

Letter to the editor

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Population recovery of the critically endangered western black crested gibbon (*Nomascus concolor*) in Mt. Wuliang, Yunnan, China

We conducted the third population survey of western black crested gibbons (*Nomascus concolor*) in Mt. Wuliang, Yunnan Province, China, from November 2020 to March 2021 following the first and second surveys conducted in 2001 and 2010, respectively. We recorded 104 gibbon groups during the current survey. Compared to the second survey (87 groups), our results suggest that the gibbon population has increased over the last decade in Mt. Wuliang. Among the 104 groups, 16 live outside the Wuliangshan National Nature Reserve (Wuliangshan NNR). Hunting and large-scale commercial logging are no longer the primary threats in the region, however, habitat degradation caused by livestock grazing and food competition with other primates may limit further gibbon population increase in the future.

Gibbons (Family Hylobatidae) are small apes that live in evergreen forests throughout Southeast Asia (Fan & Bartlett, 2017). Currently, 20 species in four genera are recognized. Due to habitat loss and poaching, populations of all gibbon species, except the Hainan gibbon (*N. hainanus*), are declining (IUCN, 2021). Consequently, all gibbon species are listed as Endangered (EN) or Critically Endangered (CR) on the IUCN Red List (IUCN, 2021), except the eastern hoolock gibbon (*Hoolock leuconedys*), which is listed as Vulnerable. Due to their slow life history, gibbon populations take a long time to recover. In the wild, male gibbons reach sexual maturity at about 10 years old, while females reach maturity at about 8 years old and give birth to a single infant every 3–4 years (Hu et al., 2018; Reichard et al., 2012), except for female Hainan gibbons, who give birth once every two years (Zhou et al., 2008).

Western black crested gibbons are primarily distributed in Yunnan, China, with a small distribution range also in northern Laos and Vietnam (Yang et al., 2021). In 2021, the western

black crested gibbon was listed as one of the 12 flagship and keystone species for biodiversity conservation by the State Forestry Bureau of China. Located in the center of Yunnan, Mt. Wuliang (N24°17'–24°55', E100°19'–100°45') extends from north-northwest to south-southeast along the eastern bank of the Mekong River. The main vegetation types are monsoon evergreen broad-leaved forest or pine forest from 1 300 to 1 800 m above sea level (a.s.l.), semi-humid evergreen broad-leaved forest from 1 800 to 2 200 m a.s.l., mid-montane humid evergreen broad-leaved forest from 2 200 to 2 700 m a.s.l., and elfin or rhododendron dwarf forest above 2 700 m a.s.l. (Jiang et al., 2006). The Wuliangshan Provincial Nature Reserve was first established in 1986 in Jingdong County and was upgraded to a national level reserve in 2000 and extended to cover the north section in Nanjian County. The current reserve is about 83 km long and 5–7 km wide, and mainly protects the semi-humid and mid-montane humid evergreen broad-leaved forest above 1 800 m a.s.l. Mt. Wuliang, which includes forest inside and outside the reserve, supports about 40% of the total population of *N. concolor* and therefore plays a crucial role in its conservation (Fan, 2017).

Since the 1980s, the Mt. Wuliang population of black crested gibbons has attracted considerable conservation and research attention from both regional and international scientists (Fan, 2017). From November 2001 to January 2002, researchers and reserve rangers conducted the first population survey of *N. concolor* in Mt. Wuliang, covering the Jingdong, Nanjian, and Zhenyuan counties. Because all gibbon species produce loud early-morning calls that can be heard from a distance of 1–2 km, Brockelman and Srikosamatara (1993) developed a method to estimate gibbon group numbers by listening to the loud calls at fixed listening posts. This approach has been widely applied in gibbon surveys (Fan et al., 2011). Jiang et al. (2006) used the

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approach to estimate the number of gibbon groups (98) at Mt. Wuliang in 2001. In January and February 2010, a second survey was conducted using the same method, with 87 groups reported (Luo, 2011), suggesting a population decline from 2001 to 2010. Thus, to evaluate conservation effectiveness from 2010 to 2020 and inform future conservation actions, we conducted a third survey of *N. concolor* supported by the Wuliangshan NNR to assess current population size and distribution in Mt. Wuliang.

Before the field survey, all surveyors participated in a one-day indoor training course and a two-day field training course to gain basic knowledge on gibbon ecology, behavior, and conservation status, as well as survey methods, including recognition of male and female gibbon calls. The field survey was conducted from November 2020 to March 2021 and covered the entire Mt. Wuliang gibbon range in the Jingdong, Nanjian, and Zhenyuan counties (Figure 1). In total, the survey included 112 person-times and 93 listening posts. Every survey team included at least two surveyors monitoring gibbon vocal activity from sunrise (ca. 0700h in the study area) to 1200h for three successive days following Jiang et al. (2006) and Luo (2011). Jiang et al. (2006) found that monitoring gibbon vocalization for three consecutive days was sufficient for detecting potential gibbon groups. During the survey, the geographical coordinates of the listening post, direction and estimated distance to calling gibbons, starting/stopping time of calling bouts, times of female great calls, and number of singing individuals per group were recorded in a datasheet (Fan et al., 2011). We used triangulation to estimate the location of each singing group (Brockelman & Srikosamatara, 1993). Calls that occurred simultaneously, partially overlapped in time, or within 10 min of each other were distinguished as being from different groups because a group never produced two bouts with an interval of less than 10 min according to our long-term behavioral study on the western slopes of Mt. Wuliang (Fan PF, unpublished data). Calls occurring at locations more than 500 m apart were also considered to be produced by two separate groups (Brockelman & Srikosamatara, 1993; Jiang et al., 2006).

We recorded a total of 104 groups of gibbons during the field survey, including 90 groups in Jingdong, 11 in Zhenyuan, and three in Nanjian. More groups were distributed in the southern part of the mountain than in the northern part, as also reported in the first and second surveys (Jiang et al., 2006; Luo, 2011). Most gibbon groups (92%) were heard at elevations of 2 000 to 2 600 m a.s.l. Only one group was heard below 1 900 m a.s.l. during the first survey (Jiang et al., 2006), which decreased to zero during the second survey (Luo, 2011). However, during this survey, we heard three groups calling below 1 900 m a.s.l., indicating that several gibbon groups have shifted their range to lower elevations or new groups have been formed at lower elevations in the last decade. The calling locations of 16 groups were more than 500 m from the Wuliangshan NNR boundary and were thus thought to live outside the reserve. Among them, 11 groups were in Zhenyuan County (Figure 1).

Illegal hunting and habitat loss have long been recognized as the main threats to gibbons in China (Fan, 2017). At present, all gibbon species are listed as Class I protected

animal species in China, and hunting gibbons is illegal according to the China Wildlife Protection Law. Due to the gradual improvement in law enforcement and gun confiscation, gibbon hunting has not been recorded at Mt. Wuliang over the last ten years (unpublished data from Wuliangshan NNR). Furthermore, commercial logging of primary forest in Mt. Wuliang was completely banned in 2016, and no signs of logging were observed during the survey in the area. These results suggest that illegal hunting and habitat loss caused by commercial logging are no longer the main threats to gibbons in the region, which has likely contributed to the recovery of the gibbon population in Mt. Wuliang.

Small population size and isolation are increasingly serious concerns for gibbon conservation in China (Fan, 2017). For example, the critically endangered Hainan gibbon consists of a tiny and isolated population of only 35 individuals in Bawangling (https://www.sohu.com/a/488135925_121106994). The endangered skywalker hoolock gibbon (*Hoolock tianxing*) population consists of less than 150 individuals in China, with many local subpopulations containing less than five groups (Zhang et al., 2021). The Mt. Wuliang gibbon population was found to be relatively well connected, with only one distribution gap (from Bangmai Village in Wenlong Town to Longshu Village in Jingpin Town) larger than 5 km identified in the middle of the mountain (Figure 1). However, gibbons may be able to cross this gap or form new groups in this area in the future. Six groups in the northern part of the mountain, including three in Nanjian and three in Jingdong, were isolated from the other groups by a road (G357). Thus, constructing a forest corridor to connect these groups with the main population would be beneficial.

Livestock grazing and non-timber forest product collection still widely occur in and near Wuliangshan NNR. Livestock grazing and associated human disturbance can have a direct impact on forest regeneration and deter gibbons from using the forest (Dooley & Judge, 2015). During the survey, local people were observed collecting many *Spatholobus suberectus* and *Kadsura sp.* vines to sell at the market. Gibbons are heavily reliant on the young leaves and fruits of *Kadsura sp.* in April and May and in September and October, respectively (Chen et al., 2020; Fan et al., 2009). Collecting *Kadsura sp.* vines from gibbon habitat could directly reduce gibbon food resources. Therefore, how gibbons respond to livestock grazing and other types of human disturbance deserves further research.

Three gibbon groups were recorded below 1 900 m a.s.l. during the survey. It is not clear whether they were new groups that formed at lower elevations or established groups that shifted their home ranges to lower elevations. According to long-term behavioral studies of three gibbon groups at Dazhaizi, gibbons have increased their use of areas ranging from 1 700 to 1 900 m a.s.l. in recent years due to improved forest quality and increased habituation to humans (Fan PF, unpublished data). However, Wuliangshan NNR is located close to the main mountain ridge and only covers a small proportion of forest below 1 800 m a.s.l. Given that 16 groups are distributed outside the current reserve boundary, we suggest the reserve be expanded and community co-management encouraged to protect both the potential and

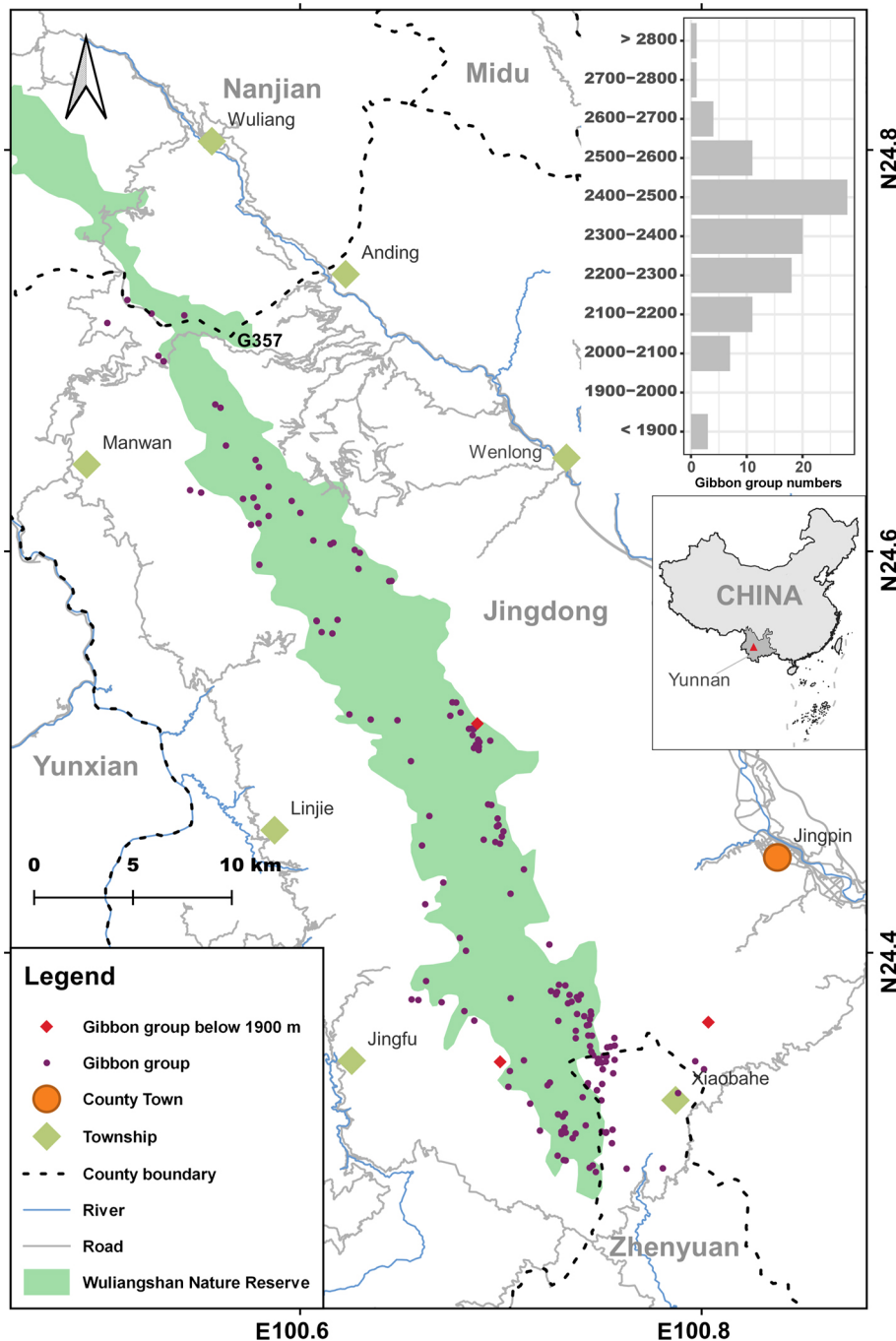


Figure 1 Distribution and altitudinal range (upper right corner) of critically endangered western black crested gibbon (*Nomascus concolor*) groups in Mt. Wuliang, Yunnan Province, China (Red triangle in map indicates location of Mt. Wuliang)

current gibbon range. Furthermore, Zhenyuan County needs to assume greater responsibility in this endeavor as 11 groups outside the reserve were distributed within this county. Jingdong County supports most of the Mt. Wuliang gibbon population and has very good experience in gibbon research and conservation. Thus, the Jingdong Management Bureau of Wuliangshan NNR should provide technical support to Zhenyuan to monitor and protect its gibbon population. Conservation education and community co-management are also encouraged to protect groups outside the reserve (Zhang

et al., 2021).

Along with the recovery of gibbons, populations of sympatric animal species have also increased in Mt. Wuliang. For example, the Indochinese gray langur (*Trachypithecus crepusculus*) population has increased from 80 individuals in one group to more than 160 individuals in three groups at Dazhaizi (Chen et al., 2020). Of the 26 primary food items that comprise the annual gibbon diet, 14 are also consumed by langurs. In addition, langurs tend to consume fruits before they are sufficiently ripe for gibbons (Chen et al., 2020) and often

break branches containing fruit during feeding. Their larger group size and faster life history (females reach sexual maturity at 4–5 years old and reproduce once every two years) compared to gibbons also increases the negative effects of feeding competition on gibbons. Furthermore, based on images taken by camera traps, three species of macaque (*Macaca mulatta*, *M. assamensis*, and *M. arctoides*) also occur in Mt. Wuliang (unpublished data). At present, we do not know the diets of these macaque species in Mt. Wuliang, although other populations are known to consume a large proportion of fruit (Thierry, 2007), and thus may compete for food resources with gibbons. Similar to langurs, population recovery of sympatric macaques may limit gibbon population recovery in the future.

SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Permission for field surveys in Mt. Wuliang was granted by the Wuliangshan National Nature Reserve. No specimens were collected during the survey.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

P.F.F. designed the study. P.F.F., L.Z., X.H., K.C.S., G.Q.L., and C.H.W. conducted the field survey. P.F.F. and L.Y. conducted the analyses. P.F.F. wrote the manuscript with input from the other authors. All authors read and approved the final version of the manuscript.

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Peng-Fei Fan^{1,*}, Lu Zhang¹, Li Yang¹, Xia Huang¹, Kai-Chong Shi¹, Guo-Qing Liu², Chun-Hua Wang²

¹ School of Life Sciences, Sun Yat-Sen University, Guangzhou, Guangdong 510275, China

² Jingdong Management Bureau of Wuliangshan National Nature Reserve, Jingdong, Yunnan 676200, China

*Corresponding author, E-mail: fanpf@mail.sysu.edu.cn

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