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# Mammals of Gaoligong Mountain in China: Diversity, distribution, and conservation

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## ABSTRACT

Gaoligong Mountain (hereafter, GLGM) is located at the intersection of Myanmar and China's Yunnan Province and Xizang Zizhiqu, and spans three globally significant biodiversity hotspots: the Himalayas, Indo-Burma, and the Mountains of Southwest China. Although surveys of mammals in this ecologically important region have a long history, there is no comprehensive systematic checklist and distribution account of the mammals of GLGM. Here, we compiled a mammal species checklist of GLGM based on thorough field investigations and literature reviews. We also examined specimen collections and applied camera trapping surveys to explore the region's mammal diversity and distribution patterns. We recorded 212 mammal species in nine orders, 33 families, and 119 genera, which accounts for 30.5% of China's mammal species, and a high proportion of nationally protected (50) and globally threatened (29) species. Mammal species richness showed a symmetrical unimodal curve along the elevation gradient, peaking at intermediate elevations (2 000 to 2 500 m above sea level (asl)), and increasing generally from south to north, slightly higher in the east slope than in

the west. Cluster analysis and non-metric multidimensional scaling revealed three distinct elevational assemblages (<900 m asl., 900–3 500 m asl., and >3 500 m asl) and significant south-to-north variation, but no substantial differences between the east and west slopes. The GLGM present a unique conservation value due to the high proportions of rare and endangered mammal species, complex faunal composition, high endemism, and being the distribution boundary for many species. This study is an important phased account of mammal diversity in GLGM and makes a prospect for future research.

**Keywords:** Biodiversity hotspot; Eastern Himalaya; Gaoligong Mountain; Endemism; Mammal

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conservation; Hengduan Mountains

## INTRODUCTION

Mammals are the most dominant life forms on earth due to their diversity, broad distributions, and prominent body size range (Wilson & Mittermeier, 2009). They occupy virtually every habitat from the poles to the equator, including terrestrial and aquatic habitats (Wilson & Mittermeier, 2009). However, field research on mammals is relatively difficult due to highly diverse lifestyles, such as nocturnal activity, arboreal and fossorial, and being dominated by small mammals that are difficult to identify because of similar appearance (Borisenko et al., 2008; Dos Santos et al., 2020; Pei et al., 2022).

China is one of the countries with the highest mammal diversity in the world, with a total of 694 species of mammals in 12 orders, 58 families, 256 genera currently recorded (Wei et al., 2022). Yunnan Province alone has 315 species of mammals, ranking the first among 34 provincial-level administrative regions in China (Jiang et al., 2021a). Gaoligong Mountain (hereafter, GLGM) is situated in the watershed between the Salween River to the east and the Irrawaddy River to the west. It lies at the intersection of Myanmar and Southwest China's Yunnan Province and Xizang Zizhiqu, a region where three globally significant biodiversity hotspots converge, i.e., the Himalayas, Indo-Burma, and Southwest China mountains (Mittermeier et al., 2011). GLGM is one of the most important localities for type specimen collections of various taxa, including mammals (e.g., Ai et al., 2018; Fan et al., 2017; Li et al., 2019b; Ma et al., 1990; Thomas, 1922).

The earliest scientific survey of mammals in this region can be traced back to the late 19<sup>th</sup> century. In 1871 and 1876, the Scottish zoologist, John Anderson, conducted animal surveys in western Yunnan (including southern GLGM) (Anderson, 1871, 1876). During these expeditions, 67 species of mammals were recorded, including new species (Anderson, 1878). Subsequently, many other expeditions were conducted in the GLGM region covering mammals and other wildlife, e.g., Prince Henri d'Orlean, 1895 (D'orléans, 1898); Malcolm Playfair Anderson, 1904–1911 (Thomas, 1912a); George Forrest, 1904–1932 (Forrest, 1910; Plantexplorers.Com, 2023); Frank Kingdon-Ward, 1911–1926 (Kingdon-Ward, 1913, 1921, 1924; Schilling, 1991); Joseph Francis Rock, 1922 (Wagner, 1992); and Brooke Dolan, 1931–1932 (Stone, 1933). The mammal collections from these expeditions were mainly collated and published by Oldfield Thomas (Thomas, 1912a, 1912b, 1914, 1920, 1921, 1922). Allen (1938, 1940), in the book *The Mammals of China and Mongolia*, included mammals from GLGM collected by Roy Chapman Andrews during the Asiatic Zoological Expedition (Andrews, 1918, Andrews & Andrews, 1918). Anthony (1941) subsequently studied the mammal from northeastern Myanmar, including the middle section of GLGM, collected by Arthur Stannard Vernay and Charles Suydam Cutting, and published the monograph *Mammals Collected by the Vernay-Cutting Burma Expedition*.

After the founding of the People's Republic of China in 1949, a series of zoological surveys were conducted by Chinese researchers in the GLGM region. From 1956 to 1960, Qinghua Pan from Kunming Institute of Zoology, Chinese Academy of Sciences (hereafter, KIZ) organized joint surveys of birds and mammals in the southern part of GLGM (including

Dehong Prefecture and Baoshan City) with Beijing Natural Museum, Peking University, Wuhan University and Yunnan University (Song et al., 2023). Subsequently, KIZ carried out three other animal surveys in GLGM (1962 in Longling; 1964–1965 in Luxi, Yingjiang, Tengchong, and Longyang; and 1973–1974 in Gongshan, including Dulongjiang, and Lushui, including Pianma). These surveys collected 1 356 mammal specimens (Peng & Wang, 1981) with a series of new taxa published (*Moschus fuscus* Li, 1981; *Paguma larvata chichingensis* Wang, 1981; *Petaurista petaurista nigra* Wang, 1981; *Callosciurus erythraeus gongshanensis* Wang, 1981; and *Micromys minutus pianmaensis* Peng, 1981; *Ochotona gaoligongensis* Wang et Gong, 1988; *Muntiacus gongshanensis* Ma, 1990; *Ochotona nigritia* Gong et Wang, 2000). Gong & Xie (1989) investigated the elevational distribution of small mammals in five different vegetation types on the eastern slope of GLGM and recorded 30 small mammal species. From 1992 to 1994, KIZ conducted zoological surveys in GLGM and recorded 178 mammal species (Lan & Dunbar, 2000). From 1989 to 2004, based on the previous expeditions and surveys, and towards the establishment and management of nature reserves, Southwest Forestry University and Yunnan Forestry Survey and Planning Institute led several comprehensive scientific investigations in GLGM, leading to the publication of four monographs: *Gaoligong Mountain National Nature Reserve* (115 mammals recorded) (Wang et al., 1995), *Nujiang Nature Reserve* (106 mammals recorded) (Wang, 1998), *Integrated Scientific Studies of Tongbiguan Yunnan Nature Reserve* (101 mammals recorded) (Qu et al., 2006), and *Xiaoheishan Nature Reserve* (131 mammals recorded) (Ma et al., 2006). From 2001 to 2005, cooperative Sino-US Zoological Surveys between KIZ and the California Academy of Sciences, USA, employed regular altitudinal and latitudinal sampling of mammals in GLGM. With extensive use of new techniques, such as DNA barcoding-based species identification, molecular phylogenetics, and camera trap sampling, many new and rare mammal species were recorded, recognized, and described in the GLGM and China, including new species: *Hoolock tianxing* Fan et al., 2017; *Mesechinus wangi* Ai et al., 2018; *Biswamoyopterus gaoligongensis* Li et al., 2019; *Eupetaurus nivamons* Li et al., 2021; *Neodon bershulaensis* Liu et al., 2022; *Neodon zayuensis* Liu et al., 2022; new genus: *Priapomys* Li et al., 2021; and new records: *Rhinopithecus strykeri* (Long et al., 2012) and *Capricornis rubidus* (Chen et al., 2019; Li et al., 2019a).

Notably, the previous surveys and studies in GLGM were either limited to certain areas or restricted to particular mammal groups (Chen et al., 2016; Gao et al., 2017; Gong & Xie, 1989; Li, 2020), with many areas and groups remaining poorly surveyed. Knowledge of the overall mammalian diversity and distribution patterns in the region is poor, constraining effective biodiversity conservation and management of this ecologically significant area. Here, we compiled a comprehensive checklist of mammals in the GLGM by examining available specimens, and camera trapping records held at the KIZ Mammal Research Group and reviewing substantial literature. We then analyzed the distribution patterns, endemism, and conservation status of the mammals of the GLGM region to inform effective biodiversity conservation. Since altitude is a combined environmental gradient in mountain forests which is associated with climate and vegetation variation (Rahbek et al., 2019), we hypothesized that the distribution patterns of

mammalian diversity in the GLGM region is dominated by altitudinal effects.

## MATERIALS AND METHODS

### Study area

This study focuses on the Chinese part of GLGM (E97.355–99.095°, N24.137–29.183°, 218–6 155 m above sea level (asl)), which is located in the suture zone formed by the collision and subduction of the Indian and Eurasian plates (Li & Li, 2020). This region is at the watershed of Nu Jiang (Salween River) to the east and Dulong Jiang (Irrawaddy River) to the west (Figure 1). It is a narrow north-south mountain range with low latitude and significant variation in elevation, from the Bershula Mountain in Zayu, Xizang Zizhiqu in the north through Gongshan, including Dulongjiang, Fugong, Lushui including Pianma, Longyang, Tengchong to Longling in the south and Yingjiang in the southwest (Figure 1). The elevation gradually decreases from north to south, highest at 6 155 m asl in Chagelazi, Xizang Zizhiqu, and lowest at 218 m asl in Nabang, Yingjiang, Yunnan.

As the first mountain range on the westernmost side of the Hengduan Mountains to meet the Indian Ocean monsoon, GLGM has higher rainfall than other regions at the same

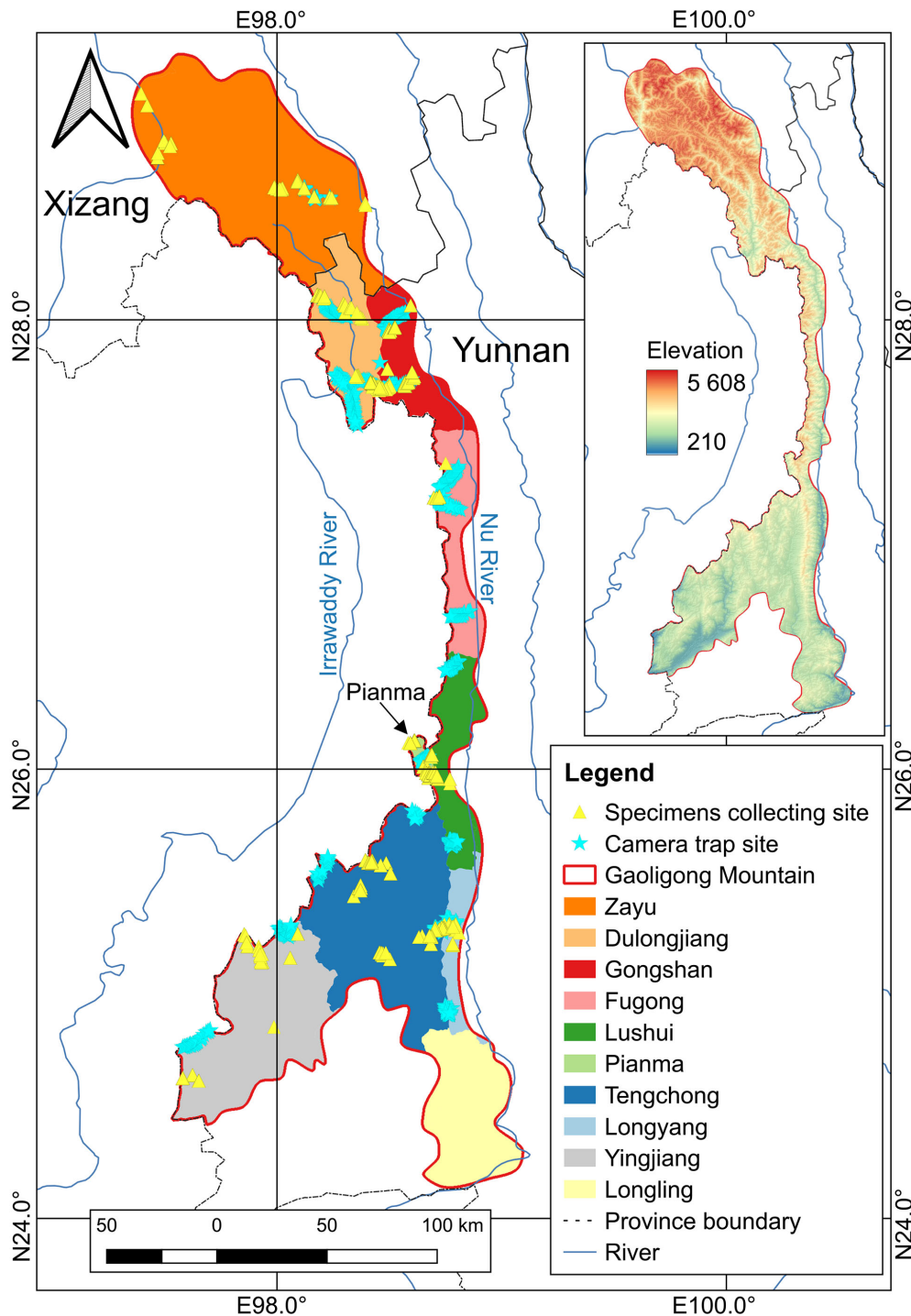


Figure 1 Study area and sampling sites in Gaoligong Mountain (reference drawing No. GS (2021) 6375)

latitude (Li & Zhang, 2010). The annual precipitation is evenly distributed in the northern part of the mountain but divided into dry and wet seasons in the southern part (Li & Li, 2020). Although GLGM only spans about 1.74° longitude from east to west (ca. 50 km), the western windward slope receives more rainfall and has more humid vegetation (such as more epiphytes) than the eastern leeward slope (Li et al., 2000). The temperature of GLGM decreases latitudinally from south to north and altitudinally from the valley to the mountaintop (Li & Li, 2020).

The GLGM spans about 5° latitude from north to south (ca. 600 km), with the vegetation portraying noticeable north-south changes, i.e., dry valley sclerophyll forest (Zayu) to humid evergreen broad-leaved forest (Gongshan/Dulongjiang, 1 600 m asl), semi-humid evergreen broad-leaved forest (Fugong, 1 400 m asl), dry and hot tropical semi-evergreen monsoon forest and monsoon evergreen broad-leaved forest (Baoshan/Longling, 600–800 m asl) (Li et al., 2000). In addition to the difference in vegetation at the foot of the mountain, the altitudinal vegetation spectrum of the middle and upper range of the GLGM is similar from north to south: middle-mountain moist evergreen broadleaved forest (1 900–2 600 m asl), hemlock coniferous broad-leaved mixed forest (2 600–2 900 m asl), fir forest (2 900–3 400 m asl), alpine scrub and meadow (>3 300 m asl) (Li et al., 2000). The Xizang Zizhiqu part of GLGM is more distant from the sea with a significant reduction in precipitation that results to arid vegetation with a simpler altitudinal spectrum (Li et al., 2000).

#### Data collection and checklist formation

There are three nature reserves in the GLGM region (Gaoligongshan National Nature Reserve, Tongbiguan Provincial Nature Reserve, and Xiaoheishan Provincial Nature Reserve), for which four comprehensive scientific research monographs have been published (Ma et al., 2006; Qu et al., 2006; Wang, 1998; Wang et al., 1995) (hereafter, four natural reserve monographs). Based on these data, we compiled a preliminary mammal checklist of GLGM (hereafter, preliminary list). However, these publications are 15–25 years old, over which the status of some species has been reevaluated and changed. We, thus, collected more data through ongoing field survey efforts and identified mammal taxa using contemporary taxonomic and systematic research methods developed in the last decade. We identified 11 158 mammal specimens and 57 344 camera trap photos and videos hosted by the KIZ, and reviewed 105 scientific publications (as of December 31, 2022) on the taxonomy, wildlife monitoring, field surveys, and distribution records of mammals in GLGM to update and revise the preliminary list. A species was included in the final checklist if it was vouchered/verified by any of the specimens, photos/videos, or taxonomic literature from GLGM. If a species was recorded from GLGM only by the four natural reserve monographs, we further reviewed its global distribution range and habitat to decide whether it should be excluded or included in the final checklist.

The taxonomic system of the final checklist followed the *Illustrated Checklist of the Mammals of the World* (Burgin et al., 2020a, 2020b) and the *Taxonomy and Distribution of Mammals in China* (Wei et al., 2022). The species extinction risk/threat status was obtained from the *International Union for Conservation of Nature Red List of Threatened Species* (IUCN) (2022) and *China's Red List of Biodiversity* (2021) (Jiang et al., 2021b). The conservation category of species followed the *List of key protected wild animals in China* (2021)

and *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) Appendices (2022).

We further collected data on the distribution of the species in the final checklist. The distribution of small mammals was mainly obtained by examining specimens from field surveys in the past five decades, while that of medium and large-sized mammals was primarily evidenced by camera trapping records in the past ten years. The distribution information was assigned to ten sampling sites: Yingjiang, Longling, Tengchong, Longyang, Pianma, Lushui, Fugong, Dulongjiang, Gongshan, and Zayu (Figure 1). To compare the mammal diversity with seed plant diversity (Wang et al., 2004), the altitudinal distribution at each sampling site was further divided into ten ranges (<600 m asl, 600–900 m asl, 900–1 500 m asl, 1 500–2 000 m asl, 2 000–2 500 m asl, 2 500–3 000 m asl, 3 000–3 500 m asl, 3 500–4 000 m asl, 4 000–4 600 m asl, >4 600 m asl).

#### Data analysis

The taxonomic composition and threatened and protected species were first analyzed based on the final checklist. We then identified species whose distribution ranges were limited to GLGM and adjacent areas, and classified them into four types of regional endemics: (i) GLGM, (ii) Eastern Himalayas, (iii) Hengduan Mountains, and (iv) Western Yunnan and Northern Myanmar.

Based on the final species checklist, we built a species presence-absence matrix for each sampling site/altitude range to further analyze the diversity and distribution patterns. Considering the terrain characteristics of GLGM (5° north-south span, 1.74° east-west span, and 5 937 m elevational range) and the availability of data (the amount of data in Longling in the southeast of GLGM was significantly lesser than other sampling sites; we did not have data of sites opposite the Fugong sampling site which is in Myanmar), we analyzed the variation of species richness and community composition along the latitude, aspect, and altitude. For the latitudinal analysis, we assigned species distribution data of Yingjiang, Longling, Tengchong, Longyang, Pianma, and Lushui into the *south section* (dry-hot valley); Fugong, Dulongjiang, and Gongshan into the *middle section* (wet-temperate valley), and Zayu into the *north section* (dry-temperate valley) based on the noticeable latitudinal variation in vegetation and climate at the foot of the mountain (Figure 1). For the aspect analysis, we assigned species distribution data of Longling, Longyang, Lushui, Fugong, and Gongshan into the *east slope* and Yingjiang, Tengchong, Pianma, and Dulongjiang into the *west slope* based on the sampling sites located to the east or west of the main vein of GLGM. Zayu was excluded due to an unclear distinction between the east and west slopes compared with other sampling sites. For the altitude analysis, we not only analyzed the elevation variation of each sampling site but also combined the data of the same elevation range of all sampling sites to analyze the elevation variation of the whole mountain. We performed One-way ANOVA to test the differences in species richness across sampling sites and employed non-metric multidimensional scaling (NMDS) to evaluate community similarity across sampling sites, between the *south*, *middle*, and *north* sections, and the *east* and *west* slopes. In terms of altitude variation, a one-way ANOVA was used to test the differences in species richness, and hierarchical cluster analysis was used to evaluate the community dissimilarity. The analyses were performed in R using the “vegan” package (Oksanen et al., 2022).

## RESULTS

### Taxonomic composition

The final checklist of mammals in the GLGM was comprised of 212 species, belonging to 119 genera, 33 families, and nine orders (Table 1), accounting for 30.5% of China's (694 species) and 67.3% of Yunnan's (315 species) mammal species.

Among the nine orders, Rodentia was represented by the highest number of species (63), accounting for 29.7% of the mammal species richness in the region, followed by Chiroptera (47 species, 22.2%), Carnivora (35 species, 16.5%), Eulipotyphla (33 species, 15.6%), Cetartiodactyla (15 species, 7.1%), Primates (10 species, 4.7%), Lagomorpha (6 species, 2.8%), Pholidota (2 species, 0.9%), and Scandentia (1 species, 0.5%). Among the 33 families, Muridae was

**Table 1 Mammal checklist of Gaoligong Mountain**

	Voucher			China Key Protected Animals	CITES Appendices	IUCN Red List	China's Red List of Biodiversity	Notes
	Specimen	Photo	Literature					
<b>I. PRIMATES Linnaeus, 1758 灵长目</b>								
<b>1. Lorisidae Gray, 1821 懒猴科</b>								
<i>Nycticebus bengalensis</i> (Lacépède, 1800) 蜂猴	√	√	√	I	I	EN	EN	
<b>2. Cercopithecidae Gray, 1821 猴科</b>								
<i>Macaca arctoides</i> (Geoffroy, 1831) 红面猴	√	√	√	II	II	VU	VU	
<i>Macaca mulatta</i> (Zimmermann, 1780) 猕猴	√	√	√	II	II	LC	LC	
<i>Macaca leonina</i> (Blyth, 1863) 北豚尾猴	√	√		I	II	VU	CR	
<i>Macaca assamensis</i> (McClelland, 1839) 熊猴	√	√	√	II	II	NT	VU	
<i>Macaca leucogenys</i> Li et al., 2015 白颊猕猴		√		II		EN	CR	◆
<i>Rhinopithecus strykeri</i> Geissmann et al., 2011 缅甸金丝猴	√	√	√	I	I	CR	CR	●
<i>Trachypithecus melamera</i> (Elliot, 1909) 中缅灰叶猴	√	√	√	I		NE	NE	●
<i>Trachypithecus shortridgei</i> (Wroughton, 1915) 肖氏乌叶猴	√	√	√	I	I	EN	EN	●
<b>3. Hylobatidae Gray, 1871 长臂猿科</b>								
<i>Hoolock tianxing</i> Fan et al., 2017 高黎贡白眉长臂猿	√	√	√	I	I	EN	CR	●
<b>II. SCANDENTIA Wagner, 1855 攀鼯目</b>								
<b>4. Tupaiidae Gray, 1825 树鼯科</b>								
<i>Tupaia belangeri</i> (Wagner, 1841) 北树鼯	√	√	√		II	LC	LC	
<b>III. LAGOMORPHA Brandt, 1855 兔形目</b>								
<b>5. Leporidae Fischer, 1817 兔科</b>								
<i>Lepus comus</i> Allen, 1927 云南兔	√	√	√			LC	NT	
<i>Lepus oostolus</i> Hodgson, 1840 灰尾兔		√				LC	LC	
<b>6. Ochotonidae Thomas, 1897 鼠兔科</b>								
<i>Ochotona forresti</i> Thomas, 1923 灰颈鼠兔	√	√	√			LC	NT	◆
<i>Ochotona macrotis</i> (Günther, 1875) 大耳鼠兔			√			LC	LC	
<i>Ochotona curzoniae</i> (Hodgson, 1857) 高原鼠兔		√				LC	LC	
<i>Ochotona thibetana</i> (Milne-Edwards, 1871) 藏鼠兔			√			LC	LC	▲
<b>IV. RODENTIA Bowdich, 1821 啮齿目</b>								
<b>7. Spalacidae Gray, 1821 鼯形鼠科</b>								
<i>Cannomys badius</i> (Hodgson, 1842) 小竹鼠		√	√			LC	DD	
<i>Rhizomys pruinosus</i> Blyth, 1851 银星竹鼠	√	√	√			LC	LC	
<i>Rhizomys sinensis</i> Gray, 1831 中华竹鼠	√	√	√			LC	LC	
<b>8. Muridae Illiger, 1811 鼠科</b>								
<i>Apodemus chevrieri</i> (Milne-Edwards, 1868) 高山姬鼠	√		√			LC	LC	
<i>Apodemus ilex</i> Thomas, 1922 澜沧江姬鼠	√		√			NE	LC	
<i>Apodemus latronum</i> Thomas, 1911 大耳姬鼠	√					LC	LC	▲
<i>Bandicota indica</i> (Bechstein, 1800) 板齿鼠	√		√			LC	LC	
<i>Berymys bowersi</i> (Anderson, 1878) 青毛巨鼠	√		√			LC	LC	
<i>Berymys manipulus</i> (Thomas, 1916) 小泡灰鼠	√		√			DD	DD	●
<i>Chiropodomys gliroides</i> (Blyth, 1855) 笔尾树鼠	√					LC	LC	
<i>Dacnomys millardi</i> Thomas, 1916 大齿鼠	√		√			DD	NT	
<i>Leopoldamys neilli</i> Marshall, 1976 耐氏大鼠	√					LC	EN	
<i>Micromys erythrotis</i> Blyth, 1856 红耳巢鼠	√					NE	LC	
<i>Mus caroli</i> Bonhote, 1902 卡氏小鼠	√		√			LC	LC	
<i>Mus pahari</i> Thomas, 1916 锡金小鼠	√		√			LC	LC	
<i>Mus cookii</i> Ryley, 1913 丛林小鼠	√		√			LC	LC	
<i>Mus musculus</i> Linnaeus, 1758 小家鼠	√		√			LC	LC	
<i>Niviventer andersoni</i> (Thomas, 1911) 安氏白腹鼠	√		√			LC	LC	▲

Continued

	Voucher			China Key Protected Wild Animals	CITES Appendices	IUCN Red List	China's Red List of Biodiversity	Notes
	Specimen	Photo	Literature					
<i>Niviventer brahma</i> (Thomas, 1914) 梵鼠	√		√			LC	NT	●
<i>Niviventer confucianus</i> (Milne-Edwards, 1871) 北社鼠	√		√			LC	LC	
<i>Niviventer eha</i> (Wroughton, 1916) 灰腹鼠	√		√			LC	LC	
<i>Niviventer excelsior</i> (Thomas, 1911) 川西白腹鼠	√		√			LC	LC	▲
<i>Niviventer fulvescens</i> (Gray, 1847) 针毛鼠	√		√			LC	LC	
<i>Niviventer huang</i> (Bonhote, 1905) 华南针毛鼠			√			NE	LC	
<i>Niviventer niviventer</i> (Hodgson, 1836) 喜马拉雅社鼠			√			LC	DD	◆
<i>Niviventer pianmaensis</i> Li et Yang, 2009 片马社鼠	√		√			NE	NE	▲
<i>Rattus andamanensis</i> (Blyth, 1860) 黑缘齿鼠	√					LC	LC	
<i>Rattus nitidus</i> (Hodgson, 1845) 大足鼠	√		√			LC	LC	
<i>Rattus norvegicus</i> (Berkenhout, 1769) 褐家鼠	√		√			LC	LC	
<i>Rattus tanezumi</i> (Temminck, 1845) 黄胸鼠	√		√			LC	LC	
<i>Vandeleuria oleracea</i> (Bennett, 1832) 长尾攀鼠	√		√			LC	NT	
<i>Vernaya fulva</i> (Allen, 1927) 滇攀鼠	√		√			LC	EN	▲
<b>9. Cricetidae Fischer, 1817 仓鼠科</b>								
<i>Neodon bershulaensis</i> Liu et al., 2022 伯舒拉松田鼠	√		√			NE	NE	★
<i>Neodon chayuensis</i> Liu et al., 2022 察隅松田鼠	√		√			NE	NE	★
<i>Neodon clarkei</i> (Hinton, 1923) 克氏松田鼠	√		√			LC	DD	
<i>Neodon irene</i> (Thomas, 1911) 高原松田鼠			√			LC	LC	▲
<i>Eothenomys cachinus</i> (Thomas, 1921) 克钦绒鼠	√		√			LC	NT	●
<i>Eothenomys eleusis</i> Thomas, 1911 滇绒鼠	√		√			NE	LC	
<i>Eothenomys miletus</i> Thomas, 1914 大绒鼠	√		√			LC	LC	▲
<i>Urocrinetus kamensis</i> Satunin, 1902 藏仓鼠	√					LC	NT	▲
<b>10. Hystricidae Fischer, 1817 豪猪科</b>								
<i>Atherurus macrourus</i> (Linnaeus, 1758) 帚尾豪猪	√	√	√			LC	LC	
<i>Hystrix brachyura</i> Linnaeus, 1758 马来豪猪	√	√	√			LC	LC	
<b>11. Sciuridae Fischer von Waldheim, 1817 松鼠科</b>								
<i>Callosciurus erythraeus</i> (Pallas, 1779) 赤腹松鼠	√	√	√			LC	LC	
<i>Callosciurus phayrei</i> (Blyth, 1856) 黄足松鼠	√	√	√			LC	LC	●
<i>Callosciurus quinquestriatus</i> (Anderson, 1871) 纹腹松鼠	√	√	√			LC	NT	●
<i>Dremomys lokriah</i> (Hodgson, 1836) 橙腹长吻松鼠	√		√			LC	NT	
<i>Dremomys pernyi</i> (Milne-Edwards, 1867) 珀氏长吻松鼠	√	√	√			LC	LC	
<i>Dremomys rufigenis</i> (Blanford, 1878) 红颊长吻松鼠	√	√				LC	LC	
<i>Tamiops mccllellandii</i> (Horsfield, 1840) 明纹花鼠	√		√			LC	LC	
<i>Tamiops swinhoei</i> (Milne-Edwards, 1874) 隐纹花鼠	√	√	√			LC	LC	
<i>Ratufa bicolor</i> (Sparman, 1778) 巨松鼠	√	√	√	II	II	NT	VU	
<i>Belomys pearsonii</i> (Gray, 1842) 毛耳飞鼠	√	√	√			DD	LC	
<i>Biswamoyopterus gaoligongensis</i> Li et al., 2019 高黎贡比氏鼯鼠	√	√	√			NE	NE	★
<i>Eupetaurus nivamons</i> Li et al., 2021 云南绒毛鼯鼠	√	√	√			NE	NE	▲
<i>Hylopetes alboniger</i> (Hodgson, 1836) 黑白飞鼠	√	√	√			LC	NT	
<i>Petaurista caniceps</i> (Gray, 1842) 灰头小鼯鼠	√	√	√			LC	LC	
<i>Petaurista marica</i> Thomas, 1912 斑点鼯鼠	√	√	√			LC	LC	
<i>Petaurista sybilla</i> Thomas et Wroughton, 1916 橙色小鼯鼠	√		√			NE	LC	
<i>Petaurista yunnanensis</i> (Anderson, 1875) 云南大鼯鼠	√	√	√			NE	DD	▲
<i>Priapomys leonardi</i> (Thomas, 1921) 李氏小飞鼠	√	√	√			NE	NE	●
<i>Trogopterus xanthipes</i> (Milne-Edwards, 1867) 复齿鼯鼠	√	√				NT	VU	
<i>Marmota himalayana</i> (Hodgson, 1841) 喜马拉雅旱獭	√	√	√			LC	LC	
<i>Sciurotamias forresti</i> (Thomas, 1922) 侧纹岩松鼠	√	√	√			LC	LC	
<b>V. EULIPOTYPHILA Waddell et al., 1999 劳亚食虫目</b>								
<b>12. Talpidae G. Fischer, 1814 鼩科</b>								
<i>Scaptonyx fuscicaudus</i> Milne-Edwards, 1872 长尾鼩	√		√			LC	LC	
<i>Euroscaptor grandis</i> Miller, 1940 宽齿鼩	√		√			LC	VU	▲
<i>Euroscaptor longirostris</i> (Milne-Edwards, 1870) 长吻鼩			√			LC	LC	
<i>Euroscaptor micrura</i> (Hodgson, 1841) 短尾鼩	√		√			LC	VU	
<i>Parascaptor leucura</i> (Blyth, 1850) 白尾鼩	√		√			LC	NT	

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<i>Uropsilus investigator</i> (Thomas, 1922) 贡山鼯鼠	√		√			DD	NT		★
<i>Uropsilus nivatus</i> (Allen, 1923) 雪山鼯鼠	√					LC	NE		▲
<b>13. Erinaceidae G. Fischer, 1814 猬科</b>									
<i>Mesechinus wangi</i> He, Jiang et Ai, 2018 高黎贡林猬	√	√	√			NE	DD		★
<i>Hylomys suillus</i> Müller, 1840 毛猬	√		√			LC	LC		
<i>Neotetracus sinensis</i> Trouessart, 1909 中国鼯猬	√		√			LC	LC		
<b>14. Soricidae G. Fischer, 1814 鼯鼠科</b>									
<i>Crocidura attenuata</i> Milne-Edwards, 1872 灰麝鼯			√			LC	LC		
<i>Crocidura dracula</i> Thomas, 1912 白尾梢大麝鼯	√		√			NE	NE		
<i>Crocidura indochinensis</i> Robinson et Kloss, 1922 印支小麝鼯			√			LC	NT		
<i>Crocidura rapax</i> Allen, 1923 华南中麝鼯			√			DD	NT		
<i>Suncus etruscus</i> (Savi, 1822) 小臭鼯	√					LC	VU		
<i>Suncus murinus</i> (Linnaeus, 1766) 臭鼯	√		√			LC	LC		
<i>Anourosorex squamipes</i> Milne-Edwards, 1872 四川短尾鼯	√		√			LC	LC		
<i>Blarinella wardi</i> Thomas, 1915 狭颌黑齿鼯	√		√			LC	NT		●
<i>Chimarrogale himalayica</i> (Gray, 1842) 喜马拉雅水鼯	√		√			LC	NT		
<i>Chimarrogale styani</i> de Winton, 1899 灰腹水鼯	√		√			LC	VU		▲
<i>Chodsigoa furva</i> Anthony, 1941 烟黑缺齿鼯	√		√			NE	DD		●
<i>Chodsigoa hypsibia</i> (de Winton, 1899) 川西缺齿鼯	√					LC	LC		
<i>Chodsigoa parva</i> Allen, 1923 云南缺齿鼯	√		√			LC	LC		
<i>Episoriculus caudatus</i> (Horsfield, 1851) 褐腹长尾鼯	√		√			LC	LC		
<i>Episoriculus leucops</i> (Horsfield, 1855) 大长尾鼯	√		√			LC	LC		
<i>Episoriculus macrurus</i> (Blanford, 1888) 小长尾鼯	√		√			LC	LC		
<i>Episoriculus sacratu</i> (Thomas, 1911) 灰腹长尾鼯			√			NE	DD		▲
<i>Nectogale elegans</i> Milne-Edwards, 1870 蹠足鼯	√		√			LC	LC		
<i>Soriculus nigrescens</i> (Gray, 1842) 大爪长尾鼯	√		√			LC	NT		◆
<i>Sorex bedfordiae</i> Thomas, 1911 小纹背鼯	√		√			LC	LC		
<i>Sorex cansulus</i> Thomas, 1912 甘肃鼯	√					DD	NT		▲
<i>Sorex cylindricauda</i> Milne-Edwards, 1871 纹背鼯	√		√			LC	NT		▲
<i>Sorex thibetanus</i> Kastschenko, 1905 藏鼯	√					DD	NT		▲
<b>VI. CHIROPTERA Blumenbach, 1779 翼手目</b>									
<b>15. Pteropodidae Gray, 1821 狐蝠科</b>									
<i>Cynopterus sphinx</i> (Vahl, 1797) 犬蝠	√		√			LC	NT		
<i>Eonycteris spelaea</i> (Dobson, 1871) 大长舌果蝠	√		√			LC	VU		
<i>Megaerops ecaudatus</i> (Temminck, 1837) 无尾果蝠	√		√			LC	DD		
<i>Megaerops niphanae</i> Yenbutra et Felten, 1983 泰国无尾果蝠	√		√			LC	DD		
<i>Rousettus amplexicaudatus</i> (Geoffroy, 1810) 抱尾果蝠			√			LC	VU		
<i>Rousettus leschenaultii</i> (Desmarest, 1820) 棕果蝠	√		√			NT	NT		
<i>Sphaerias blanfordi</i> (Thomas, 1891) 球果蝠	√		√			LC	VU		
<b>16. Megadermatidae H. Allen, 1864 假吸血蝠科</b>									
<i>Megaderma lyra</i> Geoffroy, 1810 印度假吸血蝠			√			LC	VU		
<b>17. Hipposideridae Lydekker, 1891 蹄蝠科</b>									
<i>Aselliscus stoliczkanus</i> (Dobson, 1871) 三叶小蹄蝠	√		√			LC	NT		
<i>Hipposideros armiger</i> (Hodgson, 1835) 大蹄蝠	√		√			LC	LC		
<i>Hipposideros cineraceus</i> (Blyth, 1853) 灰小蹄蝠	√					LC	NT		
<i>Hipposideros fulvus</i> Gray, 1838 大耳小蹄蝠			√			LC	DD		
<i>Hipposideros pomona</i> Andersen, 1918 小蹄蝠	√					EN	LC		
<i>Hipposideros lylei</i> Thomas, 1913 莱氏蹄蝠	√		√			LC	VU		
<b>18. Rhinolophidae Gray, 1825 菊头蝠科</b>									
<i>Rhinolophus ferrumequinum</i> (Schreber, 1774) 马铁菊头蝠	√		√			LC	LC		
<i>Rhinolophus affinis</i> Horsfield, 1823 中菊头蝠	√		√			LC	LC		
<i>Rhinolophus pearsoni</i> Horsfield, 1851 皮氏菊头蝠	√		√			LC	LC		
<i>Rhinolophus yunnanensis</i> Dobson, 1872 云南菊头蝠	√					LC	VU		
<i>Rhinolophus macrotis</i> Blyth, 1844 大耳菊头蝠	√					LC	LC		

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<i>Rhinolophus osgoodi</i> Sanborn, 1939 丽江菊头蝠	√					LC	DD		
<i>Rhinolophus pusillus</i> Temminck, 1834 小菊头蝠	√					LC	LC		
<i>Rhinolophus sinicus</i> Andersen, 1905 中华菊头蝠	√					LC	LC		
<i>Rhinolophus thomasi</i> Andersen, 1905 托氏菊头蝠	√					LC	NT		
<i>Rhinolophus luctus</i> Temminck, 1834 大菊头蝠	√		√			LC	NT		
<b>19. Miniopteridae Miller-Butterworth et al., 2007 长翼蝠科</b>									
<i>Miniopterus fuliginosus</i> Hodgson, 1835 亚洲长翅蝠	√		√			NE	NT		
<i>Miniopterus pusillus</i> Dobson, 1876 南长翼蝠	√					LC	NT		
<b>20. Vespertilionidae Gray, 1821 蝙蝠科</b>									
<i>Kerivoula picta</i> (Pallas, 1767) 彩蝠	√		√			NT	EN		
<i>Murina aurata</i> Milne-Edwards, 1872 金管鼻蝠			√			DD	NT		
<i>Murina cyclotis</i> Dobson, 1872 圆耳管鼻蝠	√		√			LC	NT		
<i>Myotis annectans</i> (Dobson, 1871) 缺齿鼠耳蝠			√			LC	NT		
<i>Myotis chinensis</i> (Tomes, 1857) 中华鼠耳蝠	√					LC	NT		
<i>Myotis laniger</i> Peters, 1870 华南水鼠耳蝠	√		√			LC	LC		
<i>Myotis montivagus</i> (Dobson, 1874) 山地鼠耳蝠			√			DD	LC		
<i>Myotis muricola</i> (Gray, 1846) 喜山鼠耳蝠	√		√			LC	NT		
<i>Myotis siligorensis</i> (Horsfield, 1855) 高颅鼠耳蝠	√					LC	NT		
<i>Arielulus circumdatus</i> (Temminck, 1840) 大黑伏翼	√		√			LC	VU		
<i>Eptesicus pachyomus</i> (Tomes, 1857) 东方棕蝠	√		√			LC	NE		
<i>Hypsugo affinis</i> (Dobson, 1871) 茶褐伏翼			√			LC	LC		
<i>Ia io</i> Thomas, 1902 南蝠	√		√			NT	NT		
<i>Mirostrellus joffrei</i> (O. Thomas, 1915) 杰氏伏翼	√		√			DD	NE		
<i>Nyctalus noctula</i> (Schreber, 1774) 褐山蝠	√		√			LC	NT		
<i>Pipistrellus javanicus</i> (Gray, 1838) 爪哇伏翼			√			LC	NT		
<i>Pipistrellus paterculus</i> Thomas, 1915 棒茎伏翼	√		√			LC	LC		
<i>Scotomanes ornatus</i> (Blyth, 1851) 斑蝠	√					LC	LC		
<i>Scotophilus heathii</i> Horsfield, 1831 大黄蝠	√		√			LC	LC		
<i>Tylonycteris fulvida</i> (Blyth, 1859) 华南扁颅蝠			√			NE	LC		
<i>Tylonycteris tonkinensis</i> Tu, Csorba, Ruedi et Hassanin, 2017 托京褐扁颅蝠			√			NE	NE		
<b>VII. CETARTIODACTYLA Montgelard, Catzeffis et Douzery, 1997 鲸偶蹄目</b>									
<b>21. Suidae Gray, 1821 猪科</b>									
<i>Sus scrofa</i> Linnaeus, 1758 野猪	√	√	√			LC	LC		
<b>22. Cervidae Goldfuss, 1820 鹿科</b>									
<i>Rusa unicorn</i> (Kerr, 1792) 水鹿			√	√	II	VU	NT		
<i>Elaphodus cephalophus</i> Milne-Edwards, 1872 毛冠鹿	√	√	√		II	NT	NT		
<i>Muntiacus feae</i> (Thomas et Doria, 1889) 菲氏鹿			√			DD	DD		
<i>Muntiacus gongshanensis</i> Ma, 1990 贡山鹿	√	√	√		II	DD	EN	◆	
<i>Muntiacus vaginalis</i> (Boddaert, 1785) 赤鹿	√	√	√			LC	NT		
<b>23. Bovidae Gray, 1821 牛科</b>									
<i>Budorcas taxicolor</i> Hodgson, 1850 喜马拉雅扭角羚	√	√	√		I	VU	CR	◆	
<i>Capricornis milneedwardsii</i> David, 1869 中华鬣羚	√	√	√		II	VU	VU		
<i>Capricornis rubidus</i> Blyth, 1863 红鬣羚		√	√		II	VU	DD	●	
<i>Naemoredus baileyi</i> Pocock, 1914 赤斑羚	√	√	√		I	VU	EN	◆	
<i>Naemoredus evansi</i> (Lydekker, 1905) 缅甸斑羚	√	√			II	NE	DD		
<i>Pseudois nayaur</i> (Hodgson, 1833) 岩羊	√	√			II	LC	LC		
<b>24. Moschidae Gray, 1821 麝科</b>									
<i>Moschus berezovskii</i> Flerov, 1929 林麝	√	√	√		I	EN	CR		
<i>Moschus chrysogaster</i> Hodgson, 1839 马麝		√			I	EN	CR		
<i>Moschus fuscus</i> Li, 1981 黑麝	√		√		I	EN	CR	◆	
<b>VIII. PHOLIDOTA Weber, 1904 鳞甲目</b>									
<b>25. Manidae Gray, 1821 鱗鲤科</b>									
<i>Manis javanica</i> Desmarest, 1822 马来穿山甲		√			I	CR	CR		
<i>Manis pentadactyla</i> Linnaeus, 1758 中华穿山甲	√		√		I	CR	CR		

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<b>IX. CARNIVORA Bowdich, 1821 食肉目</b>								
<b>26. Felidae Fischer von Waldheim, 1817 猫科</b>								
<i>Catopuma temminckii</i> (Vigors et Horsfield, 1827) 金猫	√	√	√	I	I	NT	EN	
<i>Felis chaus</i> Schreber, 1777 丛林猫	√		√	I	II	LC	CR	
<i>Lynx lynx</i> (Linnaeus, 1758) 猞猁			√	II	II	LC	EN	
<i>Pardofelis marmorata</i> (Martin, 1837) 云猫		√	√	II	I	NT	EN	
<i>Prionailurus bengalensis</i> (Kerr, 1792) 豹猫	√	√	√	II	II	LC	VU	
<i>Neofelis nebulosa</i> (Griffith, 1821) 云豹		√	√	I	I	VU	CR	
<i>Panthera pardus</i> (Linnaeus, 1758) 豹			√	I	I	VU	EN	
<i>Panthera uncia</i> (Schreber, 1775) 雪豹		√		I	I	VU	EN	
<b>27. Prionodontidae Gray, 1864 林狸科</b>								
<i>Prionodon pardicolor</i> Hodgson, 1842 斑林狸	√	√	√	II	I	LC	VU	
<b>28. Viverridae Gray, 1821 灵猫科</b>								
<i>Arctictis binturong</i> (Raffles, 1821) 熊狸	√		√	I		VU	CR	
<i>Paguma larvata</i> (C.E.H. Smith, 1827) 花面狸	√	√	√			LC	NT	
<i>Paradoxurus hermaphroditus</i> (Pallas, 1777) 椰子狸		√	√	II		LC	EN	
<i>Viverra zibetha</i> Linnaeus, 1758 大灵猫	√	√	√	I		LC	CR	
<i>Viverricula indica</i> (Geoffroy Saint-Hilaire, 1803) 小灵猫	√		√	I		LC	NT	
<b>29. Herpestidae Bonaparte, 1845 獴科</b>								
<i>Urva javanicus</i> (Geoffroy Saint-Hilaire, 1818) 红颊獴	√		√			LC	NE	
<i>Urva urva</i> (Hodgson, 1836) 食蟹獴	√	√	√			LC	VU	
<b>30. Canidae Fischer von Waldheim, 1817 犬科</b>								
<i>Canis lupus</i> (Linnaeus, 1758) 狼		√	√	II	II	LC	NT	
<i>Cuon alpinus</i> (Pallas, 1811) 豺	√	√	√	I	II	EN	EN	
<i>Nyctereutes procyonoides</i> (Gray, 1834) 貉			√	II		LC	NT	
<i>Vulpes vulpes</i> (Linnaeus, 1758) 赤狐	√	√	√	II		LC	NT	
<b>31. Ursidae Fischer von Waldheim, 1817 熊科</b>								
<i>Helarctos malayanus</i> (Raffles, 1821) 马来熊		√	√	I	I	VU	CR	
<i>Ursus thibetanus</i> Cuvier, 1823 亚洲黑熊	√	√	√	II	I	VU	VU	
<b>32. Ailuridae Gray, 1843 小熊猫科</b>								
<i>Ailurus styani</i> Thomas, 1902 中华小熊猫	√	√	√	II	I	EN	VU	▲
<b>33. Mustelidae Fischer von Waldheim, 1817 鼬科</b>								
<i>Aonyx cinerea</i> (Illiger, 1815) 小爪水獭	√		√	II	I	VU	CR	
<i>Lutra lutra</i> (Linnaeus, 1758) 欧亚水獭	√		√	II	I	NT	EN	
<i>Lutrogale perspicillata</i> Geoffroy Saint-Hilaire, 1826 江獭	√		√	II	I	VU	CR	
<i>Arctonyx collaris</i> Cuvier, 1825 猪獾		√	√			VU	NT	
<i>Meles leucurus</i> (Hodgson, 1847) 亚洲狗獾	√		√			LC	NT	
<i>Melogale moschata</i> (Gray, 1831) 鼬獾	√	√	√			LC	NT	
<i>Melogale personata</i> Geoffroy Saint-Hilaire, 1831 缅甸鼬獾			√			LC	EN	
<i>Martes flavigula</i> (Boddaert, 1785) 黄喉貂	√	√	√	II		LC	VU	
<i>Martes foina</i> (Erxleben, 1777) 石貂		√		II		LC	EN	
<i>Mustela kathiah</i> Hodgson, 1835 黄腹鼬	√	√	√			LC	NT	
<i>Mustela sibirica</i> Pallas, 1773 黄鼬	√	√	√			LC	LC	
<i>Mustela strigidorsa</i> Gray, 1853 纹鼬	√	√	√			LC	EN	

★: Gaoligong Mountain endemic species; ▲: Hengduan Mountains endemic species; ◆: Eastern Himalayan endemic species; ●: Western Yunnan and northern Myanmar endemic species; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern; DD: Data Deficient; NE: Not evaluated

represented by the highest number of species (29), accounting for 13.7% of the total mammal species richness in the region, followed by Soricidae (23 species, 10.8%), Vespertilionidae and Sciuridae (21 species, 9.9%), and Mustelidae (12 species, 5.7%). The rest of the families were each represented by no more than ten species. Among the 119 genera, *Rhinolophus* had the most species (10), accounting for 4.7% of the total mammal species richness in

the region, followed by *Niviventer* (9 species, 4.2%), *Myotis* (6 species, 2.8%), *Macaca* and *Hipposideros* (5 species, 2.4%), and the rest (113 genera) were each represented by at most four species.

#### Distribution and endemism patterns

Most of the mammals from the GLGM are Oriental endemic species (179/212 species, accounting for 84.4%). The remaining species have different geographic ranges/origins;

nine are typical Palaearctic/plateau species (*Lynx lynx*, *Martes foina*, *Pseudois nayaur*, *Panthera uncia*, *Nyctalus noctule*, *Lepus oiostolus*, *Ochotona macrotis*, *Ochotona curzoniae*, and *Marmota himalayana*), other fifteen range across both the Palaearctic and Oriental realms (*Miniopterus fuliginosus*, *Myotis laniger*, *Eptesicus pachyomus*, *Macaca mulatta*, *Ursus thibetanus*, *Mustela sibirica*, *Martes flavigula*, *Meles leucurus*, *Cuon alpinus*, *Nyctereutes procyonoides*, *Felis chaus*, *Prionailurus bengalensis*, *Niviventer confucianus*, *Rattus tanezumi*, and *Trogopterus xanthipes*), and nine have much broader geographic ranges: including global (*Mus musculus*), Holarctic (*Canis lupus* and *Vulpes vulpes*), and Old World tropical to temperate (*Rhinolophus ferrumequinum*, *Panthera pardus*, *Sus scrofa*, *Lutra lutra*, *Rattus norvegicus*, and *Suncus etruscus*).

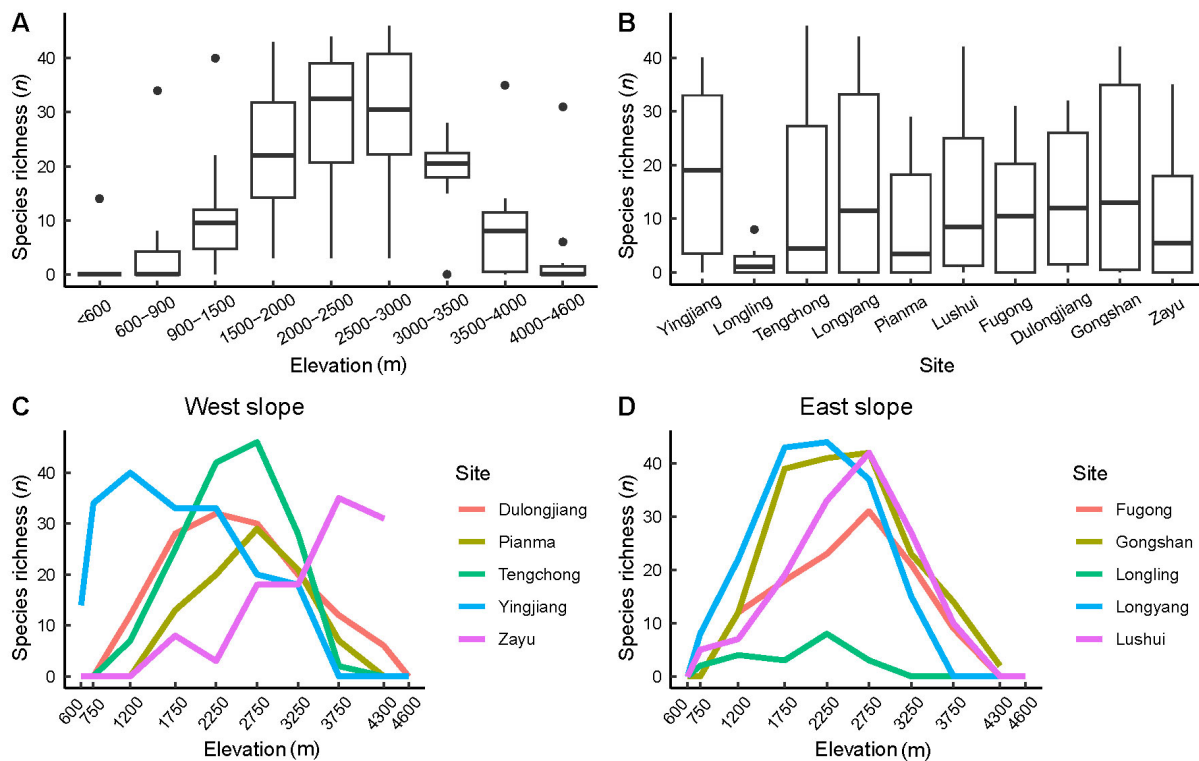
For the Oriental species, 39 species have a wide distribution throughout the Oriental realm (e.g., *Cynopterus sphinx*, *Paguma larvata*, *Rusa unicolor*); 81 species are distributed in tropical to subtropical regions of Southeast Asia without extending to the Indian Peninsula (e.g., *Hylomys suillus*, *Ratufa bicolor*, *Neofelis nebulosa*); and 14 species are mainly distributed in South China (e.g., *Elaphodus cephalophus*, *Rhizomys sinensis*, *Niviventer huang*). The remaining 45 species (constituting 21.2% of the total mammal species richness in the region) were regionally endemic species distributed only in GLGM and adjacent areas (Table 1). Of these 45 species, five were endemic to GLGM (*Biswamoyopterus gaoligongensis*, *Uropsilus investigator*, *Mesechinus wangi*, *Neodon bershulaensis*, and *Neodon zayuensis*); eight were endemic to the Eastern Himalayas (e.g., *Macaca leucogenys*, *Ochotona forresti*, *Muntiacus*

*gongshanensis*); 19 were endemic to Hengduan Mountains (e.g., *Uropsilus nivatus*, *Ailurus styani*, *Niviventer excelsior*); and 13 were endemic to Western Yunnan and Northern Myanmar (e.g., *Rhinopithecus strykeri*, *Capricornis rubidus*, *Niviventer brahma*). Besides, distribution of 13 species within Chinese territory was represented only in GLGM, including *Rhinopithecus strykeri*, *Trachypithecus shortridgei*, *Hoolock tianxing*, *Cannomys badius*, *Berylmys manipulus*, *Eothenomys cachinus*, *Callosciurus phayrei*, *Callosciurus quinquestriatus*, *Megaerops ecaudatus*, *Megaerops niphanae*, *Myotis annectans*, *Mirostrellus joffrei*, and *Capricornis rubidus*.

## Diversity and community composition patterns

### Latitudinal variation

Along the 600 km long and narrow montane range running north to south and branching out southwest in the southern part of GLGM, the species richness of most sampling sites gradually increased from south to north ( $df=9$ ,  $F=1.181$ ,  $P=0.317$ ) (Figure 2B). However, species richness was higher in Longyang and lower in Zayu, with the highest species richness recorded in Yingjiang. The  $\beta$ -diversity based on NMDS showed the community composition varied significantly between the south and the north sampling sites, with the 95% confidence interval (CI) of the scaling metrics completely separating them (Figure 3A). We found that the mammal community in the middle part of GLGM comprised species from both the south and the north communities, with the 95% CI of the scaling metrics intercepting with the two communities (Figure 3A).



**Figure 2** Variation of mammal species richness in Gaoligong Mountain

A: Species richness of the whole Gaoligong Mountain estimated by Analysis of Variance (ANOVA). B: Species richness of each sampling sites estimated by ANOVA. C: The observed species richness along altitude on the west slope by sampling sites. D: The observed species richness along altitude on the east slope by sampling sites. In the box and whisker plots, the whisker limits show the minimum and maximum values, line in the center of the box show the median, box limits show the lower and upper quartiles, and dots show outliers. The elevation is above sea level.

### Aspect variation

Except for Yingjiang and Longling at the southernmost part of GLGM, the estimated species richness of the other three pairs of sampling sites (Longyang vs. Tengchong, Lushui vs. Pianma, Gongshan vs. Dulongjiang) were higher in the east than west slope ( $df=9$ ,  $F=1.181$ ,  $P=0.317$ ) (Figure 2B). The NMDS showed no significant difference in mammal species composition between the east and west slopes, with the 95% confidence interval of the scaling metrics overlapping (Figure 3B).

### Altitude variation

The species richness in GLGM showed a nearly symmetrical pattern ( $df=9$ ,  $F=11.337$ ,  $P<0.001$ ) (Figure 2A, C, D), gradually increasing from low to middle altitude, peaking at intermediate elevations (about 2 000 to 2 500 m asl), then decreasing rapidly. However, the peak at Yingjiang was biased towards low altitude, and Zayu was approximately monotone increasing (Figure 2C). Our hierarchical cluster analysis showed that the community composition of mammals across the mountain was strongly shaped by elevational range, with three distinct groups based on Bray-Curtis dissimilarity among communities, i.e., low elevation (<900 m asl), middle and high elevation (900–3 500 m asl), and peak elevation (>3 500 m asl) (Figure 4).

### Species conservation status

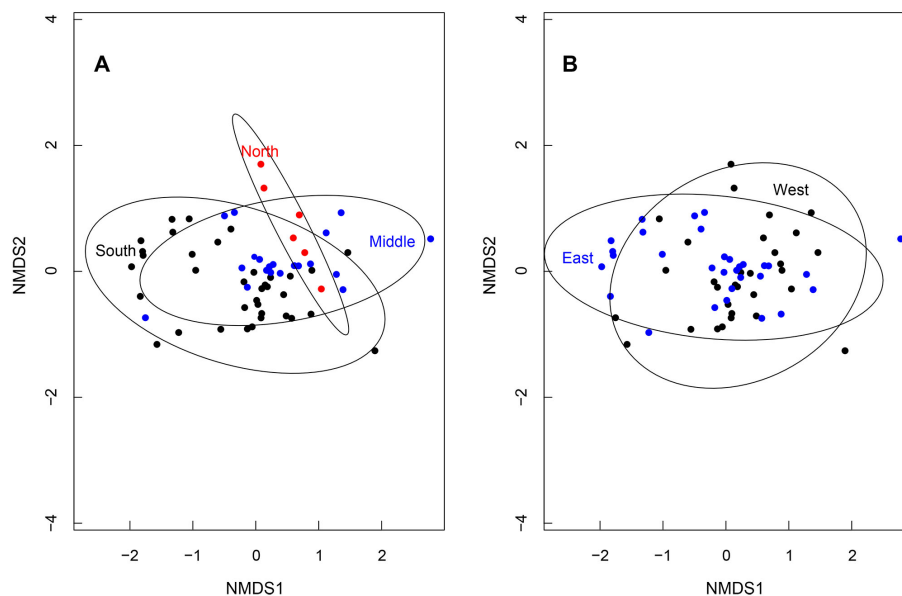
Among the 212 mammal species in GLGM, 50 were listed as national key protected wild animals of China (class I—23 species and class II—27 species), accounting for 23.6% of the regional mammal diversity (Table 1). Thirty-seven species were listed in the CITES (2022) (Appendix I—22 species and Appendix II—15 species), accounting for 17.5% of the regional mammal diversity (Table 1). Twenty-nine species were assessed as threatened by the IUCN Red List (2022) (Critically Endangered (CR)—three species: *Rhinopithecus strykeri*, *Manis pentadactyla*, and *Manis javanica*; Endangered

(EN)—10 species: *Nycticebus bengalensis*, *Trachypithecus shortridgei*, *Hoolock tianxing*, *Cuon alpinus*, *Moschus berezovskii*, *Moschus chrysogaster*, *Moschus fuscus*, *Macaca leucogenys*, *Ailurus styani*, and *Hipposideros pomona*; Vulnerable (VU)—16 species (Table 1)), accounting for 13.7% of the regional mammal diversity (Figure 5A). Fifty-eight mammal species were assessed as threatened in China's Red List of Biodiversity (2021) (Jiang et al., 2021b) (CR—17 species, EN—18 species, VU—23 species (Table 1)), accounting for 27.4% of the regional mammal diversity (Figure 5B).

## DISCUSSION

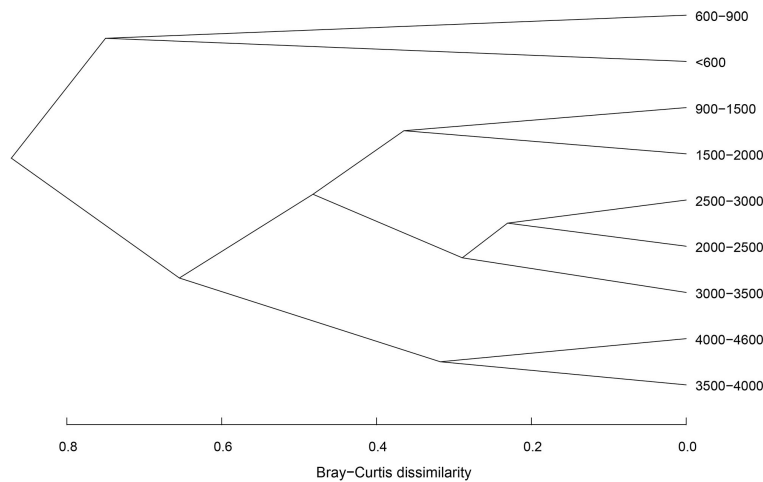
### Comparison between the preliminary list and the final checklist

A comprehensive animal checklist of a region is crucial for understanding its diversity and conservation management (Rodrigues et al., 2006). Compared with the preliminary list (194 species) of mammals in GLGM obtained from the four natural reserve monographs and some literature, the final checklist of this study increased the number by 18 species which is mainly due to many changes and updates of taxonomic status based on advances with taxonomic studies and revisions (Supplementary Table S1). The final checklist, thus, retained 162 species from the preliminary list, of which only 116 species have not had changes in species status and their Latin names, 26 species changed their generic placement (e.g., the Crab-eating Mongoose and the Java Mongoose moved to *Urva* (*U. urva* and *U. javanicus*)) and 20 taxa were elevated to full species from subspecies/synonym/population status in the preliminary list (e.g., *Ailurus styani* and *Chodsigoa furva*) according to the *Illustrated Checklist of the Mammals of the World* (Burgin et al., 2020a, 2020b) and the *Taxonomy and Distribution of Mammals in China* (Wei et al., 2022). With the advances of phylogenetic studies and taxonomic revisions, 12 species in the preliminary list had

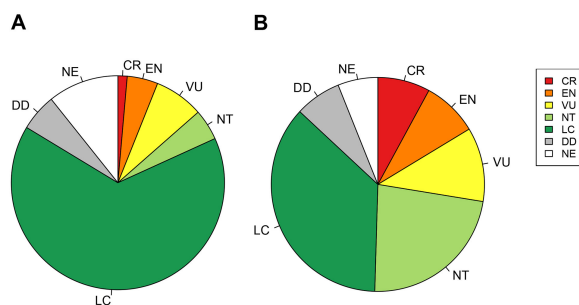


**Figure 3** Latitudinal (A) and slope (B) variation of species community composition in Gaoligong Mountain based on non-metric multidimensional scaling

North: North section (included Zayu); Middle: Middle section (included Fugong, Dulongjiang, and Gongshan); South: South section (included Yingjiang, Longling, Tengchong, Longyang, Pianma, and Lushui); East: East slope (included Longling, Longyang, Lushui, and Gongshan); West: West slope (included Yingjiang, Tengchong, Pianma, and Dulongjiang).



**Figure 4** Hierarchical clustering of mammal species community composition in Gaoligong Mountain along altitude gradients based on Bray-Curtis dissimilarity



**Figure 5** The proportion of threatened mammals in Gaoligong Mountain, extracted from IUCN (A) and China's Red List of Biodiversity (B)

CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern; DD: Data Deficient; NE: Not evaluated.

distribution ranges that no longer extend to the GLGM region, with their presumed populations currently identified as new or belonging to other species under the same genera. For example, *Hoolock tianxing* replaced the eastern hoolock gibbon *Hoolock leuconedys* in GLGM (Fan et al., 2017) and *Meles leucurus* replaced the European Badger *Meles meles* (Abramov & Puzachenko, 2013). This study also dropped 27 “species” from the preliminary list, of which 12 are now known to no longer occur in the GLGM region (Burgin et al., 2020a, 2020b; Wei et al., 2022) (e.g., *Eothenomys melanogaster* and *Petaurista alborufus*). Twelve “species” were dropped as they are now recognized as subspecies or synonyms (e.g., *Rhizomys wardi* as *R. sinensis wardi*, *Rattus koratensis* as synonyms of *R. andamanensis*) (Wei et al., 2022; Wilson & Reeder, 2005). *Panthera tigris* and *Elephas maximus* were considered regionally extinct from GLGM. *Bos frontalis* was removed as it is considered a domestic mammal (Burgin et al., 2020b). However, we added 43 species to the final checklist, of which six are new species published after 2000—*Niviventer pianmaensis* Li et al., 2009; *Rhinopithecus strykeri* Geissmann et al., 2011; *Biswamoyopterus gaoligongensis* Li et al., 2019; *Eupetaurus nivamons* Li et al., 2021; *Neodon bershulaensis* Liu et al., 2022, and *Neodon zayuensis* Liu et al., 2022. The remaining 37 species are new records in the GLGM region added through specimen collection (e.g., *Chiropodomys gliroides*, *Mirostrellus joffrei*, and *Suncus*

*etruscus*) and checking photos and videos evidenced by camera trapping (e.g., *Pseudois nayaur*, *Panthera uncia*, *Capricornis rubidus*, and *Martes foina*) and literature reviews (e.g., *Megaerops ecaudatus* (Feng et al., 2006), *Myotis annectans* (Luo, 1987), and *Niviventer huang* (Ge et al., 2021)), details and vouchers of the changes showed in Supplementary Table S1.

#### Mammal diversity pattern in Gaoligong Mountain

The distribution pattern of biodiversity on the planet is influenced by various factors, mainly ecological limits (e.g., biotic interaction, dispersal, area, climate and productivity) (Paquette & Hargreaves, 2021; Rabosky & Hurlbert, 2015; Siren et al., 2021) and human activities (Faurby & Svenning, 2015). This study found that the species richness of mammals in GLGM increased gradually from south to north; slightly higher in the east than west slope; a pattern that was strongly influenced by altitude evidenced by a unimodal species richness curve, peaking at 2 000–2 500 m asl. The 2 000–2 500 m altitude range has the largest area in GLGM and a well-grown evergreen broad-leaved forest zone (Wang et al., 2004). MacArthur & Wilson (2001) proposed that the number of species increases as the sampling area increases. Colwell & Hurr (1994) and Colwell & Lees (2000) proposed the “mid-domain effect” hypothesis to explain geometric boundaries’ limitations to biodiversity patterns. In GLGM, the evergreen broad-leaved forest at middle altitudes has better precipitation and temperature balance leading to higher productivity than the coniferous forest/meadow at higher altitudes and dry hot valley vegetation at lower altitudes (Li et al., 2000; Wang et al., 2004). Thus, the larger area, mid-domain effect, and better habitat conditions may explain why mammal species richness peaks at the intermediate altitudes in the GLGM. The west slopes of the GLGM are cooler and wetter than the east slope (Li et al., 2000). Based on the complex relationship between temperature and biodiversity (Brodie, 2019; Svenning & Condit, 2008), the higher temperature on the east slope may have yielded higher productivity supporting the higher species richness (De Souza Ferreira Neto et al., 2022; Gebert et al., 2019; Ramírez-Bautista & Williams, 2019). The temperature of GLGM gradually decreases from south to north, while the elevation difference between the bottom and summit of the mountain increases, resulting in richer vegetation and habitat variation along the elevation gradient from south to north

(Zayu is an exception due to its dry climate) (Li et al., 2000). This level of habitat heterogeneity is conducive to the differentiation and colonization of species (Stein et al., 2014), which may support higher mammalian species richness in the north in GLGM. In addition, the human population in the north of GLGM is lower than in the south (Li, 2017), leading to higher mammal species richness in the north. Interestingly, the highest mammal species richness of GLGM occurs in Yingjiang, which may be explained by the large preserved areas of complete tropical rainforest ecosystem (Yin, 2006), and a large altitude span, 218–3 404 m asl.

Results of NMDS and hierarchical cluster analysis showed that the mammal community composition varied significantly between the south and the north sampling sites, while the middle part of the mountain comprised species from both the south and the north communities. Notably, there was no significant difference in mammal species composition between the east and west slopes. The mammal communities clustered into three distinct groups along altitude. These results are consistent with our field surveys; the hot-adapted mammals, such as *Nycticebus bengalensis*, *Arctictis binturong*, and *Hoolock tianxing* are mainly distributed in the south section of GLGM, while the cold-adapted mammals, such as *Panthera uncia*, *Pseudois nayaur*, and *Martes foina* are mainly distributed in the north section (Zayu). While the high altitude in the middle section presents a cold habitat similar to the north section, and the Dulong Jiang valley presents a humid and hot habitat similar to the south section, both northern and southern species can find suitable habitats in the middle section (Fugong, Gongshan, and Dulongjiang). The broad altitudinal difference between the ridge and the foot of GLGM creates significantly different habitats between the high, middle and low altitudes (Li et al., 2000). There are no iconic species in the middle elevations; *Rattus* spp., *Suncus* spp., and *Rhizomys pruinosus* only inhabit the hot low-altitude and dry valley, while *Ochotona* spp. and *Neodon* spp. only inhabit the high-altitude forest and meadow. The ridges of the GLGM are not high enough to be covered with snow all year round, so they do not form an effective barrier to the dispersal of mammals between the east and west slopes.

### The conservation significance of GLGM

This study recorded 212 mammal species in the GLGM region, far more than other Nature Reserves located in tropical or temperate zones nearby, e.g., the Xishuangbanna National Nature Reserve with 130 mammal species (Yang et al., 2006) and the Wuliangshan National Nature Reserve with 123 mammal species (Jiang et al., 2004). Such a high diversity makes GLGM a mammal diversity hotspot in Yunnan and even in China. As the intersection of the three biodiversity hotspots of the Himalayas, Indo-Burma, and southwest China mountains, the faunal composition in GLGM is very complex. In addition to the dominant proportion of Oriental species, there are globally distributed species, Holarctic species, Palearctic species, and Palearctic-Oriental species, with up to 21.2% of the mammal species being regional endemics. Some endemic species have ancient origins (*Uropsilus investigator*, 6 million years ago (Ma): Wan et al. (2018)), while others are newly speciated (*Neodon bershulaensis* and *Neodon zayuensis*, 1 Ma: Liu et al. (2022)), suggesting that GLGM is both an “old species museum” and a “new species cradle” (López-Pujol et al., 2011). The protected mammals and threatened species in GLGM accounted for a high proportion

of the recorded species, with 50 national key protected species, 37 species in Appendix I and II of CITES, and 29 and 58 threatened according to IUCN and China’s Red List of biodiversity, respectively. Some of China’s threatened mammals only occur in GLGM with very small populations, e.g., *Hoolock tianxing* (ca. 150 individuals: Zhang et al. (2020)), *Rhinopithecus strykeri* (ca. 280 individuals: Yang et al. (2022a)), *Trachypithecus shortridgei* (ca. 250–370 individuals: Cui et al. (2016)). The diversity of medium and large-sized mammals in GLGM is very rich, especially the carnivores and primates. We recorded 35 species of carnivores, accounting for 16.5% of mammals of GLGM and 55.6% of the carnivores of China, making the region one of the most species-rich for carnivore diversity in China. Similarly, we recorded ten species of primates in GLGM, accounting for 34.5% of the primates of China, making it an area with the highest primate diversity in China.

The unique geographical location, north-south trend and topography of high mountains and deep valleys of GLGM provide a migration channel for some mammals and a barrier for others, forming species distribution limits from different directions.

#### (a) The northern limit of tropical mammals

The altitudinal variation in climate generated by the topography of high mountains and deep valleys introduced a higher temperature in the Dulong Jiang (=Irrawaddy River) and Nu Jiang (=Salween River) valleys than in other regions at the same latitude (Li et al., 2000). Some tropical species have been able to extend their distribution limit further north along the valley habitats in GLGM, such as *Hylomys suillus*, *Nycticebus bengalensis*, *Chiropodomys gliroides*, *Trachypithecus melamera*, *Hoolock tianxing*, *Berylmys manipulus*, and *Callosciurus phayrei*.

#### (b) The southern limit of Qinghai-Xizang Plateau and Hengduan Mountains mammals

The mountain-valley-related climate variation also formed a lower temperature in the ridge of GLGM than in other regions at the same latitude (Li et al., 2000). The cold-adapted mammals in the Qinghai-Xizang Plateau and Hengduan Mountains, such as *Neodon clarkei*, *Neodon irene*, *Apodemus latronum*, *Moschus chrysogaster*, *Sorex bedfordiae*, and *Niviventer excelsior* dispersed southward along the ridge of GLGM, extending their southern distribution limit to the region.

#### (c) The western limit of South China mammals

As the westernmost mountain range of the Hengduan Mountains, GLGM acted as a natural geographical boundary separating the mountains of northwest Yunnan and the lowlands of north Myanmar (Li et al., 2000). This boundary prevented the westward dispersal of some South China mammals into the lowlands of northeast Myanmar, consequently forming their western distribution limits in GLGM, such as *Uropsilus nivatus*, *Euroscaptor longirostris*, *Blarinella wardi*, *Elaphodus cephalophus*, *Moschus berezovskii*, *Apodemus chevrieri*, and *Rhizomys sinensis*.

#### (d) The eastern limit of the Indo-Burma mammals

GLGM is the watershed of the Dulong Jiang and Nu Jiang (Li et al., 2000). Some mammals mainly distributed in the eastern Himalayas or Myanmar have their eastern distribution limit in GLGM. Some of these species such as *Rhinopithecus strykeri*, *Trachypithecus melamera*, *Trachypithecus shortridgei*, *Hoolock tianxing*, *Capricornis rubidus*, *Euroscaptor micrura*, *Berylmys manipulus*, *Niviventer brahma*, *Callosciurus quinquestriatus*, and *Callosciurus phayrei* are

only distributed on the west slope of GLGM, which form their eastern distribution limits.

The high diversity and endemism, complex faunal origin, and marginal distribution of mammals in GLGM make this region irreplaceable in the study and conservation of mammals in regional, national, and even global.

### Research prospective

The mammals in the GLGM region have a long history of research, with scientific publications on biodiversity and endangered mammals increasing significantly after 2000 (Figure 6). However, the mammal research in this region is still insufficient. Our literature review showed that most previous studies were focused on endangered species—*Hoolock tianxing* (Bai et al., 2007; Fei et al., 2019, 2017; Huang et al., 2010; Li et al., 2015; Wu et al., 2016; Yang et al., 2020a; Zhang et al., 2020) and *Rhinopithecus strykeri* (Chen et al., 2015, 2022; Li et al., 2014; Meyer et al., 2017; Yang, 2019; Yang et al., 2018, 2019, 2020b, 2022a, 2022b), and non-flying small mammals (Gong & Xie, 1989; Song et al., 2020; Thomas, 1914, 1921), with little attention to many other mammal groups, especially bats. With the application of new technologies such as camera traps and molecular systematics, five new mammal species were recently described from GLGM (Ai et al., 2018; Fan et al., 2017; Li et al., 2019b; Liu et al., 2022), and others as new records to China or Yunnan, including medium-sized mammals such as *Rhinopithecus strykeri*, *Capricornis rubidus*, and *Macaca leucogenys* (Chen et al., 2019; Li et al., 2019a; Long et al., 2012). Similar findings have also been achieved in spiders (Zhang et al., 2023) and amphibians and reptiles (Wang et al., 2022; Yuan et al., 2022). Altogether, these progresses suggest that broad and detailed surveys and research will probably lead to the discovery of more new taxa in the GLGM region. We also found that available data are mainly from three major survey routes on both sides of the mountain (Gongshan to Dulongjiang, Lushui to Pianma, and Longyang to Tengchong). Despite recent surveys extending to Zayu in the north and Yingjiang and Longling in the south, many sites are still poorly surveyed or even not surveyed at all. Thus,

more field investigations are necessary to cover these areas.

The mammal checklist shows that some taxa are highly diverse in the GLGM region. For example, 21 species of squirrels (Sciuridae), 10 species of horseshoe bats (*Rhinolophus*), and nine species of white-bellied rats (*Niviventer*) have been recorded from GLGM. How such high diversity formed or originated should be investigated in depth. Moreover, as the intersection of three diversity hotspots and the border between China and Myanmar, GLGM should also receive special attention regarding the transboundary conservation of threatened mammals and the transmission risk of pathogens carried by mammals. A long-term monitoring system for biodiversity, including mammals, should be established to better understand the spatial-temporal dynamics of the biodiversity pattern in GLGM.

### SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Fieldwork in Gaoligong Mountain was permitted by the Forestry and Grassland Administration of Yunnan Province (permit no. (2020) 398 of 27 March 2020).

### SUPPLEMENTARY DATA

Supplementary data to this article can be found online.

### COMPETING INTERESTS

The authors declare that they have no competing interests.

### AUTHORS' CONTRIBUTIONS

Q.L. contributed to finalizing the checklist, data analysis, and manuscript writing. X.Y.L. performed the data analysis and contributed to manuscript writing. W.Q.H. collected and sorted the camera trap photos and data. W.Y.S. reviewed the research history of mammals in GLGM. S.W.H. performed barcoding analysis for species identification. Z.C.H. prepared figures. H.J.W. digitized the data. M.C.L. contributed to the discovery of the new record of *Mirostrellus joffrei* in China. C.Z.P. contributed to specimen collection. K.O.O., W.Y.S., X.Y. L and Z.Z.C edited the language and made valuable comments. Y.X., C.H.R., F.Y.Z., and C.S.Z. assisted in field surveys. X.L.J. designed, supervised the study and revised the manuscript. All authors read and approved the final version of the manuscript.

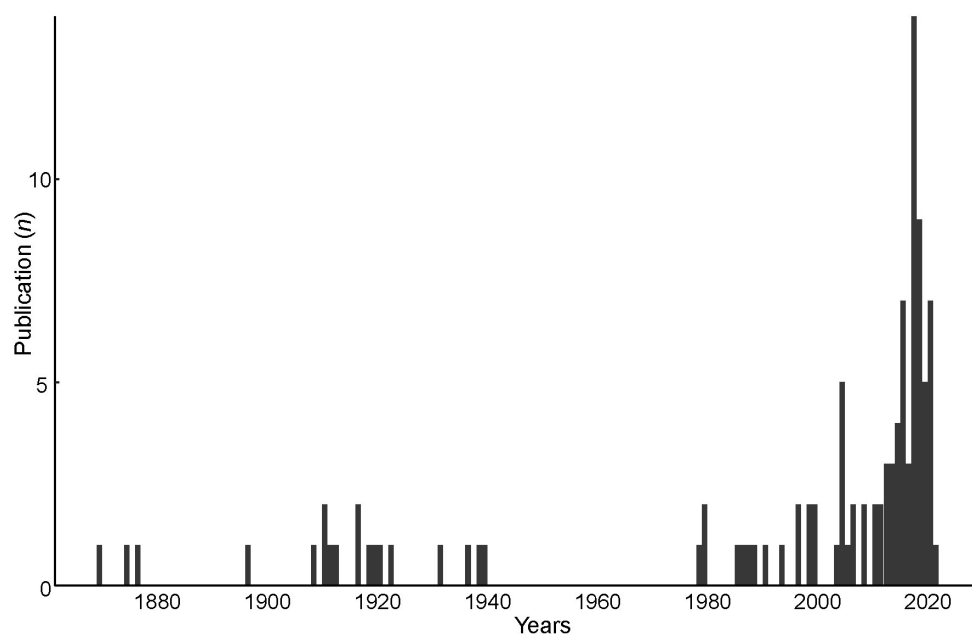


Figure 6 Mammal research literatures in Gaoligong Mountain by year

## ACKNOWLEDGEMENT

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## REFERENCES

- Abramov AV, Puzachenko AY. 2013. The taxonomic status of badgers (Mammalia, Mustelidae) from Southwest Asia based on cranial morphometrics, with the redescription of *Meles canescens*. *Zootaxa*, **3681**(1): 44–58.
- Ai HS, He K, Chen ZZ, et al. 2018. Taxonomic revision of the genus *Mesechinus* (Mammalia: Erinaceidae) with description of a new species. *Zoological Research*, **39**(5): 335–347. (in Chinese)
- Allen GM. 1938. The Mammals of China and Mongolia. Pt. 1. New York: American Museum of Natural History.
- Allen GM. 1940. The Mammals of China and Mongolia. Pt. 2. New York: American Museum of Natural History.
- Anderson J. 1871. A report on the expedition to western Yunan via Bhamo. Calcutta: Office of the Superintendent of Government Printing.
- Anderson J. 1876. Mandalay to Momi: A Narrative of the Two Expeditions to Western China of 1868 and 1875 Under Colonel Edward B. Sladen and Colonel Horace Browne. London: Macmillan and Company.
- Anderson J. 1878. Anatomical and Zoological Researches: Comprising an Account of the Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875; and a Monograph of the Two Cetacean Genera, *Platinista* and *Orcella* [text]. London: B. Quaritch.
- Andrews RC. 1918. Traveling in China's southland. *Geographical Review*, **6**(2): 133–146.
- Andrews RC, Andrews YB. 1918. Camps and Trails in China: A Narrative of Exploration, Adventure, and Sport in Little-Known China. New York: D. Appleton and Company.
- Anthony HE. 1941. Mammals collected by the Vernay-Cutting Burma expedition. In: Allen GM. Papers on Mammalogy, Published in Honor of Wilfred Hudson Osgood. Chicago: Field Museum of Natural History.
- Bai B, Zhou W, Ai HS, et al. 2007. Habitat use of the hoolock gibbon (*Hoolock hoolock*) at Nankang, Mt. Gaoligong in Spring. *Zoological Research*, **28**(2): 179–185.
- Borisenko AV, Lim BK, Ivanova NV, et al. 2008. DNA barcoding in surveys of small mammal communities: a field study in Suriname. *Molecular Ecology Resources*, **8**(3): 471–479.
- Brodie JF. 2019. Environmental limits to mammal diversity vary with latitude and global temperature. *Ecology Letters*, **22**(3): 480–485.
- Burgin CJ, Wilson DE, Mittermeier RA, et al. 2020a. Illustrated Checklist of the Mammals of the World. Volume 1: Monotremata to Rodentia. Barcelona: Lynx Edicions.
- Burgin CJ, Wilson DE, Mittermeier RA, et al. 2020b. Illustrated Checklist of the Mammals of the World. Volume 2: Eulipotyphla to Carnivora. Barcelona: Lynx Edicions.
- Chen GS, Cui LW, Fan PF. 2016. Foraging behavior of squirrels on walnut trees and damage to walnuts in Baihualing, Gaoligong mountain. *Journal of Dali University*, **1**(6): 69–74. (in Chinese)
- Chen YX, Xiang ZF, Wang XW, et al. 2015. Preliminary study of the newly discovered primate species *Rhinopithecus strykeri* at Pianma, Yunnan, China using infrared camera traps. *International Journal of Primatology*, **36**(4): 679–690.
- Chen YX, Xiao ZS, Zhang L, et al. 2019. Activity rhythms of coexisting red serow and Chinese serow at Mt. Gaoligong as identified by camera traps. *Animals*, **9**(12): 1071.
- Chen YX, Yu Y, Li C, et al. 2022. Population and conservation status of a transboundary group of black snub-nosed monkeys (*Rhinopithecus strykeri*) between China and Myanmar. *Zoological Research*, **43**(4): 523–527.
- Colwell RK, Hurtt GC. 1994. Nonbiological gradients in species richness and a spurious rapoport effect. *The American Naturalist*, **144**(4): 570–595.
- Colwell RK, Lees DC. 2000. The mid-domain effect: geometric constraints on the geography of species richness. *Trends in Ecology & Evolution*, **15**(2): 70–76.
- Cui LW, Li YC, Ma C, et al. 2016. Distribution and conservation status of Shortridge's capped langurs *Trachypithecus shortridgei* in China. *Oryx*, **50**(4): 732–741.
- De Souza Ferreira Neto G, Ortega JCG, Carneiro FM, et al. 2022. Productivity correlates positively with mammalian diversity independently of the species' feeding guild, body mass, or the vertical strata explored by the species. *Mammal Review*, **52**(3): 377–391.
- D'orléans PH. 1898. From Tonkin to India by the sources of the Irawadi, January '95-January '96. London: Methuen & Co.
- Dos Santos JW, Correia RA, Malhado ACM, et al. 2020. Drivers of taxonomic bias in conservation research: a global analysis of terrestrial mammals. *Animal Conservation*, **23**(6): 679–688.
- Fan PF, He K, Chen X, et al. 2017. Description of a new species of *Hoolock* gibbon (Primates: Hylobatidae) based on integrative taxonomy. *American Journal of Primatology*, **79**(5): e22631.
- Faurby S, Svenning JC. 2015. Historic and prehistoric human - driven extinctions have reshaped global mammal diversity patterns. *Diversity and Distributions*, **21**(10): 1155–1166.
- Feng Q, Jiang XL, Li S, et al. 2006. A new record genus *Megaerops* and its two species of bat in China (Chiroptera, Pteropodidae). *Zoological Systematics*, (1): 224–230.
- Fei HL, Thompson C, Fan PF. 2019. Effects of cold weather on the sleeping behavior of Skywalker hoolock gibbons (*Hoolock tianxing*) in seasonal montane forest. *American Journal of Primatology*, **81**(9): e23049.
- Fei HL, Zhang D, Yuan SD, et al. 2017. Antipredation sleeping behavior of skywalker hoolock gibbons (*Hoolock tianxing*) in Mt. Gaoligong, Yunnan, China. *International Journal of Primatology*, **38**(4): 629–641.
- Forrest G. 1910. The land of the crossbow. *National Geographic Magazine*, **21**(1-6): 132–156.
- Gao G, Wang B, He CX, et al. 2017. Biodiversity of birds and mammals in alpine habitat of Mt. Gaoligong, Lushui County, Yunnan. *Biodiversity Science*, **25**(3): 332–339. (in Chinese)
- Ge DY, Feijo A, Abramov A V, et al. 2021. Molecular phylogeny and morphological diversity of the *Niviventer fulvescens* species complex with emphasis on species from China. *Zoological Journal of the Linnean Society*, (2): 528–547.
- Geibert F, Njovu HK, Treydte AC, et al. 2019. Primary productivity and habitat protection predict elevational species richness and community biomass of large mammals on Mt. Kilimanjaro. *Journal of Animal Ecology*, **88**(12): 1860–1872.
- Gong ZD, Xie BQ. 1989. Survey of small mammals in gaoligong mountain. *Chinese Journal of Zoology*, **24**(1): 28–32. (in Chinese)
- Huang XX, Zhou W, Ai HS. 2010. Mating behavior of Hoolock gibbon (*Hoolock hoolock*) in the field: a case study at Mt. Gaoligong, Yunnan, China. *Journal of Southwest Forestry University*, **30**(2): 52–55. (in Chinese)
- Jiang XL, Wang YX, Chen SH. 2004. Mammal. In: Yu QG. Wuliangshan National Nature Reserve. Kunming: Yunnan Science & Technology Press, 172–203.
- Jiang ZG, Li S, Liu SY, et al. 2021a. Mammal. In: Gao ZW, Sun H. Species Red List of Yunnan Province. Kunming: Yunnan Science and Technology Press.
- Jiang ZG, Wu Y, Liu SY, et al. 2021b. China's Red List of Biodiversity: Vertebrates Mammals. Beijing: Science Press. (in Chinese)
- Kingdon-Ward F. 1913. The Land of the Blue Poppy: Travels of a Naturalist in Eastern Tibet. Cambridge: University Press.

- Kingdon-Ward F. 1921. In *Farthest Burma: the Record of an Arduous Journey of Exploration and Research through the Unknown Frontier Territory of Burma and Tibet*. London: Seeley, Service.
- Kingdon-Ward F. 1924. *From China to Hkamti Long*. London: Edward Arnold & Co..
- Lan DY, Dunbar R. 2000. Bird and mammal conservation in Gaoligongshan Region and Jingdong County, Yunnan, China: patterns of species richness and nature reserves. *Oryx*, **34**(4): 275–286.
- Li F, Huang XY, Zhang XC, et al. 2019a. Mammals of tengchong section of gaoligongshan national nature reserve in Yunnan province, China. *Journal of Threatened Taxa*, **11**(11): 14402–14414.
- Li GS, Chen YX, Sun WM, et al. 2014. Preliminary observation of population status and social organization of *Rhinopithecus strykeri* in Pianma Town, Nujiang County, China. *Acta Theriologica Sinica*, **34**(4): 323–328.
- Li H, Guo HJ, Dao ZL. 2000. *Flora of Gaoligong Mountains*. Beijing: Science Press. (in Chinese)
- Li H, Li R. 2020. *Plant Resources and Geography of the Gaoligong Mountains in Southeast Tibet*. Wuhang: Hubei Science & Technology Press. (in Chinese)
- Li Q. 2020. Taxonomic Study of Flying Squirrels(Pteromyini)of Mount Gaoligong. Ph. D. dissertation, University of Chinese Academy of Sciences.
- Li Q, Li XY, Jackson SM, et al. 2019b. Discovery and description of a mysterious Asian flying squirrel (Rodentia, Sciuridae, *Biswamoyopterus*) from Mount Gaoligong, southwest China. *ZooKeys*, **864**(33678): 147–160.
- Li WH, Zhang YG. 2010. *Vertical Climate in the Hengduan Mountains and its Impact on Forest Distribution*. Beijing: China Meteorological Press. (in Chinese)
- Li X, Wu JP, Zhou W, et al. 2015. Diet and dietary composition of eastern hoolock gibbon at Nankang, Mt. Gaoligong, Yunnan, China. *Journal of Southwest Forestry University*, **35**(2): 84–89. (in Chinese)
- Li XW. 2017. Optimization of Protected Areas in Nujiang River Basin in Yunnan Based on Human Disturbance Index. Master thesis, Yunnan University, Kunming. (in Chinese)
- Liu SY, Zhou CR, Meng GL, et al. 2022. Evolution and diversification of Mountain voles (Rodentia: Cricetidae). *Communications Biology*, **5**(1): 1417.
- Long YC, Momberg F, Ma J, et al. 2012. *Rhinopithecus strykeri* Found in China!. *American Journal of Primatology*, **74**(10): 871–873.
- Luo YN. 1987. A new record of mammal in China——*Myotis annectans* in Yunnan. *Acta Theriologica Sinica*, (2): 159.
- López-Pujol J, Zhang FM, Sun HQ, et al. 2011. Mountains of southern China as “plant museums” and “plant cradles”: Evolutionary and conservation insights. *Mountain Research and Development*, **31**(3): 261–269.
- Ma SL, Chen SH, Yang XH, et al. 2006. Mammal. In: Yu QG, Qian DR. *Xiaoheshan Nature Reserve*. Kunming: Yunnan Science and Technology Press. (in Chinese)
- Ma SL, Wang YX, Shi LM. 1990. A new species of the genus *muntiacus* from Yunnan, China. *Zoological Research*, **11**(1): 47–53.
- Macarthur RH, Wilson EO. 2001. *The Theory of Island Biogeography*. Princeton: Princeton University Press.
- Meyer D, Momberg F, Mataushek C, et al. 2017. Conservation status of the Myanmar or black snub-nosed monkey *Rhinopithecus strykeri*. Göttingen: Fauna & Flora International, Yangon, Myanmar and German Primate Center.
- Mittermeier RA, Turner WR, Larsen FW, et al. 2011. Global biodiversity conservation: the critical role of hotspots. In: Zachos FE, Habel JC. *Biodiversity Hotspots: Distribution and Protection of Conservation Priority Areas*. Berlin: Springer, 3–22.
- National Forestry and Grassland Administration and National Park Administration. 2021. List of key protected wild animals in China. [https://www.forestry.gov.cn/html/main/main\\_3954/20210225160347342521589/file/20210225160401102702964.pdf](https://www.forestry.gov.cn/html/main/main_3954/20210225160347342521589/file/20210225160401102702964.pdf).
- Oksanen J, Simpson GL, Blanchet FG, et al. 2022. *Vegan: community ecology package, R package version 2.6-4*.
- Paquette A, Hargreaves AL. 2021. Biotic interactions are more often important at species' warm versus cool range edges. *Ecology Letters*, **24**(11): 2427–2438.
- Pei XX, Qu WY, Ren XY, et al. 2022. Diversity and inventory of non-volant small mammals in southern Anhui. *Biodiversity Science*, **30**(4): 21301. (in Chinese)
- Peng HS, Wang YX. 1981. New mammals from the Gaoligong mountains (1). *Acta Theriologica Sinica*, **1**(2): 167–175. (in Chinese)
- Plantexplorers. com. 2023. George Forrest (1873–1932). <https://www.plantexplorers.com/explorers/biographies/forrest/george-forrest.htm>.
- Qu WZ, Zhang GJ, Qu CX, et al. 2006. Mammal. In: Yang YM, Du F. *Intergrated Scientific studies of Tongbiguan Yunnan Nature Reserve*. Kunming: Yunnan Science and Technology Press.
- Rabosky DL, Hurlbert AH. 2015. Species richness at continental scales is dominated by ecological limits. *The American Naturalist*, **185**(5): 572–583.
- Rahbek C, Borregaard MK, Colwell RK, et al. 2019. Humboldt's enigma: What causes global patterns of mountain biodiversity?. *Science*, **365**(6458): 1108–1113.
- Ramírez-Bautista A, Williams JN. 2019. The importance of productivity and seasonality for structuring small rodent diversity across a tropical elevation gradient. *Oecologia*, **190**(2): 275–286.
- Rodrigues ASL, Pilgrim JD, Lamoreux JF, et al. 2006. The value of the IUCN Red List for conservation. *Trends in Ecology & Evolution*, **21**(2): 71–76.
- Schilling T. 1991. Frank Kingdon-Ward: Plant Hunter and Romantic.
- Siren APK, Sutherland CS, Bernier CA, et al. 2021. Abiotic stress and biotic factors mediate range dynamics on opposing edges. *Journal of Biogeography*, **48**(7): 1758–1772.
- Song WY, Gao JY, Wu YH, et al. 2023. Research history. In: Zhou J et al. *Comprehensive Scientific Research on Gaoligong Mountain in Yunnan Province*. Beijing: Science Press, 522–527.
- Song WY, Li XY, Chen ZZ, et al. 2020. Isolated alpine habitats reveal disparate ecological drivers of taxonomic and functional beta-diversity of small mammal assemblages. *Zoological Research*, **41**(6): 670–683.
- Stein A, Gerstner K, Kreft H. 2014. Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. *Ecology Letters*, **17**(7): 866–880.
- Stone W. 1933. Zoological results of the dolan west China expedition of 1931: part 1. Birds. *Proceedings of the Academy of Natural Sciences of Philadelphia*, **85**: 165–222.
- Svenning JC, Condit R. 2008. Biodiversity in a warmer world. *Science*, **322**(5899): 206–207.
- Thomas O. 1912a. The duke of bedford's zoological exploration of eastern Asia. —XV. On mammals from the provinces of Szechwan and Yunnah, Western China. *Proceedings of the Zoological Society of London*, **82**(1): 127–141.
- Thomas O. 1912b. LV. —On Insectivores and Rodents collected by Mr. F. Kingdon Ward in N. W. Yunnan. *Annals and Magazine of Natural History*, **9**(53): 513–519.
- Thomas O. 1914. LIX. —Second list of small mammals from Western Yunnan collected by Mr. F. Kingdon Ward. *Annals and Magazine of Natural History*, **14**(84): 472–475.
- Thomas O. 1920. XLII. —Four new squirrels of the genus *Tamiops*. *Annals and Magazine of Natural History*, **5**(27): 304–308.
- Thomas O. 1921. On small mammals from the Kachin province, northern Burma. *Journal of the Bombay Natural History Society*, **27**: 499–505.

- Thomas O. 1922. XLIV. —On mammals from the Yunnan highlands collected by Mr. George Forrest and presented to the British Museum by Col. Stephenson R. Clarke, D. S. O. *Annals and Magazine of Natural History*, **10**(58): 391–406.
- Wagner J. 1992. The botanical legacy of Joseph Rock. *Arnoldia*, **52**(2): 29–35.
- Wan T, He K, Jin W, et al. 2018. Climate niche conservatism and complex topography illuminate the cryptic diversification of Asian shrew-like moles. *Journal of Biogeography*, **45**(10): 2400–2414.
- Wang K, Lyu ZT, Wang J, et al. 2022. The updated checklist and zoogeographic division of the reptilian fauna of Yunnan Province, China. *Biodiversity Science*, **30**(4): 21326. (in Chinese)
- Wang YX. 1998. Mammal. In: Xu ZH. Nujiang Nature Reserve. Kunming: Yunnan Fine Art Publishing House.
- Wang YX, Wang WM, Zhan Y, et al. 1995. Mammal. In: Xue JR. Gaoligong Mountain National Nature Reserve. Beijing: China Forestry Publishing House.
- Wang ZH, Chen AP, Piao SL, et al. 2004. Pattern of species richness along an altitudinal gradient on Gaoligong Mountains, Southwest China. *Biodiversity Science*, **12**(1): 82–88. (in Chinese)
- Wei FW, Yang QS, Wu Y, et al. 2022. Taxonomy and Distribution of Mammals in China. Beijing: Science Press. (in Chinese)
- Wilson DE, Mittermeier RA. 2009. Handbook of the Mammals of the World. Volume 1: Carnivores. Barcelona: Lynx Edicions, 381–387.
- Wilson DE, Reeder DM. 2005. Mammal Species of the World: a Taxonomic and Geographic Reference. 3<sup>rd</sup> ed. Baltimore: Johns Hopkins University Press.
- Wu JP, Zhou W, Li MH. 2016. Singing frequency and behavior significance of Eastern White-browed Gibbon (*Hoolock leuconedys*) at Nankang, Mt. Gaoligong of Yunnan. *Journal of West China Forestry Science*, **45**(2): 129–134. (in Chinese)
- Yang DH, Dong YH, Wang QY. 2006. Mammal. In: Wang ZQ, Xiong YX. Xishuangbanna National Nature Reserve. Kunming: Yunnan Education Publishing House, 575.
- Yang JH, Huang XY, Jin SH, et al. 2020a. Filling a longstanding knowledge gap: Population size and conservation status of the Endangered Gaoligong hoolock Gibbon (*Hoolock tianxing*) in Houqiao Town, Yunnan. *Global Ecology and Conservation*, **24**: e01347.
- Yang Y. 2019. Feeding Ecology and Conservation Biology of the Black Snub-Nosed Monkey (*Rhinopithecus Strykeri*). Ph. D. dissertation, The Australian National University, Canberra.
- Yang Y, Groves C, Garber P, et al. 2019. First insights into the feeding habits of the Critically Endangered black snub-nosed monkey, *Rhinopithecus strykeri* (Colobinae, Primates). *Primates*, **60**(2): 143–153.
- Yang Y, Li QH, Garber PA, et al. 2020b. Cafeteria - style feeding trials provide new insights into the diet and nutritional strategies of the black snub - nosed monkey (*Rhinopithecus strykeri*): Implications for conservation. *American Journal of Primatology*, **82**(3): e23108.
- Yang Y, Lin AK, Garber PA, et al. 2022a. The 10th anniversary of the scientific description of the black snub-nosed monkey (*Rhinopithecus strykeri*): it is time to initiate a set of new management strategies to save this critically endangered primate from extinction. *American Journal of Primatology*, **84**(6): e23372.
- Yang Y, Tian YP, He CX, et al. 2018. The critically endangered Myanmar snub-nosed monkey *Rhinopithecus strykeri* found in the Salween River Basin, China. *Oryx*, **52**(1): 134–136.
- Yang Y, Youlatos D, Behie AM, et al. 2022b. Positional behavior and canopy use of black snub-nosed monkeys *Rhinopithecus strykeri* in the Gaoligong Mountains, Yunnan, China. *Current Zoology*, **68**(4): 401–409.
- Yin WY. 2006. Studies on Plant Diversity and Conservation of Tongbiguan Nature Reserve in Yunnan Province. Ph. D. dissertation, Beijing Forestry University, Beijing. (in Chinese)
- Yuan ZY, Chen JM, Wu YH, et al. 2022. Revision of the list of amphibian species in Yunnan Province. *Biodiversity Science*, **30**(4): 21470. (in Chinese)
- Zhang L, Guan ZH, Fei HL, et al. 2020. Influence of traditional ecological knowledge on conservation of the skywalker hoolock gibbon (*Hoolock tianxing*) outside nature reserves. *Biological Conservation*, **241**: 108267.
- Zhang QQ, Li Y, Lin YC, et al. 2023. Regression of East Tethys resulted in a center of biodiversity: A study of Mysmenidae spiders from the Gaoligong Mountains, China. *Zoological Research*, **44**(4): 737–738.