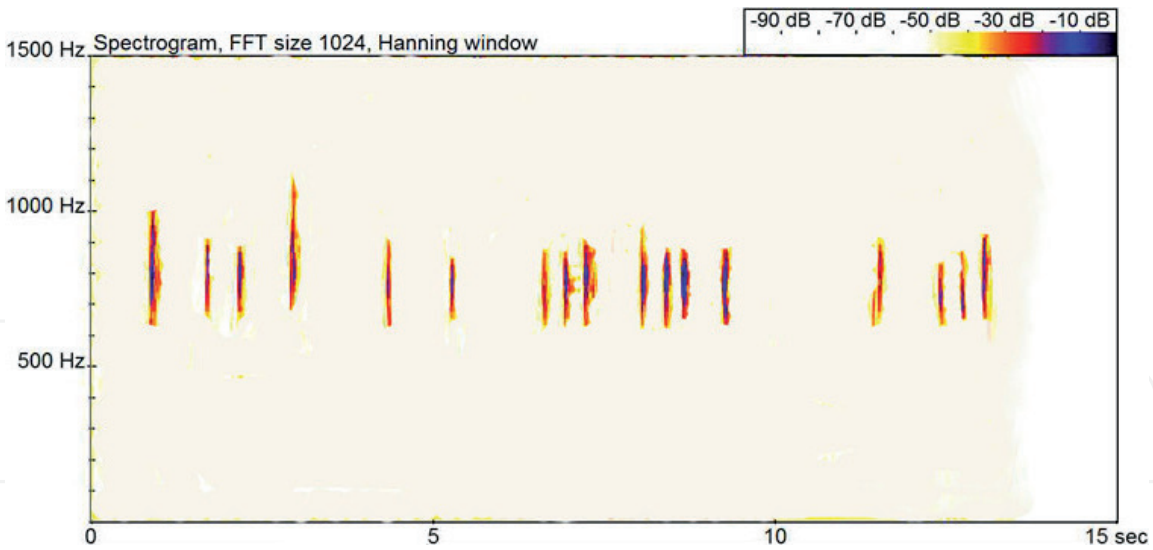


Figure 6.
The alarming call in a group of Hainan gibbons (group B) (Reference from [52]).

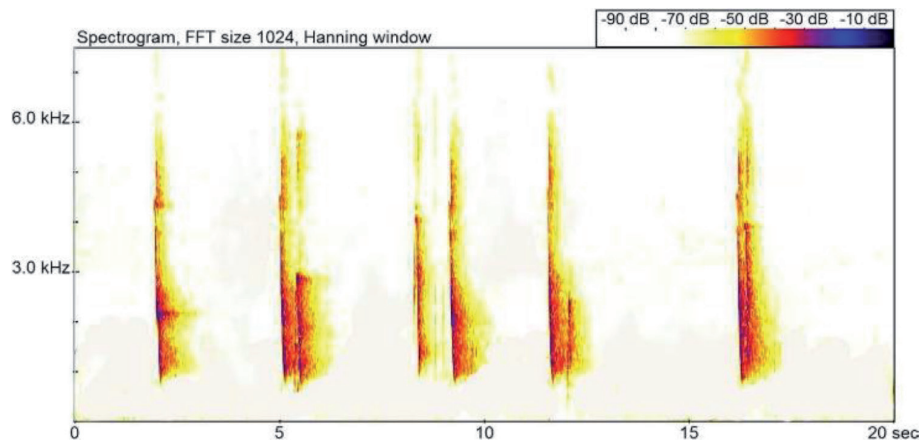


Figure 7.
The mobbing call in a group of Hainan gibbons (group B) (Reference from [52]).

tree branches; we term the group call following the alarming call the mobbing call hereafter (**Figure 7**). During mobbing calls, gibbons occupied the crown canopy, which remained relatively concealed while calling and continued to survey the external environment.

The alarming call was composed of short simple syllables (aa notes). Different individuals in a group often repeated these simple syllables. The duration of an alarming call was 7–10 min. There was a difference in the duration of alarming calls among the three groups (ANOVA: $F = 8.42$, $df = 14$, $P < 0.05$), and the duration was longer in larger groups ($A > B > C$). Acoustic spectrum analysis indicated that the mean duration of a syllable in an alarming call was 0.078 ± 0.014 s and 520–1000 Hz. Acoustic frequency differed between groups, and a difference was detected in the highest and lowest alarming call frequencies between groups (ANOVA: $F_1 = 17.34$, $df = 112$, $P_1 < 0.01$; $F_2 = 15.752$, $P_2 = < 0.01$).

The alarming behavior is the adaptation strategy of animals when they faced threaten from the habitat, especially for the primates and the group living animals. Alarm call of Hainan gibbon is simple, composed of only simple syllables and the frequency is low, but effective. This may be easier for young gibbons to learn, different gender and age stages of individuals have two sound signals, and indicate that the Hainan gibbon is a simple primitive species in the family Hylobatidae.

4. Discussion

Hainan gibbon is most rare and endangered wild animals that is only one in the world without zoos captive breeding has a very high protection value. In recent years, Hainan gibbon population is growing, but the suitable habitat area is too small, the low quality of food resources seriously limits the further recovery of its population. Zhang et al. [53] reported that the suitable habitat of Hainan gibbon decreased 35% in 17 years from 1991 to 2008. The protection regulators lack independence and administrative level is low in Bawangling nature reserve, the law enforcement power and management power are insufficient [54]. To make gibbon to get rid of extinction state, we must provide them with more habitat, together with the present situation of the vegetation and existing management measures in Bawangling nature reserve, we suggested that short-term is given priority to with local protection, lowland rain forest as the main measures to restore living habitat, medium and long term are focused on through the establishment of ecological corridors connecting the reserves in the central mountains, such as Yinggeling, Wuzhishan, and Diaoluoshan which have had the Hainan gibbon distribution, through the construction of the habitat corridors, connect the reserves and establish covers a variety environment characteristics of the protection of the reserve system. We can believe that under the joint efforts of all departments at all levels, the Hainan gibbon will have better development.

Current research results show that the population of Guizhou sub-nosed monkeys has no significant growth in recent decades and the active region is at elevations above 1400 m. So, the conservation of existing habitat is crucial, human disturbance from tourism should be strictly controlled. A total of 28 different plant species were eaten by the monkeys during different seasons in the whole year, some of the dominant species with high elevation distribution are important food resources for the monkeys, such as *Acer flabellatum*, *Pterostyrax psilophyllus*, *Sorbus xanthoneura* and *Magnolia sprengeri*. We should artificially plant important food resources for the monkeys to increase the food resources of the monkeys and expand the range of monkey activities.

5. Conclusions

Due to habitat fragmentation and human disturbance, the population and distribution range of Hainan gibbon and Guizhou sub-nosed monkey are drastically decreasing. The population of China's peculiar treasure endangered primates Hainan gibbon and Guizhou sub-nosed monkeys is extremely low. Distribution area was confined to an isolated island. It is very important to make strict protection measures for the endangered animals. To make the endangered species from extinction, the relevant research and conservation of protected species should be constantly strengthened.

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