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Front cover—Green-spotted Torrent Frog *Amolops viridimaculatus* from Tengchong Gaoligongshan, Yunnan Province, China. © Jian-Huan Yang.
Back cover—Gaoligong Hoolock Gibbon *Hoolock tianxing* from Gaoligongshan, Yunnan Province, China. © Zheng Bi.

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COMMUNICATION

Introduction to a four-year biodiversity survey of Tengchong Section of Gaoligongshan National Nature Reserve, in the footsteps of pioneering naturalists in western Yunnan, China

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Abstract: The Gaoligongshan Mountains in Yunnan Province, southwestern China, is one of the biologically richest areas on Earth. In 2014, we launched a four-year biodiversity survey in the Tengchong Section of Gaoligongshan National Nature Reserve and its immediate vicinity, aiming to update the current diversity, distribution, and status of the mammals, birds, herpetofauna, freshwater fishes, and butterflies on which we have expertise. Despite the intensity of earlier scientific explorations, our survey resulted in the discoveries of a new genus, a number of new species, genera and species new to China, Gaoligongshan, or Tengchong County, and updated the altitude limits for some species. Species richness of mammalian and avian fauna, the two groups most susceptible to habitat loss and hunting, remains remarkably high, but past impacts of hunting and habitat degradation were in evidence. Our results clearly illustrate the immense conservation value of this mountain range and the necessity for more in-depth, focused biodiversity field surveys. This monograph summarizes our findings, and this chapter gives an overview of the geography, climate, vegetation, and ecology of Tengchong, a history of earlier and present biodiversity explorations, and conservation recommendations based on our findings.

Keywords: Birds, biodiversity, conservation recommendations, eastern Himalaya, mammals, new records, new species, southwestern China.

Chinese 摘要： 云南高黎贡山位处中国西南边陲，北起青藏高原，南达中南半岛，山体横跨 5 个纬度，垂直落差巨大，植被与生境类型丰富。由于独特的自然条件，高黎贡山是公认的全球生物多样性热点之一，历来受到国内外生物学家的关注，在过去一世纪进行了多次的调查研究，发表了大量新种与相关文献。为了对高黎贡山国家级自然保护区生物多样性实施更有效的保护，2014–2018 年间，我们在保护区南段西坡的腾冲辖区及其周边对脊椎动物类群及蝴蝶开展了系统性调查编目，发现了世界新属、新种，以及一系列中国、高黎贡山及腾冲的新纪录属/种，亦更新了一些物种的海拔分布上限。鸟兽等类群对人为干扰尤其敏感，腾冲仍保存了极高的物种多样性，但历史上的人为破坏也导致一些类群的消减及灭绝。调查成果充分凸显了高黎贡山丰富的生物多样性，同时继续开展长期、详细野外调查的必要性。本专刊是我们野外考察工作的一个阶段性总结，而本文介绍了腾冲地区的气候、地理、植被及生态概况，对阐述了腾冲地区生物多样性研究历史，并根据调查结果提出了几个重点保育建议。

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Author contribution: BPLC wrote the paper, ZB and S-ZD contributed data.

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INTRODUCTION

The Gaoligongshan Mountains (hereafter GLGS) is a long, narrow mountain chain in the western part of China's Yunnan Province adjoining northern Myanmar. Due to its complex geography and biotic assemblage, scientists of different disciplines define the exact boundary of GLGS somewhat differently. Nonetheless, it is generally agreed upon that the main range of GLGS is the western edge of the Hengduan Mountains, spanning from the Tibetan Plateau to Myanmar, measuring some 600km over 5° in latitude. It has an altitude range from 210m to over 5,000m and it covers an area of over 111,000km^2. The rugged, contiguous ridge divides the Irrawaddy (Ayayerwaddy) and Salween (the Chinese section is called Nujiang) basins, and these rivers cut gorges over 2,000m deep parallel to the mountain range. The topography and geography of this mountain range were described in detail by Chaplin (2005), who considered it to be "one of the world's most significant biodiversity hotspots outside of the tropics" and analyzed its geography in relation to its rich and unique biodiversity.

The unique geographic location and tectonic history of GLGS, along with its extreme topographic relief and complexity in geology, landforms, hydrology, and climate, have produced many diverse habitat types that support biotic components from the Himalaya, the mountains of southwestern China, and the Indo-Burma biodiversity hotspot. This makes GLGS one of the biologically richest places on earth (Li et al. 1999; Hoffmann 2001; Mittermeier et al. 2011; Lei et al. 2015; Liu et al. 2016) and a treasure trove for new discoveries (e.g., Ma et al. 2013; Fritsch et al. 2015; Yang et al. 2016a; Zhu et al. 2016; Chen et al. 2017; Fan et al. 2017). Since the 19th Century, GLGS has been a magnet for naturalists and scientists from China and abroad (e.g., Anderson 1876; Rothschild 1923; Allen 1938; Tang 1996; Stotz et al. 2003; Long 2008; Liang et al. 2015).

To safeguard these exceptional biodiversity assets, the Chinese government began to protect parts of GLGS as early as 1962, and the Gaoligongshan National Nature Reserve (hereafter GLGSNNR), created in 1986, is the largest protected area in Yunnan. GLGSNNR has an area of 4,052km^2 and is geographically separated into three sections straddling over 3° in latitude (24.933–28.367 ^{0}N): the northern Gongshan Section managed by Nujiang Prefecture (2,428km^2, 27.517–28.367 ^{0}N), the middle Fugong Section managed by Nujiang Prefecture (379km^2, 25.183–26.250 ^{0}N), and the southern section jointly managed by Lushui of Nujiang Prefecture and Baoshan Municipal City (1,245km^2, 24.933–26.150 ^{0}N). GLGSNNR is divided into two administrative bureaus (Nujiang and Baoshan) and the management of the Baoshan Section is shared by two management centres—the eastern Salween slope as Longyang District managed by the Baoshan Administrative Bureau and the western Irrawaddy slope managed by the Tengchong Management Bureau (hereafter TC-GLGS) (Fig. 1).

GLGSNNR has some of the largest and most intact tracts of natural forests in southeastern Asia, with impressive lists of animal and plant groups including numerous endemic and relic species (Stotz et al. 2003; Xiong & Ai 2006; Dumbacher et al. 2011; Long et al. 2012). Studies show that it supports China's largest population of the Gaoligong Hoolock Gibbon *Hoolock tianxing* (Chan et al. 2017) and contains a large part of the world population of the Black Snub-nosed Monkey *Rhinopithecus strykeri* (Ma et al. 2014). Scientists have estimated GLGSNNR to harbour more than 5,000 vascular plants and over 600 bird species (Stotz et al. 2003). Its immense conservation value is widely recognized, having been listed as a UNESCO biosphere reserve (UNESCO 2017), a UNESCO world heritage site under the "Three Parallel Rivers of Yunnan Protected Areas" (UNESCO 2003), and an IUCN key biodiversity area under "Gaoligongshan-CN244" (BirdLife International 2018).

In 2014, we launched a four-year systematic faunal survey in TC-GLGS and its immediate environs, focused on vertebrates and butterflies on which we have expertise. Detailed survey methodology and results of the studied taxon groups are provided in various articles of this monograph (Li et al. 2019; Lo & Bi 2019; Yang et al. 2019; Zheng et al. 2019). The present paper aims to provide background information on the geography, climate, vegetation, and ecology of Tengchong, as well as a brief summary of earlier and current biodiversity explorations in the area. Future directions for conservation management are also provided based on our findings.

Geography of Tengchong and Glgsnnr

Tengchong County is managed under Baoshan Municipal City, with a land area of 5,845km^2 and a human population of over 680,000, sharing ca. 150km of the international border with Kachin State of northern Myanmar. The area was variously known as Tengyue, Tingyueh, Teng Yueh, Momein, and Momien in English-language literature of the late 19th and early 20th centuries. The topography of Tengchong is of a horseshoe-shape, being surrounded by a series of fringing high mountains on all sides with the opening facing south. The lowest

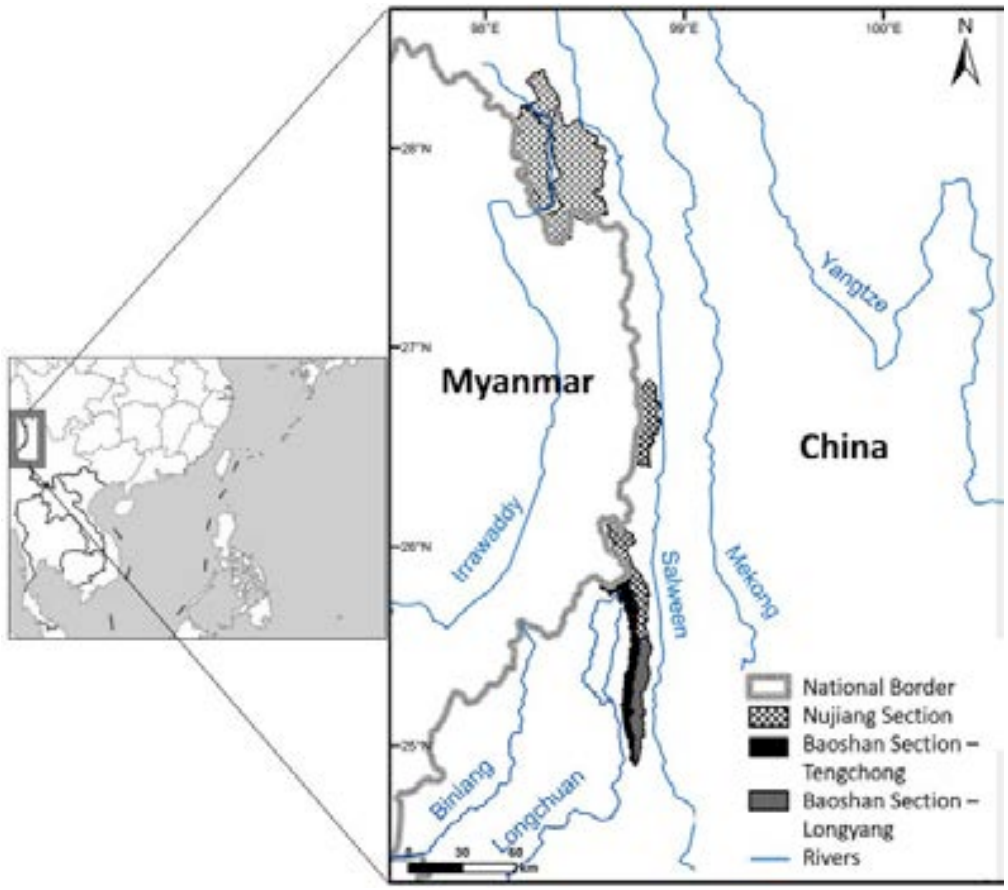

Figure 1. Gaoligongshan National Nature Reserve in Yunnan, China, with locations mentioned in the text.

point is Xinhua Township at 930m, climbing northwards to an elevation of 1,650m at Tengchong Town. The main spine of GLGS is merely 20km to the east of Tengchong Town, rising abruptly to an average altitude of 3,000m, reaching its highest point at Mt. Danaozi (3,780m) in northern Tengchong. Numerous steep hill streams originating from TC-GLGS feed the two major tributaries of the Irrawaddy in China—the Longchuan River flows along the foothills of GLGS and exits China as Shweili River in Myanmar, while the Binglang River draining the mountains of northwestern Tengchong is the main source of the Daying (Taiping) River which flows towards Myanmar's Bhamo. Tengchong County has a forest cover of 73%; the major settlements and farmlands are scattered along the alluvial plains.

The whole western slope of southern GLGS has been included in TC-GLGS. The reserve covers an area of 424.18km^2 between 24.933 ^{0}N and 25.833 ^{0}N, with an altitude range of 1,900–3,780 m. TC-GLGS has a 90% forest cover which is managed by six management sections, each with its own management station, substations, and ranger teams. An eco-corridor measuring 2,600ha (24.817–24.933 ^{0}N) has been established at the southern tip of TC-GLGS to connect the reserve with Xiaoheishan Provincial Nature Reserve, providing additional lower-elevation habitats (Fig. 2).

Climate of Tengchong

The major influence on the climate of Tengchong is the annual monsoon cycle. From May to October, the deep river valleys of the Irrawaddy funnel southwestern monsoon rains from the Indian Ocean through the lowland tropics to GLGS. This is the wettest and warmest period of the year, accounting for ca. 87% of the annual rainfall with the temperature approaching 30°C under the sun. The weather is the driest and coldest from November to April, with occasional frost in the valleys while snow covers the higher grounds above 3,000m (Image 1). In Tengchong Town at 1,650m, the annual mean temperature is 15.4°C and the annual rainfall is ca. 1,500mm with annual humidity of 77%. Because of the rapid changes along the altitude gradient, distinct climatic zones can be found within a few kilometres: subtropical zone occurs below ca. 2,000m, temperate

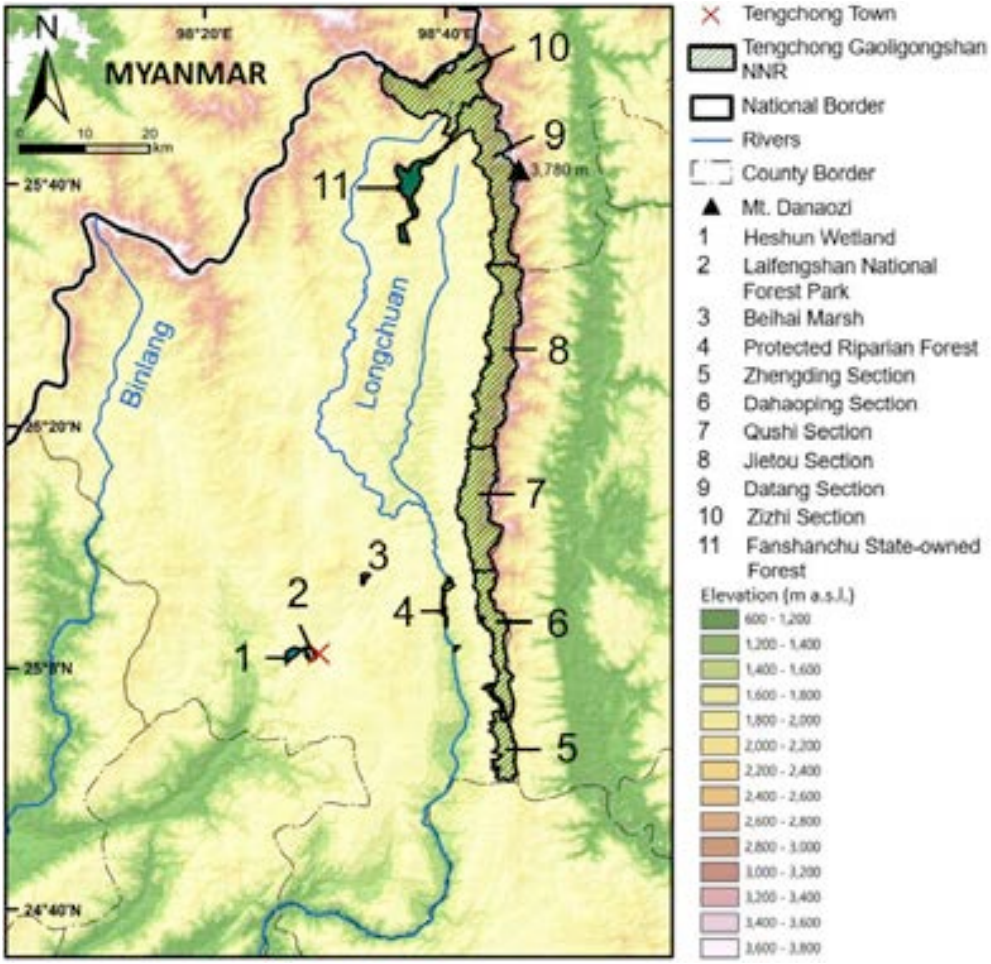

Figure 2. Tengchong in Yunnan, China, with survey locations mentioned in the text.

zone from 2,000m to 3,000m, and subalpine zone above 3,000m. The high, contiguous range of GLGS creates pronounced rain shadow effect; being on the windward side of GLGS, Tengchong receives higher rainfall compared to the eastern slope (Chettri et al. 2010; Liu 2014).

Vegetation of Tengchong

Tengchong has long been a major trading hub in southwestern China and was used by Chinese and foreign merchants as a major stopover along the ancient Southwest Silk Road, which linked central China to the Middle East dating back 2,000 years. Three major trails were used by caravan fleets to traverse the main range, and caravansaries were built on mountain passes for these arduous expeditions. One such ancient caravanserai sitting by a saddle at 3,160m (25.283 ^{0}N & 98.733 ^{0}E), called "South Alms Inn" ('Nanzhaigongfang' in Chinese), is particularly well-preserved and continues to be used by visiting researchers and eco-tourists for overnight stays (Image 2). Tengchong was a major battlefield during the Japanese invasion in World War II; many trenches and pillboxes were constructed on the mountains and some are still visible today. These historical events imply that the vegetation of TC-GLGS cannot be considered pristine and that the primary vegetation for much of the alluvial plains and low hills have been destroyed. Despite the sustained human footprints, the rugged and largely inaccessible slopes above 2,000m are covered in vast expanses of intact broadleaf forests up to the timberline.

Because of the complex local geomorphology, the north-south orientation of the ridge, and the huge vertical differences in topography, vertical vegetation zonation is well developed in TC-GLGS; humid subtropical forest quickly turns to moist temperate forest and then to subalpine thickets within a few kilometres along the elevation gradient, with two major altitude transitions at 1,800–2,000 m and near 2,800m, respectively (Xue et al. 1995; Stotz et al. 2003) (Fig. 3). The flora and

Image 1. Gaoligongshan Mountains in Tengchong, Yunnan, China, in winter, with the snow-covered Mt. Danaozi in the middle.

Image 2. South Alms Inn (Nanzhaigongfang in Chinese) at 3,160m, the best-preserved caravanserai in Gaoligongshan, China.

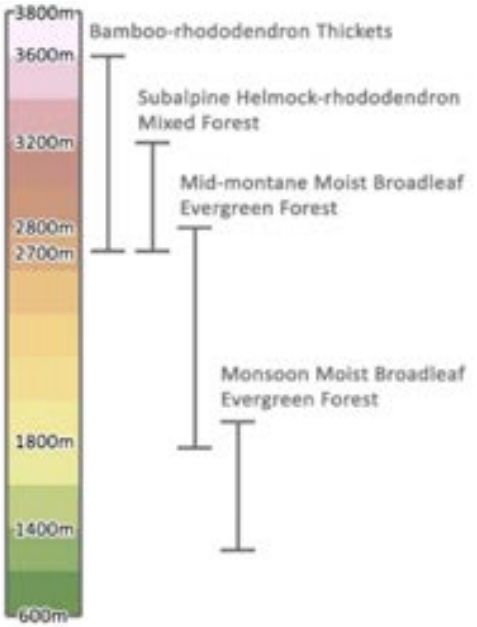

Figure 3. Altitude zonation of vegetation of Tengchong in Yunnan, China.

vegetation of TC-GLGS are relatively well-studied; a general description can be found in Wen et al. (2003) while more detailed botanical accounts can be found in Xue et al. (1995), Li et al. (2000), Xiong & Ai (2006), and Liu (2014).

According to Xue et al. (1995), there are four major altitude vegetation types in TC-GLGS. These are:

(1) Monsoon moist evergreen broadleaf forest (Image 3a) dominated by *Castanopsis hystrix* and *Lindera communis*. This forest type is distributed below 2,000m where human activities have destroyed much of the original vegetation; only remnant patches or secondary regrowth can be found. Average canopy height is currently under 20m.

(2) Mid-montane moist evergreen broadleaf forest (Image 3b) dominated by the families Fagaceae, Lauraceae, Theaceae, Ericaceae, and Magnoliaceae between 1,800m and 2,800m. TC-GLGS supports extensive tracts of old-growth forest of this vegetation type. The forest has an average canopy height of over 30m and is particularly rich in epiphytes such as mosses, ferns, orchids, and Araceae.

(3) Subalpine hemlock-rhododendron mixed forest (Image 3c) dominated by various oaks and rhododendron species, with scattered coniferous species such as *Tsuga dumosa* and *Juniperus pingii*. This forest type can be found at elevations between 2,700m and 3,200m; in areas with harsh conditions, pure stands of conifers can be found. Average canopy height is 25m, and trees are cloaked with mosses, lichens (e.g., *Usnea longissima*), and epiphytic rhododendrons (e.g., *Rhododendron sulfureum*).

(4) Subalpine bamboo-rhododendron thickets (Image 3d) are found above 2,700m. The dominant bamboo species are of the genus *Fargesia*, especially *F. orbiculata*, with clumps of dwarf rhododendrons (e.g., *R. sinogrande*) and upland herbs.

According to vegetation classification, there is also a latitude transition zone at 25°30'N at the Jietou Section (Xue et al. 1995). The difference in vegetation may have implications on distribution limits for the less mobile taxa, particularly herpetofauna.

Image 3. Major altitude vegetation types in Tengchong, Yunnan, China: a—Monsoon moist evergreen broadleaf forest near Longchuan River (ca. 1,350m) | b—Mid-montane moist evergreen broadleaf forest in Datang Section (ca. 2,400m) | c—Subalpine hemlock-rhododendron mixed forest in Jietou Section (ca. 2,900m) | d—Subalpine bamboo-rhododendron thickets in Jietou Section (ca. 3,200m).

ECOLOGY OF TENGCHONG

Major Wildlife Habitats

Old-growth forest (Image 4a): The majority of TC-GLGS is under contiguous cover of old-growth forest, except at the highest ridges above the timberline. As the lower limit of the reserve boundary is at 1,900m, mid-montane moist evergreen broadleaf forest is the reserve's dominant forest type. It supports the highest concentration of biodiversity in TC-GLGS, including flagship species such as the Gaoligong Hoolock Gibbon and the Marbled Cat *Pardofelis marmorata*, as well as restricted-range endemics such as the newly discovered amphibian *Leptobrachium tengchongense*, and is therefore of the greatest conservation significance. On the upper slopes, some pure stands of the handsome subalpine hemlock *Tsuga dumosa* and juniper *Juniperus pingii* can be found. Fragments of old-growth monsoon moist evergreen broadleaf forest below 2,000m are confined to inaccessible gullies and around temples, but these remnants are probably too small to support wildlife of particular conservation interest.

Secondary forest (Image 4b): Nearly all the original forests below the 2,000m lower boundary of TC-GLGS have been lost. The original vegetation type dominating this elevation band is monsoon moist evergreen broadleaf forest, but local residents have long cleared the forest for farming, timber plantations, and pasture. With the recent enactment of pro-conservation national policies, many hillsides are allowed to regenerate and secondary forests now cover much of these hillsides despite continued human disturbances. These secondary forests are of conservation value as globally threatened species such as the Red Panda *Ailurus fulgens* and Mrs Hume's Pheasant *Syrmaticus humiae* have been recorded in it. The lower-elevation forest (below ca. 1,500m) supports a distinct biotic community, with elements of the Oriental biogeographic realm not found at higher mountains, such as King Cobra *Ophiophagus hannah*, Ashy Bulbul *Hemixos flavala*, and Blue-throated Barbet *Psilopogon asiaticus*. Major secondary forest blocks include the Longchuan River protected riparian forest (303ha, 25.050–25117 ^{0}N & 98.650–98.667 ^{0}E, elevations from 1,300–1,680 m) and Fanshanchu State-owned forest (153ha, 25.683–25.717 ^{0}N & 98.617–98.667 ^{0}E, elevations from 2,000–2,800 m), both of which fall under the jurisdiction of TC-GLGS.

Plantation forest (Image 4c): One of the major

Image 4. Major wildlife habitats in Tengchong, Yunnan, China: a—Old-growth forest in Datang Section | b—Secondary forest in Datang Section | c—Mature stands of planted native cedar *Alnus nepalansis* in Laifengshan National Forest Park | d—Beihai Marsh Nature Reserve.

incomes of Tengchong farmers comes from household timber plantations, and many rolling hills near settlements are covered in plantation forests. In contrast to other regions of China, native timber species are used in Tengchong, such as cedars *Alnus nepalansis* and *Taiwania cryptomerioides* and birch *Betula alnoides*. Although these monoculture plantations support far lower biodiversity compared to natural forests, these native species plantations appear to be less hostile to local wildlife; adaptable forest species such as squirrels *Callosciurus erythraeus* and *Dremomys pernyi*, galliformes such as Silver Pheasant *Lophura nycthemera* and Mountain Bamboo Partridge *Bambusicola fytchii*, and woodpeckers such as Great-spotted Woodpecker *Dendrocopos major* are able to survive in less-disturbed patches. An interesting example is the Laifengshan National Forest Park in Tengchong Town, where mature stands of native cedar *Alnus nepalansis* and birch *Betula alnoides* planted after World War II are attracting bird species typical of old-growth broadleaf forest found in similar elevation bands; epiphytic orchids such as *Phalaenopsis* sp. and *Dendrobium* spp. have also colonized the older trees.

Natural freshwater wetlands (Image 4d): The most extensive and most important lentic wetland lies in the Beihai Marsh Nature Reserve (16.29km^2, 1,725m, 25.100–25.133 ^{0}N & 98.500–98.583 ^{0}E), which is a barrier lake from historical volcanic activities. Water depth of the lake varies from 2–13 m; together with the fringing marsh, it supports a rich macrophyte community with 130 species recorded growing on the floating mats that feed wintering ducks and the Common Crane *Grus grus*, as well as a healthy resident population of the Purple Swamphen *Porphyrio porphyrio*. Other wetland-dependent vertebrates have not been properly surveyed, but are expected to be impoverished due to the high human population around the lake. The Longchuan and Binglang rivers provide ample lotic wetland habitats along their courses. Many agricultural and hydropower dams, however, have been and are being built, and sand-mining pits are common near towns, destroying shingle bank and other shallow-water habitats. Wintering Black Stork *Ciconia nigra*, Ibisbill *Ibidorhyncha struthersii*, River Lapwing *Vanellus duvaucelii*, and wild ducks occur in river sections with less human disturbances. The Eurasian Otter *Lutra lutra* was once widely distributed in the rivers of Tengchong but has not been recorded in recent decades.

Man-made habitats: Some wildlife thrives in man-made habitats. Egrets, herons, grebes, and cormorants

feed and breed in the vicinity of reservoirs and ponds where they are not harassed. Interestingly, one of the most bird-rich reservoirs is in Tengchong Town, with a sizeable resident population of herons, egrets, and wintering ducks and gulls, indicating that human disturbances may be the reason behind the lack of waterbirds in other similar habitats. Shallow-shored reservoirs and flooded and abandoned farmlands offer marshy habitats for waterbirds and commensal herpetofauna, and the forest-dependent Yunnan Newt *Tylototriton shanjing* can be found in such wetlands close to natural forests. The Black-tailed Crake *Porzana bicolor* marginally occurs in southwestern China, and our Tengchong records came from marshy abandoned fields close to human habitations. Squirrels *Callosciurus erythraeus* and *Dremomys pernyi* and the Common Pheasant *Phasianus colchicus* are the more notable wildlife around village groves, tea terraces, and orchards.

BRIEF HISTORY OF EARLIER BIODIVERSITY

Explorations in Tengchong

Tengchong has a long history of biodiversity exploration and research. The first modern-day scientific account on Tengchong biodiversity was written by British explorer and zoologist John Anderson, who made two expeditions to western Yunnan in 1868 and 1875, respectively. Although he only ventured as far as the surroundings of present-day Tengchong Town, his pioneering work is invaluable for our understanding of biodiversity of this remote region, including species described with Tengchong specimens (Anderson 1871, 1876, 1878). Following Anderson's footsteps, other western naturalists and explorers visited western Yunnan on collecting expeditions; Xiong & Ai (2006) and Boufford (2014) gave brief overviews of these early explorers. Among them, the most notable is George Forrest, who made seven collecting expeditions during his extended stay in Tengchong between 1904 and 1932; his most famous Tengchong discovery is the largest rhododendron in the world, the Big Tree Rhododendron *Rhododendron protistum* var. *giganteum*, with major distribution in northern Tengchong (Maspero 2004). Several early western naturalists also made extensive zoological collections in or near Tengchong; details on the mammalian explorations from the 19th and early 20th centuries have been summarized by Allen (1938, 1940) and those on avifauna by Dumbacher et al. (2011).

Chinese scientists started exploring GLGS as early as the 1930s and the Chinese Academy of Sciences organized several major multidisciplinary expeditions to the region starting from the 1950s. Their works were published in numerous papers, monographs, and taxon-specific volumes, providing detailed documentation on the biodiversity of the region (Peng et al. 1980; Xue et al. 1995; Yang et al. 1995; Tang 1996; Yang & Yang 2004). Scientific research and surveys continue to be conducted by Chinese scientists in GLGS including Tengchong, further advancing our understanding of the biodiversity value of the area (Xiong & Ai 2006; Liu 2014).

The Current Biodiversity Survey

Although Tengchong has been the subject of intense and extended scientific interest, major biodiversity surveys were conducted over a decade ago, and a comprehensive assessment on the current diversity, distribution, and status of major wildlife groups is lacking. A common issue with many existing regional and site species checklists is that all historical records are included during compilation, irrespective of the current status of these species. Although this practice of data culmination results in impressive long checklists for a study area and can be useful for some research purposes, it can be counter-productive because the ever-growing lists mask the temporal and spatial changes in distribution and abundance for many species, which would have allowed scientists, reserve managers, and policy-makers to evaluate efficacy in protection effort and to formulate appropriate conservation actions.

It was with this in mind that we launched our survey on mammals, birds, herpetofauna, freshwater fishes, and butterflies. The benchmark data we collected is important to assist GLGSNNR in making informed management decisions. From the beginning of April 2014, our team conducted repeated surveys in TC-GLGS and, to obtain a more comprehensive picture of wildlife communities in Tengchong, some efforts were made to cover habitat types, as such low-elevation forests, wetlands and farmlands, outside the reserve. These sites include the Laifengshan National Forest Park, Beihai Wetland, and Heshun Wetland near Tengchong Town, Fanshanchu State-owned forest and Longchuan River protected riparian forest, and better-quality riparian habitats along the Longchuan and Binglang rivers (see Fig. 2). A combination of survey methods, including camera trapping, non-random transects, point counts, active searching, incidental observations, and spotlighting were deployed and are described in the respective articles of this monograph. Our systematic fieldwork cut-off point was November 2018 and significant incidental records were up to January

2019. We covered the full seasonal cycle and altitude range from 1,100m at Binglang River to the summit of Mt. Danaozi at 3,780m. A total of 682.5 man-days (172 for mammals, 334 for birds, 121 for herpetofauna, and 57.5 for butterflies, respectively) were spent conducting fieldwork, excluding incidental observation. Survey on freshwater fishes was not representative for various reasons and has been omitted from this monograph. Readers interested in the ichthyofauna of Tengchong should consult Chen (2013) and Yang et al. (2016b); and Chan & Bi (2016) illustrated some common species found in the headwaters of TC-GLGS.

DISCUSSION

In summary, it is clear that GLGS harbours enormous biodiversity and is one of the world's most important biodiversity hotspots; Tengchong is an integral part of this unique ecosystem. Our survey results indicate that the ecosystems of TC-GLGS are largely intact and maintain much of the biological assets. Vertebrate groups are the best-documented wildlife groups in TC-GLGS and are featured in all previous biodiversity inventories. We nonetheless discovered a number of new species, as well as genera and species new to China, to GLGS, and to Tengchong. Species richness of many studied groups remains high; for example, an impressive 46 species of non-volant mammals and 393 bird species were recorded; details are reported in the respective articles of this monograph. Our results may actually underestimate the true biodiversity of Tengchong, as area coverage in our survey effort was biased towards the 2,000–2,600 m elevation band where access was less challenging, and we fully expect additional species to be found in future surveys. Our study clearly demonstrates the fundamental role and irreplaceable importance of repeated, sustained, and focused field surveys, which seems to have been relegated to second place in conservation biology (Ríos-Saldana et al. 2018).

To safeguard the future of this remarkable biodiversity, it is important to conduct regular monitoring on selected key species, such as those with low population size (e.g., the Gaoligong Hoolock Gibbon and the Sclater's Monal *Lophophorus sclateri*) and those most susceptible to poaching (e.g., the Forest Musk Deer *Moschus berezovskii*) and climate change (e.g., the Fire-tailed Myzornis *Myzornis pyrrhoura*), so that GLGSNNR can make the best management decisions. The conservation and restoration of unprotected low-elevation forests and to enhance their connectivity with TC-GLGS appear to be the most pressing conservation challenges for GLGNNR, because a distinctive biotic community is restricted to below 2,000m, as demonstrated and emphasized by many researchers and conservation biologists (Lan & Dunbar 2000; Stotz et al. 2003; Wang et al. 2004; Wu et al. 2013; Wu et al. 2014; Zhang et al. 2015). Mammals, in general, are most susceptible to hunting; it is noteworthy that species richness for most mammal groups in TC-GLGS is comparable to other significant protected areas in the eastern Himalaya. The alarmingly low density of ungulates and the (near-)extirpation of large carnivores, however, are of great concern. Ungulates are the main prey base for large carnivores, and healthy populations of ungulate species are critical for the survival of top predators (Tan et al. 2018). Although rampant hunting is a thing of the past in Tengchong, every effort should be made to ensure poaching is halted for the recovery of ungulate populations, and eventually that of the large carnivores.

Tengchong is contiguous with vast expanses of forests along the eastern Himalaya mountains, connecting to Hkakaborazi National Park in northern Myanmar all the way to Namdapha National Park of India and beyond, making it amongst the largest forest landscapes in Asia with extraordinary altitude and habitat heterogeneity; the conservation value of Tengchong cannot be overstated.

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Mammals of Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China

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Abstract: We conducted field surveys on the mammalian diversity in the Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China, using camera trap and transect method between April 2014 and May 2018. A total of 46 identifiable mammal species were recorded, including one new record for China and nine new species for the Tengchong County. Of the 46 species, nine are globally threatened (three Endangered and six Vulnerable) and six are Near Threatened on the IUCN Red List of Threatened Species. Species richness of most mammal groups in Tengchong remains high compared to similar sites in neighbouring countries; however, encounter rates for species vulnerable to high hunting pressures were quite low and large carnivores, except the Asiatic Black Bear, were either extirpated or at critically low numbers. Future surveys should cover a wider elevation range and a variety of microhabitats to increase the probability of detecting the species not yet recorded. To enhance the conservation value of the reserve for the diverse mammalian community, poaching and livestock grazing should be further controlled; in addition, protection and restoration of low-altitude forests should be encouraged. Monitoring and research on selected flagship species should also be conducted.

Keywords: Camera trap, new records, spotlighting, threatened species, transect survey.

Chinese 摘要：2014 年 4 月至 2018 年 5 月，笔者利用红外线相机以及样线调查对高黎贡山国家级自然保护区腾冲片区开展了兽类考察工作。考察共记录兽类 46 种，包括 1 种中国新纪录及 9 种腾冲新纪录。其中 9 种被 IUCN 红色名录列为全球受胁物种（3 种濒危；6 种易危），6 种为近危。与临近国家的相似保护地比较，腾冲大部分类群的兽类物种丰富度较高，但容易受盗猎影响的物种的遇见率相对较低，大型食肉类动物除去黑熊外已经区域性灭绝或只残留极小的种群。建议未来调查应涵盖更广的海拔跨度以及更多的生境类型，以增加探测未被记录物种的发现几率。为了更好的保护研究区域的兽类多样性，笔者建议对道路及保护区中的放牧现象加大管理打击，加强低海拔森林的保护和恢复，并对个别旗舰物种开展进一步的研究与监测。

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Author contribution: Fei Li and Bosco Chan performed the analysis and wrote the paper. All authors collected and contributed data.

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INTRODUCTION

Gaoligongshan Mountains (hereafter GLGS) is well-known for its rich biodiversity and unique geomorphological features (Chan et al. 2019). It attracted visiting naturalists as early as the 19th Century; the most notable among them were John Anderson, George Forrest, Frank Kingdon-Ward, and Roy Chapman Andrews, who made a series of significant mammal collections from GLGS. Anderson collected the type series of Yunnan Giant Flying Squirrel *Petaurista yunnanensis* from the surroundings of Tengchong Town in 1868 (Anderson 1878) and the type specimen of Yunnan Hare *Lepus comus* from Tengchong in 1917 (Allen 1938). The collection of insectivores and rodents from GLGS by Forrest and Kingdon-Ward greatly improved our understanding of these little-studied groups in the eastern Himalaya (Thomas 1912, 1914, 1922; Hinton 1923). From the mid-20th Century, research on the area's mammals was carried out by Chinese zoologists, further enhancing understanding of the mammalian fauna of the region, especially on the species composition of communities and their geographic distribution across the vast mountain range (Pen et al. 1962; Peng & Wang 1981). A baseline survey of Gaoligongshan National Nature Reserve listed 89 mammal species for Tengchong County, including five species of Chiroptera and 16 species of Muridae (Xue et al. 1995).

In April 2014, we launched a systematic mammal survey in the Tengchong Section of Gaoligongshan National Nature Reserve (hereafter TC-GLGS). We provide a report on the current mammal diversity and conservation status in TC-GLGS based on camera trap and transect surveys conducted between April 2014 and May 2018.

MATERIALS AND METHODS

Camera trap survey

The camera trap survey was conducted between September 2014 and May 2018. The total number of camera trap stations was 147, and they covered elevations from 1,515m to 3,350m. Three models of infrared camera traps (Loreda L510, Loreda; SG-990V, Shenzhen Siyuan Digital Technology Company; Reconyx PC900, Reconyx) were used. Camera traps were deployed in microhabitats thought to likely maximize the probability of detecting medium- to large-sized ground-dwelling mammals, such as animal trails, salt licks, ridgelines, water sources, and underneath fruiting trees. A group of knowledgeable reserve wardens assisted in identifying suitable locations for deploying camera traps, and about 60% of our camera trap stations were selected based on their advice. Most of the cameras were mounted on trees at a height of c. 30–40 cm from the ground at a distance of 2–4 m to the target area. Time and date were automatically recorded on each exposure. Commercial lures (Hawbaker's Weasel and Marten Lure) were used at five camera trap stations as a trial to test the effectiveness for future camera trapping study.

Non-random transects

Both diurnal and spotlighting transects were conducted in addition to the camera trapping. Forest trails, watercourses, and quiet forest roads were walked on to complement the inefficiency of camera trapping for strictly arboreal species and to maximize encounter rate of mammal species. Fifteen transects were surveyed, amounting to a total of 180.76km and 172 man-days, covering elevations between 1,300m and 3,430m, during both the cold-dry and wet-warm seasons. During these walks, all observed animals were recorded. Tracks, feeding signs, and droppings which could be confidently identified were also recorded (see Table 2 for field signs recorded for each species). Spotlighting surveys were conducted in 11 of these transects, amounting to 37.27km; we walked along quiet roads, trails, and streams at a slow pace (under 1km/h) with two or three observers (Table 1). Locations of our camera trap and transect surveys can be found in Fig. 1.

Data analysis

We included all mammals detected except Chiroptera, Muridae, and Cricetidae, due to the difficulties in identifying species in these groups, often because of taxonomic uncertainties (e.g., Zhang et al. 2016). We included distinctive species of Insectivora in which field identification is unequivocal; these included Gaoligong Forest Hedgehog *Mesechinus wangi*, Elegant Water Shrew *Nectogale elegan*, and Northern Treeshrew *Tupaia belangeri*. Nomenclature followed Wilson & Reeder (2005), Wilson et al. (2009, 2011, 2016), and Mittermeier et al. (2013). Some species incorporated the latest taxonomic updates, and the reasons for these deviations from Wilson et al. (2009) and Wilson & Reeder (2005) are explained in the respective species account.

We defined a camera trap record as a notionally independent record if it occurred 30 minutes or more after an image of the same species at the same station. One trap night was defined as a continuous 24-hour

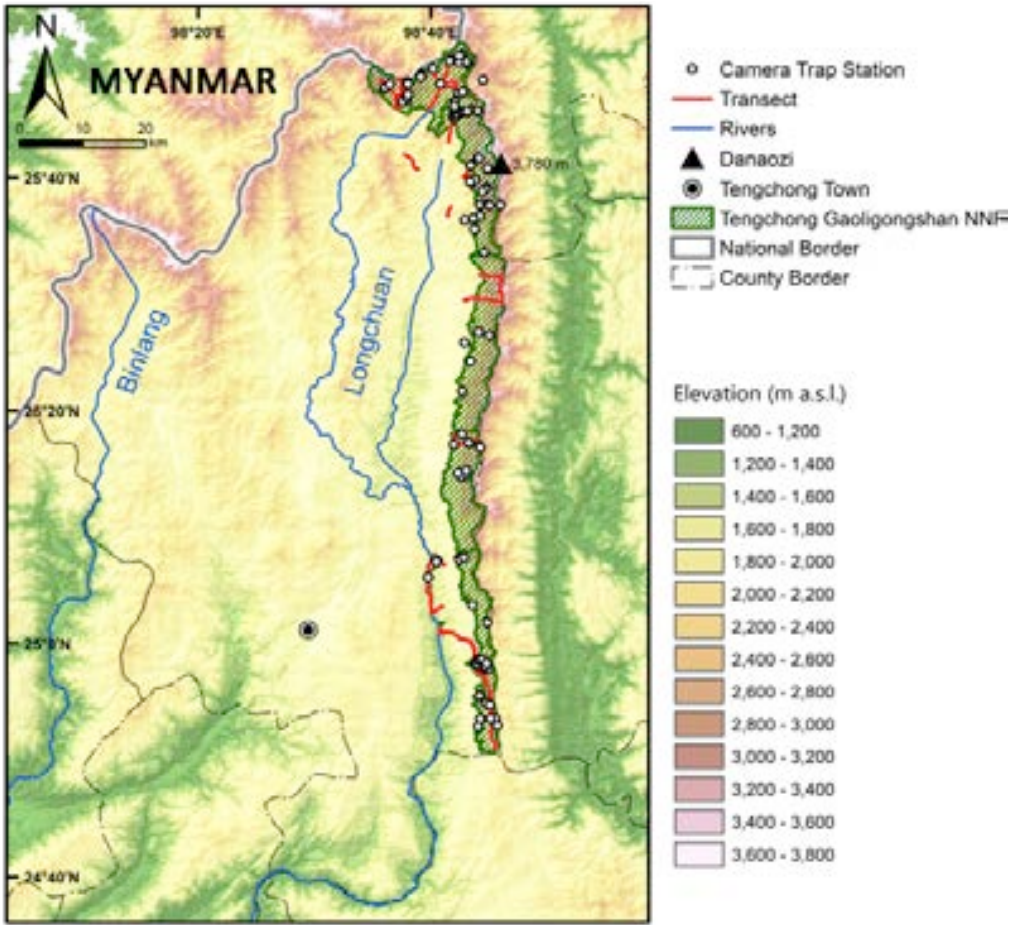

Figure 1. Camera trap stations and non-random transect surveys in Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China, 2014–2018.

period of camera operation. To understand the species richness and conservation value of mammals in TC-GLGS, we compared our camera trap data with that from two protected areas in neighbouring countries with similar geographic, climatic, and biogeographic affinities: Namdapha National Park in northeastern India and Hkakaborazi National Park in northern Myanmar.

RESULTS

Between April 2014 and May 2018, there were 147 camera trap stations set for 14,814 trap nights. Together with 180.76km of transect lines, 46 species of non-volant mammals were recorded; of these, there were five primates, 12 carnivores, and 10 ungulates. This included three globally Endangered species (Phayre's Langur *Trachypithecus phayrei*, Red Panda *Ailurus fulgens*, and Forest Musk Deer *Moschus berezovskii*), six Vulnerable species (Gaoligong Hoolock Gibbon *Hoolock tianxing*, Stump-tailed Macaque *Macaca arctoides*, Asiatic Black Bear *Ursus thibetanus*, Sambar *Rusa unicolor*, Takin *Budorcas taxicolor*, and Chinese Goral *Naemorhedus griseus*), and six Near Threatened species (Assamese Macaque *Macaca assamensis*, Marbled Cat *Pardofelis marmorata*, Tufted Deer *Elaphodus cephalophus*, Burmese Red Serow *Capricornis rubidus*, Chinese Serow *Capricornis milneedwardsii*, and Black Giant *Squirrel Ratufa bicolor*) (IUCN 2018). The Burmese Red Serow *Capricornis rubidus* was newly recorded in China and nine species were new to the Tengchong County (Yellow-bellied Weasel *Mustela kathiah,* Stripe-backed Weasel *M. strigidorsa*, Common Palm Civet *Paradoxurus hermaphroditus*, Marbled Cat *Pardofelis marmorata*, Gongshan Muntjac *Muntiacus gongshanensis*, Orange-bellied Himalayan Squirrel *Dremomys lokriah*, Spotted Giant Flying Squirrel *Petaurista marica*, Asiatic Brush-tailed Porcupine *Atherurus macrourus*, and Forrest's Pika *Ochotona forresti*).

Of the 46 recorded species, 34 were detected by

Table 1. Transect sites and survey dates in Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China, 2014–2018.

	Transect/ coordinates	Survey dates	Elevation covered (m)	Sampling effort (km) Daytime / spotlighting
1	Xiaodifang--Datiandi 24.845°N, 98.759°E – 25.019°N, 98.679°E	24–26.iv.2014, 24.ix.2014, 7–8.xii.2014, 10–12.iii.2015, 3.x.2015, 22.iii.2016, 10–11.v.2017, 22–23.v.2018, 24-26.v.2018	1,300–2,450	30.27 / 12.88
2	Longchuan River Protected Riparian Forest 25.054°N, 98.685°E – 25.114°N, 98.688°E	9–11.v.2016, 25–26.vi.2017	1,300–1,350	16.13 / 4.07
3	Linjiapu-Nanzhaigongfang, Qushi Section 25.286°N, 98.701°E – 25.288°N, 98.738°E	28–29.iv.2014, 9–10.xii.2014, 16–18.v.2015, 18.vii.2015, 5–6.x. 2015, 8–9.i.2016, 4–7.v.2017	2,050–3,185	7.22 / 2.82
4	Nanzhaigongfang ridge, Qushi Section 25.288°N, 98.738°E – 25.275°N, 98.738°E	7.v.2017	3,180–3,280	2.38 / 1.13
5	Daying--GLGS main ridge 25.491°N, 98.712°E – 25.502°N, 98.766°E	10–12.iii.2015	1,910–3,430	16.46 / --
6	Mt. Danaozi, Jietou Section 25.667°N, 98.696°E – 25.692°N, 98.735°E	24.ix.2014	2,270–3,300	5.69 / --
7	Datang Big Tree Rhododendron, Datang Section 25.715°N, 98.692°E – 25.761°N, 98.701°E	27–28.iv.2014, 25.ix.2014, 13–15.iii.2015, 12.v.2016, 24–26.v.2018	1,950–2,460	8.63 / 2.69
8	Danlonghe 25.608°N, 98.691°E – 25.622°N, 98.696°E	27.iv.2014, 19.vii.2015	1,930–1,970	3.09 / --
9	Fanshanchu State-owned Forest 25.675°N, 98.651°E – 25.698°N, 98.627°E	26.ix.2014, 17.vii.2015, 12.v.2016	1,870–2,120	4.02 / 1.66
10	Boundary marker #8, Zizhi Section 25.763°N, 98.618°E – 25.806°N, 98.625°E	27.ix.2014, 29.ix.2014, 13.xii.2014, 19–20.v.2015, 17.vii.2015, 6–8.x.2015, 7–8.i.2016, 24–26.iv.2017, 8–10.v.2017	2,120–3,050	12.02 / 5.26
11	Boundary marker #9, Zizhi Section 25.762°N, 98.661°E – 25.819°N, 98.670°E	28.ix.2014	2,080–2,650	7.96 / --
12	Dongbinghe, Zizhi Section 25.794°N, 98.682°E – 25.802°N, 98.695°E	21–22.v.2015	2,200–2,750	5.65 / 1.89
13	Pinghe, Zizhi Section 25.831°N, 98.693°E – 25.833 N, 98.706°E	21–24.xi.2017	2,450–2,700	9.11 / 0.87
14	Sanjiaojia, Zizhi Section 25.783°N, 98.616°E – 25.812°N, 98.597°E	21–25.xi.2017, 24–26.v.2018	2,200–3,000	5.70 / 1.31
15	Zhongheyakou, Zizhi Section 25.828°N, 98.708°E – 25.842°N, 98.715°E	21–25.xi.2017	2,600–3,200	9.16 / 2.69
			Total	143.49 / 37.27

camera traps, 10 by direct observation alone, and two by tracks and signs alone (Sambar and Mishmi Takin). The three species most frequently camera trapped during our survey were Malayan Porcupine *Hystrix brachyura*, Northern Red Muntjac *Muntiacus vaginalis*, and Assamese Macaque *Macaca assamensis*.

A checklist of mammal species recorded in our survey can be found in Table 2, and a selection of recorded species are illustrated in Images 1 and 2. Accounts of species of special interest (i.e., globally threatened, new Tengchong records, or rare for GLGS) are provided below. Detailed information for most recorded species can also be found in Chan & Bi (2016).

Accounts on selected species

Gaoligong Forest Hedgehog *Mesechinus wangi* (Not Assessed)

This Gaoligongshan-endemic species was recently described, although the existence of a hedgehog in southern GLGS was known by scientists and reserve staff as early as 2003 (Ai et al. 2018). It has only been recorded from Tengchong County and the surrounding areas, which is at least 1,000km south of any known distribution of its congeners. It is also the only *Mesechinus* species found in subtropical forest and it occurs at elevations above 2,100m. One individual was camera trapped on 16 October 2014 at 24.976°N & 98.741°E; another image was obtained on 19 November 2017 at 24.970°N & 98.747°E. An individual was found at night in disturbed mid-montane moist evergreen broadleaf forest at ca. 2,100m in August 2017.

Rhesus Macaque *Macaca mulatta* (Least Concern)

Only recorded in forests under 2,000m. It appears to be restricted to the lower elevation band between 1,300m and 2,000m in Tengchong, similar to observations elsewhere in the eastern Himalaya (Mishra et al. 2006). This distribution pattern may be in part due to competition with the two larger-sized macaque species common in higher elevations.

Table 2. Mammals recorded during our 2014–2018 survey in Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China. CT: camera trap; DO: daytime observation; SL: spotlighting; TS: tracks and/or signs; TD: trophy and/or carcass; encounter rates: number of notionally independent images per 1,000 trap nights.

Species	IUCN status	Evidence	Encounter rates
Gaoligong Forest Hedgehog *Mesechinus wangi*	--	CT, DO	0.14
Elegant Water Shrew *Nectogale elegans*	LC	DO, TD	--
Northern Treeshrew *Tupaia belangeri*	LC	CT, DO	3.24
Stump-tailed Macaque *Macaca arctoides*	VU	CT, DO	9.38
Assamese Macaque *Macaca assamensis*	NT	CT, DO	13.77
Rhesus Macaque *Macaca mulatta*	LC	CT, DO	1.22
Phayre's Langur *Trachypithecus phayrei*	EN	CT, DO	1.28
Gaoligong Hoolock Gibbon *Hoolock tianxing*	VU [1]	DO	--
Asiatic Black Bear *Ursus thibetanus*	VU	CT, DO, TS	1.49
Red Panda *Ailurus fulgens*	EN	CT, DO, TS	2.90
Yellow-throated Marten *Martes flavigula*	LC	CT, DO	11.75
Yellow-bellied Weasel *Mustela kathiah* *	LC	CT	0.14
Siberian Weasel *Mustela sibirica*	LC	CT, DO	0.14
Stripe-backed Weasel *Mustela strigidorsa* *	LC	DO	--
Ferret badger *Melogale* sp. [2]	LC	CT, TD	1.76
Spotted Linsang *Prionodon pardicolor*	LC	CT	3.38
Common Palm Civet *Paradoxurus hermaphroditus* *	LC	CT	0.47
Masked Palm Civet *Paguma larvata*	LC	CT, SL	6.75
Leopard Cat *Prionailurus bengalensis*	LC	CT, SL	5.47
Marbled Cat *Pardofelis marmorata* *	NT	CT	3.78
Eurasian Wild Pig *Sus scrofa*	LC	CT, TS	3.38
Forest Musk Deer *Moschus berezovskii*	EN	CT	1.22
Tufted Deer *Elaphodus cephalophus*	NT	CT	3.65
Northern Red Muntjac *Muntiacus vaginalis*	LC	CT	16.34
Gongshan Muntjac *Muntiacus gongshanensis* *	DD	CT	0.20
Sambar *Rusa unicolor*	VU	TS	--
Mishmi Takin *Budorcas taxicolor*	VU[3]	TS	--
Chinese Goral *Naemorhedus griseus*	VU	CT	1.62
Burmese Red Serow *Capricornis rubidus* **	NT	CT, TD	0.27
Chinese Serow *Capricornis milneedwardsii*	NT	CT	2.30
Pallas's Squirrel *Callosciurus erythraeus*	LC	CT, DO	--
Swinhoe's Striped Squirrel *Tamiops swinhoei*	LC	DO	--
Orange-bellied Himalayan Squirrel *Dremomys lokriah* *	LC	CT, DO	--
Perny's Long-nosed Squirrel *Dremomys pernyi*	LC	CT, DO	--
Asian Red-cheeked Squirrel *Dremomys rufigenis*	LC	CT, DO	--
Black Giant Squirrel *Ratufa bicolor*	NT	CT, DO	3.31
Hairy-footed Flying Squirrel *Belomys pearsonii*	DD	SL	--
Gray-headed Giant Flying Squirrel *Petaurista caniceps*	LC	SL	--
Spotted Giant Flying Squirrel *Petaurista marica* *	LC	SL	--
Yunnan Giant Flying Squirrel *Petaurista yunnanensis*	DD	CT, SL	--
Paticolored Flying Squirrel *Hylopetes alboniger*	LC	TD	--
Chinese Bamboo Rat *Rhizomys sinensis*	LC	DO	--
Asiatic Brush-tailed Porcupine *Atherurus macrourus* *	LC	CT	8.51
Malayan Porcupine *Hystrix brachyura*	LC	CT, TS	18.29
Forrest's Pika *Ochotona forresti* *	LC	CT	0.07
Yunnan Hare *Lepus comus*	LC	SL, DO	--

* represents new record for Tengchong County.
** represents new record for China.
[1] Assessed under Eastern Hoolock Gibbon *Hoolock leuconedys* in the current IUCN Red List.
[2] Large-toothed Ferret Badger *Melogale personata* and Small-toothed Ferret Badger *Melogale moschata* are widely distributed in tropical and subtropical Asia, and both could occur in Tengchong; the only reliable way to visually distinguish the two species is by cranial and dental examination (Abramov & Rozhnov 2014).
[3] All subspecies (*B. t. taxicolor*, *B. t. bedfordi*, *B. t. tibetana*, and *B. t. whitei*) assessed under Takin *Budorcas taxicolor* in the current IUCN Red List.

Stump-tailed Macaque *Macaca arctoides* (Vulnerable)

Htun et al. (2008) marked the northern distribution limit of this species at 25°N in China where Tengchong sits. TC-GLGS supports a healthy population of the species based on the relatively high encounter rate. A recent camera trap survey in the nearby Lushui County (25.417–26.150 ^{0}N) detected this species (Chen et al. 2016), marginally expanding its latitudinal limit further north.

Phayre's Langur *Trachypithecus phayrei* (Endangered)

An estimated population of around 500 individuals persists in the southern part of TC-GLGS. The biggest troop recorded had at least 70 individuals. Its relative rarity in the northern portion is possibly a combination of past hunting pressure and the fact that Tengchong is at its northern distribution limit in China (Chen et al. 2016; Gao et al. 2017).

Gaoligong Hoolock Gibbon *Hoolock tianxing* (Vulnerable)

This recently described gibbon is proposed to be listed as Endangered under the IUCN Red List criteria; however, more robust data on the conservation status of different subpopulations of *H. tianxing* is needed (Fan et al. 2016). A survey conducted in 2016 recorded at least 17 gibbons in six family groups in Tengchong, and the subsequent survey confirmed an additional group; the current population stands at 20 gibbons in seven groups. The Tengchong population is of particular research and conservation importance because it is both the northernmost and the largest subpopulation in China (Chan et al. 2017).

Asiatic Black Bear *Ursus thibetanus* (Vulnerable)

Bears in eastern and southeastern Asia are subject to high hunting pressures (Robinowitz & Khaing 2002; Mishara et al. 2006). In TC-GLGS, the Asiatic Black Bear remains widespread and not uncommon despite the disappearance of other large carnivores. Feeding and other signs from this species were commonly seen during fieldwork, and it was recorded in 13 camera trap stations. Breeding was confirmed by an adult with cub camera trapped in November (Image 1e). There are human-bear negative interactions resulting in casualties on both sides annually.

Red Panda *Ailurus fulgens* (Endangered)

The Red Panda is widespread and common in TC-GLGS. It mostly occurs in the higher-elevation mixed broadleaf forest with dense bamboo undergrowth just below the treeline. Their droppings, containing only coarse plant fragments with distinctive shape and colour, were frequently seen in this preferred habitat.

Yellow-bellied Weasel *Mustela kathiah* (Least Concern)

A new record for Tengchong. One individual was camera trapped on 14 May 2016 at 25.802^{0}N & 98.700^{0}E, making it the northernmost record for GLGS. Another camera trap image was obtained on 08 November 2016 at 25.120^{0}N & 98.708^{0}E. We obtained three additional camera trap images of a *Mustela* fitting the size and colouration of *M. kathiah*; however, the possibility of those being Stripe-backed Weasels cannot be excluded.

Siberian Weasel *Mustela sibirica* (Least Concern)

Siberian Weasel was camera trapped on 07 and 12 January 2016 at 25.758^{0}N & 98.716^{0}E. Wang (2003) opined that Siberian Weasel in Yunnan is an undescribed taxon, but did not provide further details. Our camera trap images show animals superficially similar to *M. s. moupinensis* from western Sichuan Province, with reddish-brown coat and a long black-tipped tail (Gao 1987). Online images of Siberian Weasels from northeastern India show animals with similar pelage and identified as *M. s. subhemachalana* (Choudhury 2016). A taxonomic study of these forms including the Tengchong population is warranted.

Stripe-backed Weasel *Mustela strigidorsa* (Least Concern)

A new record for Tengchong. One individual was observed in the riparian evergreen broadleaf forest at 25.753^{0}N & 98.704^{0}E on 28 April 2014 (Chan & Zhao 2014). As with other weasel species, Stripe-backed Weasel is likely to be under-recorded in Tengchong due to low detectability by camera traps and simply by being "an inconspicuous denizen of chronically under-surveyed regions" (Abramov et al. 2008).

Common Palm Civet *Paradoxurus hermaphroditus* (Least Concern)

A new record for Tengchong. Recorded at four camera trap stations in the southern part of TC-GLGS. Our record at 25.116^{0}N marks its northernmost distribution in GLGS.

Marbled Cat *Pardofelis marmorata* (Near Threatened)

A new record for Tengchong. We obtained 54 notionally independent records at 12 camera trap stations, all north of 25.733^{0}N. Our camera trap data shows that Marbled Cat is more diurnal than the sympatric Leopard Cat.

Forest Musk Deer *Moschus berezovskii* (Endangered)

All musk deer are heavily hunted throughout their ranges and are in serious decline (Robinowitz & Khaing 2002; Mishra et al. 2006). This species was thought to have been possibly extinct in TC-GLGS. Camera traps recorded the species at six camera trap stations, all north of 25.733^{0}N.

Tufted Deer *Elaphodus cephalophus* (Near Threatened)

This species appears to prefer higher elevation broadleaf forest in TC-GLGS—it was only recorded between 2,296m and 3,113m. Repeated camera trapping and field surveys failed to record the species in northern Myanmar (Harris & Jiang 2015), but camera trap images from TC-GLGS obtained on the international border suggest that the species must occur across the border in the high mountains of Kachin State in Myanmar.

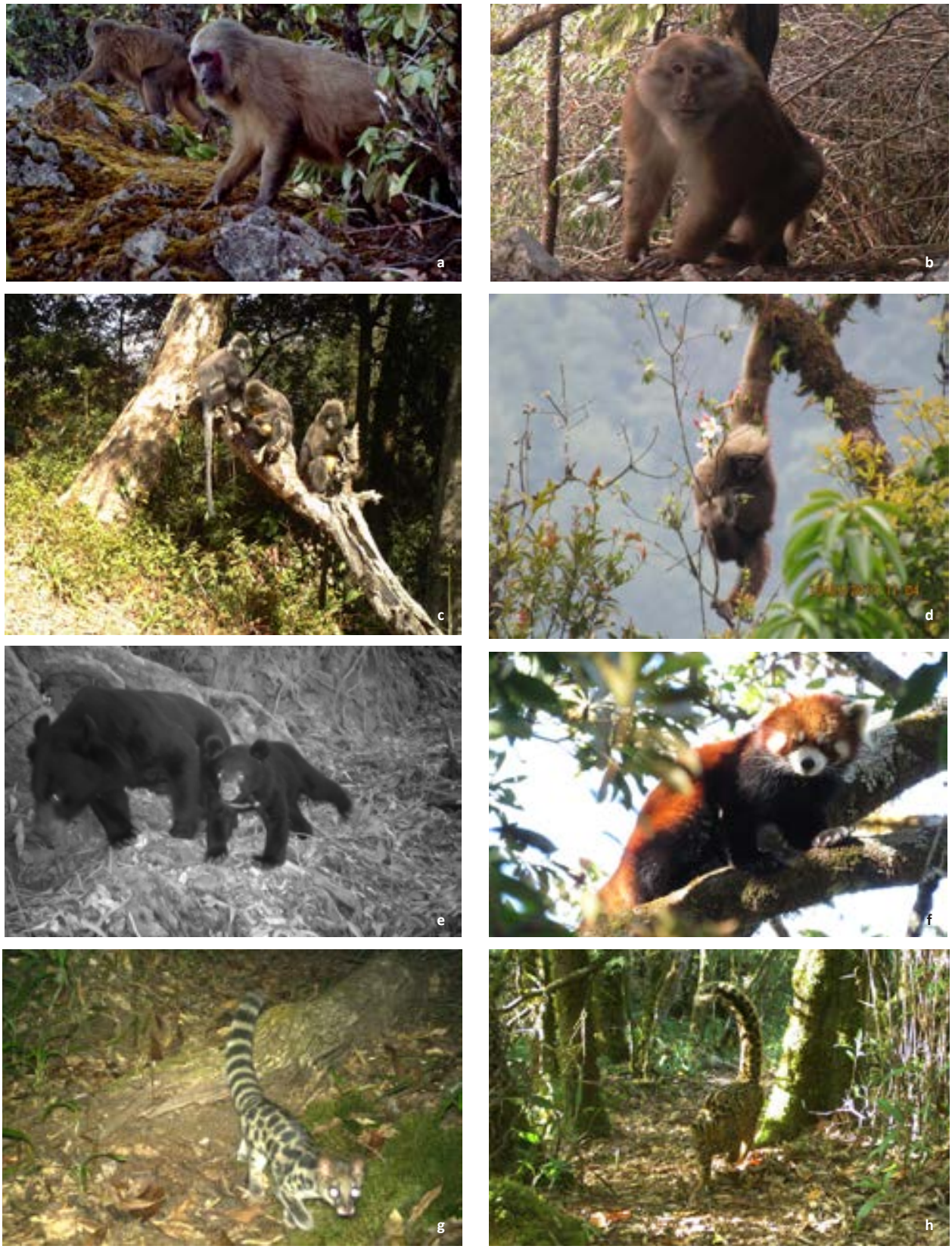

Image 1. Mammals recorded in the Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China, 2014–2018: a—Stump-tailed Macaque *Macaca arctoides* | b—Assamese Macaque *Macaca assamensis* | c—Phayre's Langur *Trachypithecus phayrei* | d—Gaoligong Hoolock Gibbon *Hoolock tianxing* | e—Asiatic Black Bear *Ursus thibetanus* | f—Red Panda *Ailurus fulgens* | g—Spotted Linsang *Prionodon pardicolor* | h—Marbled Cat *Pardofelis marmorata*. © GLGS NNR & KFBG.

Gongshan Muntjac *Muntiacus gongshanensis* (Date Deficient)

A new record for Tengchong. One male and one female were camera trapped on 04 May 2018, at 25.759^{0}N & 98.719^{0}E; a female was camera trapped on 07 May 2018 at the same site. Similar to observations in northeastern India (Choudhury 2009) and southeastern Tibet (Schaller & Rabinowitz 2004), the Northern Red Muntjac was also camera trapped at the same site, indicating that the habitats of the two muntjac species have some overlap. Gongshan Muntjac is reported to occur in western Yunnan between 25–28.167 ^{0}N (Timmins & Duckworth 2016), but we could not find any published record from Tengchong at 25^{0}N. Our finding is the first verifiable record of the species in Tengchong.

Sambar *Rusa unicolor* (Vulnerable)

According to interviews with local inhabitants, this large deer is close to local extirpation following rampant hunting in the 1980s–2000s. We had no camera trap record but tracks and droppings of this species were found at 25.527^{0}N & 98.744^{0}E in moist evergreen broadleaf forest on 12 March 2015. Targeted survey should be conducted to clarify its distribution and status in Tengchong.

Mishmi Takin *Budorcas taxicolor* (Vulnerable)

The IUCN Red List considered the takin as a single species with four subspecies (Song et al. 2008). We followed Groves & Grubb (2011) and Wilson & Mittermeier (2011) and treated the four as full species; the GLGS population is Mishmi Takin *B. taxicolor*. There are two disjunct populations of Mishmi Takin in China, one in southeastern Tibet and another in GLGS (Song et al. 2008); the current distribution in GLGS extends from Gongshan in the north (28.317^{0}N) to Tengchong in the south (24.033^{0}N). Historically, it was also reported further south in the Yingjiang County (24.033^{0}N) (Yang & Du 2006), but this southernmost population is believed to be locally extinct. This is a high-altitude species living along and above the tree line in TC-GLGS. Ai (1996) estimated that around 300 individuals lived in southern GLGS, but the population seems to be in decline. We failed to camera trap any during the survey but found fresh tracks, droppings, and feeding signs. Monitoring and scientific study is needed to shed light on the causes of the observed range retraction and population decline, especially in view of climate change.

Burmese Red Serow *Capricornis rubidus* (Near Threatened)

A new record for China. The first animal was camera trapped in the winter of 2014 (date and time unavailable due to camera malfunction) at 25.797^{0}N & 98.634^{0}E. A single animal was camera trapped on 24 August and 28 October 2017 at 25.761^{0}N & 98.724^{0}E. An adult was directly observed and video-recorded at the same site on 25 November 2017. It had also been camera trapped in the nearby Lushui County of GLGS, but the animal was misidentified as Chinese Serow *Capricornis milneedwardsii* (Chen et al. 2016). A scientific paper is being prepared to report this discovery (Chen Yixin, pers. comm., March 2018).

Orange-bellied Himalayan Squirrel *Dremomys lokriah* (Least Concern)

A new record for Tengchong. A high elevation squirrel in TC-GLGS; the highest count was 13 individuals at Nanzhaigongfang (25.288^{0}N & 98.738^{0}E, 3,150m) on 06 May 2017, which represents the southernmost distribution of *D. lokriah* in China. According to Li & Wang (1992), the Tengchong subspecies is *D. l. subflaviventris.* Population decline has been reported in northeastern India because of hunting and habitat loss (Dollo et al. 2010). High altitude forests in TC-GLGS are well-protected and the squirrel is not hunted locally, but the impact of climate change should be monitored.

Asian Red-cheeked Squirrel *Dremomys rufigenis* (Least Concern)

It is restricted to lower altitude forests in TC-GLGS, with 10 notionally independent camera trap records at 25.114^{0}N & 98.675^{0}E and two observation records during our study. One individual was photographed at Linjiapu at 25.286^{0}N & 98.701^{0}E on 28 August 2016. Two animals were photographed together at 25.016^{0}N & 98.682^{0}E on 10 May 2016. The only previous Tengchong record is of an old specimen from Jietou section at 25.317^{0}N, which marks the northernmost distribution in GLGS (Chen & Qu 2010).

Spotted Giant Flying Squirrel *Petaurista marica* (Least Concern)

Sometimes recognized as a subspecies of *P. elegans* (Choudhury 2016; Wilson et al. 2016). We followed a molecular study which pointed out that *P. e. marica* from China and northern Indo-China is distinctive and should be elevated to full species status (Li et al. 2013). New record for Tengchong with the only record at Dahaoping Section at 24.972^{0}N & 98.730^{0}E, which marks the

Image 2. Mammals recorded in the Tengchong Section of Gaoligongshan National Nature Reserve in Yunnan Province, China, 2014–2018: a—Forest Musk Deer *Moschus berezovskii* | b—Tufted Deer *Elaphodus cephalophus* | c—Red Muntjac *Muntiacus muntjak* | d—Burmese Red Serow *Capricornis rubidus* | e—Orange-bellied Himalayan Squirrel *Dremomys lokriah* | f—Yunnan Giant Flying Squirrel *Petaurista yunnanensis* | g—Asiatic Brush-tailed Porcupine *Atherurus macrourus* | h—Malayan Porcupine *Hystrix brachyuran*. © GLGS NNR & KFBG.

northernmost global distribution for this species.

Yunnan Giant Flying Squirrel *Petaurista yunnanensis* (Data Deficient)

This is the most common and widespread flying squirrel species in TC-GLGS. The species was formerly considered a subspecies of *P. philippensis*, but recent genetic studies indicate that it is taxonomically distinct (Li et al. 2013). Yunnan Giant Flying Squirrel is not yet assessed by the current IUCN Red List, and its full distribution range and population trend are unknown (Wilson et al. 2016). Tengchong is the type locality for the species; more survey and basic research to clarify its distribution, population status, and natural history are needed to clarify its conservation needs.

Asiatic Brush-tailed Porcupine *Atherurus macrourus* (Least Concern)

A new record for Tengchong. It was relatively widespread and common in this survey. It was captured at 17 out of the 147 camera trap stations; therefore, the lack of previous records seems surprising. Our record at 25.766^{0}N also marks the northernmost of its distribution in GLGS.

Forrest's Pika *Ochotona forresti* (Least Concern)

New record for Tengchong. According to Ge et al. (2012), *O. forresti* is the only *Ochotona* species in southern GLGS. One individual was camera trapped at 25.625^{0}N & 98.738^{0}E on 14 May 2015, which represents the southernmost record of its global range.

Yunnan Hare *Lepus comus* (Least Concern)

Tengchong is the type locality of Yunnan Hare, and the species mainly lives in shrubland and open habitats in lower elevations outside TC-GLGS. One individual was observed at 25.648^{0}N & 98.678^{0}E during spotlighting survey, another individual was observed during the daytime at 25.399^{0}N & 98.710^{0}E. According to our data and interview result, the Tengchong population is in decline due to land-use change and hunting. The conservation status of Yunnan Hare in Tengchong deserves some focused attention.

DISCUSSION

Importance of transect survey

The use of camera trap for wildlife research has become a mainstream tool for mammal research and surveys (Wemmer et al. 1996), particularly in research involving rare and/or secretive species (Cutler & Swann 1999; Rowcliffe & Carbone 2008). Some species, however, are strictly or mainly arboreal and therefore are rarely recorded by camera traps (e.g., Small-toothed Palm Civet: Duckworth & Nettelbeck 2008; Willcox et al. 2012). This highlights the importance of conducting non-random transect survey to compliment camera trapping in compiling a comprehensive mammal checklist for a study area.

Twelve of the 46 mammal species recorded (26.1% of total) were only detected by direct observations, which clearly illustrates the value of employing different methods in mammal surveys. Daytime observation is particularly effective to detect primates (e.g., Gaoligong Hoolock Gibbon), agile small mammals (e.g., weasels and squirrels), as well as open habitat and fossorial species (e.g., Chinese Bamboo Rat and Yunnan Hare). Spotlighting survey is, in our opinion, the only effective way to survey for flying squirrel diversity.

Rare or unrecorded species

Some species were rarely recorded, suggesting they are rare in TC-GLGS or that camera trap placement was ineffective at recording the presence of these species. While some are believed to be genuinely rare, such as Forest Musk Deer and Gongshan Muntjac, others are probably more abundant than our records show and simply evaded our survey methods. The three weasel species, for example, were rarely recorded, but villagers consider them not uncommon and reported that poultry-raiding is a regular event. Although most of our study areas are well-protected at present, past anthropogenic activities, particularly hunting, have greatly decimated populations of the more sensitive mammals in Tengchong. The complete absence of obligate large carnivores in TC-GLGS may be explained by a combination of the following factors: (1) our survey sites were at higher elevations in which biomass is naturally lower; (2) the almost complete clearance of extensive natural habitats below 2,000m means some species may be living at their upper elevation limits which restrain population growth; and (3) past rampant hunting in and around TC-GLGS has decimated populations of carnivores and has suppressed the ungulate populations.

We failed to detect 24 mammal species (excluding Chiroptera and Muridae) previously confirmed from Tengchong (Xue et al. 1995; Zhang 1997; Wang 2003; Chen & Qu 2010). Of these unrecorded species, some have specific niches which were not well-covered by our survey, such as Small Indian Civet *Viverra indica* and

Table 3. Mammal species, excluding Chiroptera, Muridae, and Cricetidae, previously recorded from Tengchong but absent in this study.

Species	Sources
Bengal Slow Loris *Nycticebus bengalensis*	Xue 1995
Chinese Pangolin *Manis pentadactyla*	Xue 1995; Zhang 1997
Indian Pangolin *Manis crassicaudata*	Wang 2003
Gray Wolf *Canis lupus*	Xue 1995
Red Fox *Vulpes vulpes*	Xue 1995
Racoon Dog *Nyctereutes procyonoides*	Xue 1995
Dhole *Cuon alpinus*	Xue 1995
Asian Badger *Meles meles*	Xue 1995
Hog Badger *Arctonys collaris*	Xue 1995; Zhang 1997
Eurasian Otter *Lutra lutra*	Xue 1995
Large Indian Civet *Viverra zibetha*	Xue 1995; Zhang 1997
Small Indian Civet *Viverra indica*	Xue 1995; Zhang 1997
Crab-eating Mongoose *Herpestes urva*	Xue 1995
Jungle Cat *Felis chaus*	Xue 1995
Asiatic Golden Cat *Pardofelis temminckii*	Xue 1995
Clouded Leopard *Neofelis nebulosa*	Xue 1995
Leopard *Panthera pardus*	Xue 1995; Zhang 1997; Chen & Qu 2010
Tiger *Panthera tigris*	Xue 1995; Chen & Qu 2010
Sumatran Rhinoceros *Dicerorhinus sumatrensis*	Wang 2003
Leaf Muntjac *Muntiacus putaoensis*	Wang 2003
Anderson's Squirrel *Callosciurus quinquestriatus*	Xue 1995
Forrest's Rock Squirrel *Sciurotamias forresti*	Xue 1995; Zhang 1997
Ward's Bamboo Rat *Rhizomys wardi*	Wang 2003
Hoary Bamboo Rat *Rhizomys pruinosus*	Xue 1995

Jungle Cat *Felis chaus* of mixed agricultural landscape in lower elevations or Crab-eating Mongoose associated with lower elevation forests. The rest are either targets for the wildlife trade (e.g., Bengal Slow Loris, pangolins, and Eurasian Otter) or large carnivores, and we believe hunting is the primary reason of their absence (Table 3).

There is no reliable evidence suggesting the presence of Tiger *Panthera tigris*, Leopard *Panthera pardus*, Gray Wolf *Canis lupus*, and Sumatran Rhinoceros *Dicerorhinus sumatrensis* after the 1990s. The last confirmed record of Sumatran Rhinoceros in Tengchong was in 1949 (Wang 2003) and that of Tiger and Leopard were in 1983 and 1985, respectively (Chen & Qu 2010). The extinction of megafauna in Tengchong comes as no surprise as they are reported to be (near-)extinct in other sites of the eastern Himalaya with vast forest tracts and much lower human populations (Rabinowitz & Khaing 2002; Datta et al. 2008). Our data suggest that ungulate densities are relatively low in TC-GLGS, and prey depletion is one of the major factors affecting the survival of large carnivores (Datta et al. 2008). The Asiatic Black Bear is the only large carnivore that remains relatively widespread and common, which is a facultative carnivore and lives on a much broader diet. Nonetheless, local villagers occasionally reported big cat pugmarks, large carnivore scats with Muntjac hoof remains, and livestock kills in recent years. Mesocarnivores such as Clouded Leopard *Neofelis nebulosa*, Golden Cat *Catopuma temminckii*, and Dhole *Cuon alpinus* may survive in extremely low numbers. We found no fresh burrows of pangolins; pangolins were occasionally reported by local villagers, but their numbers must be exceedingly low, if still present. Other restricted-range and little-known small-sized species, such as Anderson's Squirrel *Callosciurus quinquestriatus* and Forrest's Rock Squirrel *Sciurotamias forresti*, were most likely overlooked by us or have highly restricted distribution not yet surveyed by us. Further survey should cover a wider range of elevations and microhabitats to increase detection probability to understand their conservation needs.

CONSERVATION IMPLICATIONS

This survey demonstrated that TC-GLGS remains an important site for the conservation of high-altitude mammals in the eastern Himalaya, comparable to similar sites in the neighbouring countries (Mishra et al. 2006; Than Zaw et al. 2008). The mammalian community of TC-GLGS appears to be recovering from past heavy disturbances, particularly hunting, but we failed to record any large carnivores except the Asiatic Black Bear, and densities of ungulates are relatively low compared to well-protected areas such as Hong Kong (Bosco Chan, unpublished data). Nevertheless, anthropogenic disturbances have significantly reduced after more than 30 years of protection; we observed abundant wildlife signs including those of the Asiatic Black Bear *Ursus thibetanus*. Evidence of hunting and logging were rarely found, and camera traps detected very low human traffic. Poaching and illegal logging still exist near the international border with Myanmar, often involving cross-border criminals based on the reserve forest crime database. Our camera traps also recorded some livestock grazing in the southernmost and northernmost sections of the reserve. A determined effort to stamp out poaching and livestock grazing will be helpful to the recovery of mammal populations in TC-GLGS, before reintroduction of large carnivores can be

considered.

Tengchong is located in the southernmost part of GLGS and is the northern distribution limit for many species from the Indo-Malayan biogeographic realm. Some of the missing species, such as Bengal Slow Loris, Small Indian Civet, Crab-eating Mongoose, and Jungle Cat, are adaptable species of predominantly low elevations and will greatly benefit from better protection effort of lower altitude forests below 2,000m (Duckworth et al. 2005; Jennings & Veron 2011).

Long-term monitoring and research on selected mammal species, such as the rare Gaoligong Hoolock Gibbon and Marbled Cat, high altitude species susceptible to climate change such as Mishmi Takin and Orange-bellied Himalayan Squirrel, and species vulnerable to high hunting pressure such as Forest Musk Deer and Sambar, should be conducted to assess management effectiveness. If needed, necessary conservation interventions should be effected.

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Current status of birds in Tengchong Section of Gaoligongshan National Nature Reserve, China

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Abstract: We summarised the results of a four-year ornithological survey in the Tengchong Section of Gaoligongshan National Nature Reserve and its immediate vicinity, and compiled an inventory of the present avifauna. In total, 387 bird species were recorded in Tengchong from 2014 to 2018, including 116 which were hitherto undocumented. The birds of Tengchong represented 48.9% of avifauna in Yunnan province, with a particularly rich elements of the Himalayan avifauna. This immense bird species richness suggests that Tengchong is an important site for the preservation of Asian montane forest birds. Although the current protected area system covered most of the intact forests in mid- to high-elevations, more conservation intervention should be allocated to lower elevation habitats below 2000m, which are largely outside the reserve boundaries and facing intensive development pressures.

Keywords: Conservation, eastern Himalaya, Hengduan Mountains, Kachin, new bird records, western Yunnan.

Chinese 摘要： 2014 年至 2018 年针对高黎贡山国家级自然保护区保山市的腾冲片区及其周边开展了为期 4 年的鸟类考察工作，旨在更新及完善腾冲的本地鸟类名录。考察共记录 387 种鸟类，其中 116 种在腾冲尚未有文献记载。腾冲的鸟类种数占云南鸟类总数的 48.9%，其中喜马拉雅区域的山地鸟类尤其丰富，凸显了腾冲对于亚洲山地鸟类保护的重要性。虽然目前中高海拔的原始森林生境大部分涵盖在保护区内，但低海拔 2000 米以下的生境大多位处保护区之外，人为干扰强烈，面临严峻的栖息地破坏威胁，亟需加强有关保护力度。

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Author contribution: BPLC conceived and designed the analysis. XZ performed the analysis and wrote the paper. All authors collected and contributed data.

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INTRODUCTION

The Gaoligongshan Mountains (hereafter GLGS) is a massive mountain range in the southwestern corner of China. It lies at the intersection of two major biogeographic regions – the Palearctic and Indo-Malayan realms. The southwest monsoon from the Indian Ocean brings plentiful rainfall, creating a perfect condition for the rich biodiversity and high endemism (Peng et al. 1980; Dumbacher et al. 2011). The unique biogeographic and geographic characteristics of GLGS support diverse avifauna, with elements from the Himalaya, southwestern China highlands (i.e., the Hengduan Mountains), and southeastern Asian ecoregions, which has been attracting early biologists and ornithologists since the 19th Century, and continues to this date. The southern section of GLGS is part of two endemic bird areas (Yunnan Mountains and eastern Himalaya, Stattersfield et al. 1998) and an Important Bird Area (CN244, BirdLife International 2018). For details on GLGS and Tengchong, see Chan et al. (2019, this issue).

The long history of ornithological work in this region began when British zoologist John Anderson first revealed the magnificence of GLGS to the scientific community after his expeditions to Yunnan in 1868 and 1875 (Anderson 1871a,b, 1876, 1878). Many naturalists continued to survey GLGS after Anderson's pioneering work; the most well-known is arguably the British botanist George Forrest who was commissioned by Lord Lionel Walter Rothschild to collect plant and animal specimens in western Yunnan. The extensive collections made by Forrest from 1904 to 1931 produced some important early literature on the avifauna of Yunnan (Rothschild 1926, 1927a,b,c). Modern ornithological research was primarily conducted by Chinese scientists, notably by various institutes under the Chinese Academy of Sciences (Peng et al. 1980; Yang et al. 1995; Tang et al. 1996; Yang & Yang 2004). International collaborations between research institutes also contributed invaluable information for further understanding of the avifauna in GLGS (Stotz et al. 2003; Dumbacher et al. 2011).

Since 2014, Kadoorie Farm & Botanic Garden and the Management Bureau of Tengchong section of Gaoligongshan National Nature Reserve co-organized a systematic biodiversity survey on major wildlife groups (Chan et al. 2019, this issue). The updated biodiversity inventories from our survey provide baseline data for future research and monitoring, and more importantly, lay the foundation for effective management of the Nature Reserve.

STUDY AREA AND METHODS

Tengchong section of Gaoligongshan National Nature Reserve (hereafter TC-GLGS) is on the western slope of the southern part of GLGS. Tengchong sits at the meeting point of subtropical lowlands and subalpine uplands, with an altitude range of 930m to 3,780m, creating distinct vegetation zones along the elevation gradient. According to Xue (1995), there are four major vegetation zones in TC-GLGS with two major altitudinal transitions between 1,800–2,000 m and near 2,800m, they are: (1) monsoon moist evergreen broadleaf forest below 2,000m; (2) mid-montane moist evergreen broadleaf forest between 1,800m and 2,800m; (3) subalpine hemlock-rhododendron mixed forest between 2,700m and 3,200m; and (4) subalpine bamboo-rhododendron thickets above 2,700m. Details can be found in Chan et al. (2019, present issue)

There are six management sections in TC-GLGS (Nos. 5–10 in Fig. 1); these made up the core of our survey sites. As the lower limit of the reserve boundary is at 1,900m, representative habitats in lower elevations outside TC-GLGS were also surveyed, these include Heshun Wetland near Tengchong Town, Beihai Marsh Nature Reserve, Longchuan River protected riparian forest under the jurisdiction of TC-GLGS (Nos. 1, 3 & 4 in Fig. 1), and better-quality riparian habitats along the Longchuan and Binglang rivers. Protected forests below 2,000m in Laifengshan National Forest Park and Fanshanchu State-owned Forest were also visited (Nos. 2 & 11 in Fig. 1).

Our fieldwork covered the full altitudinal range and annual seasonal cycle. A total of 334 man-days were spent conducting ornithological survey from April 2014 to May 2018 (dates shown in Table 1). Abundance of birds were recorded using standard line transect methods (Sutherland 2006). Survey were conducted during daytime with 8x32 Leica, 8x32 Olympus and 10x42 Minox binoculars, audio playbacks were used occasionally to increase the probability of detecting elusive species (e.g., frogmouth and pheasants). Ad hoc records of nocturnal birds encountered during mammal and herpetofauna night surveys were also included in the list.

Previous studies highlighted the importance of camera trapping as a complimentary survey method to obtain reliable avian diversity estimates, which is especially useful for detecting rare, elusive and/or large-sized terrestrial species (Dinata et al. 2008; Zhang et al. 2018). Camera traps were deployed extensively in TC-GLGS as part of a systematic mammal survey (Li et al.

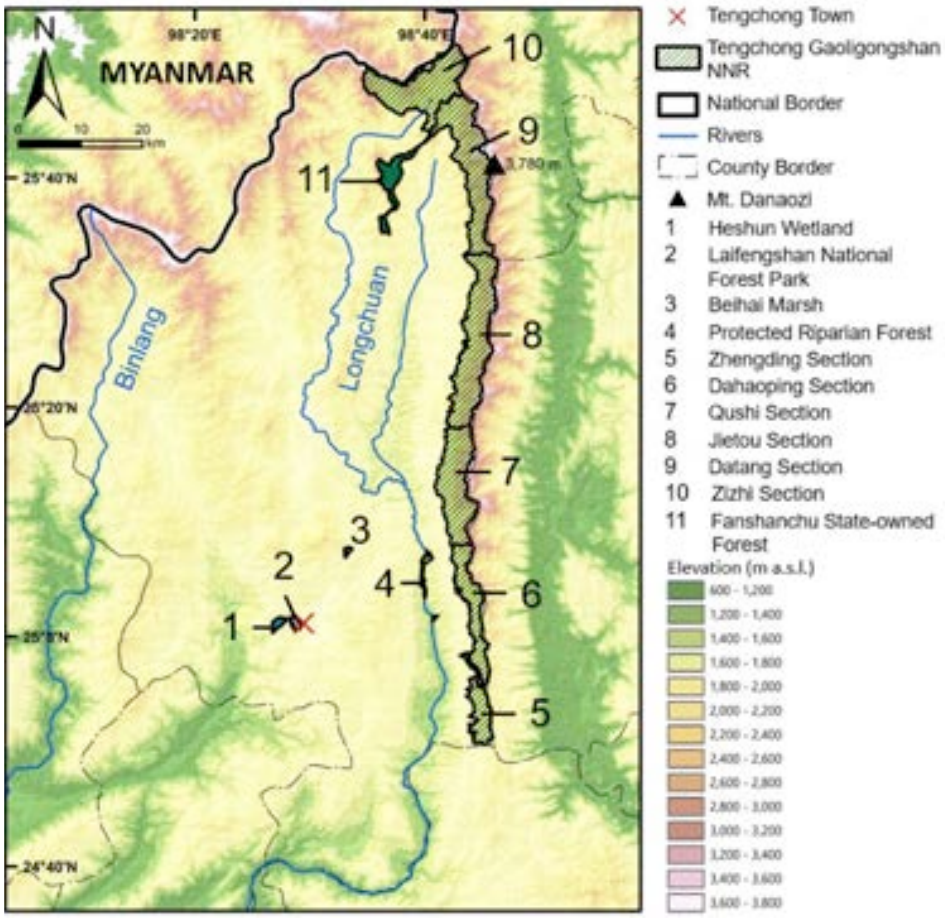

Figure 1. Tengchong, Yunnan Province, China with survey locations mentioned in text.

2019, this issue). A total of 147 camera-trap stations were installed in the study area, covering elevations between 1,515–3,350 m. A good number of bird photos generated from 14,814 trap-nights were obtained and these records were also included for bird list compilation.

TC-GLGS is part of the "birdwatching golden triangle" of western Yunnan, attracting many local and foreign birdwatchers. There is much online information on the avifauna of Tengchong written by traveling birdwatchers; however, many of these records are unauthenticated without detailed notes or associated photographs. Most of these birding records are not included in our list, unless the records are significant and verified by photographs and locality data.

RESULTS

A complete bird list for Tengchong based on our four-year survey is compiled in Appendix 1. Taxonomic arrangement and IUCN Red List status followed BirdLife International (2017a); China Red List status followed Jiang et al. (2016).

In total, 387 species were recorded, representing 75 families in 20 orders. Detectability curve (Fig. 2) generated based on the survey data demonstrated the representativeness of our study. There are two species listed as Vulnerable by the IUCN Red List, nine species listed as Vulnerable or Endangered by the China Red List. We cross-checked our checklist with relevant literature on the avifauna of the region (Peng et al. 1980; Yang et al. 1995; Tang et al. 1996; Stotz et al. 2003; Yang & Yang 2004; Dumbacher et al. 2011; Liang et al. 2015), and 116 species were previously undocumented for Tengchong, including one new record for Yunnan, significantly updated the inventory of the local avifauna. The present bird list for Tengchong represents 48.9% of avian taxa that have been documented in Yunnan province (Yang et al. 1995; Yang & Yang 2004).

The richest bird families recorded in TC-GLGS are of robins and flycatchers (Muscicapidae, 43 species, 11.1% of total) (see Fig. 3). Another notable observation is the

Table 1. Bird survey sites and dates in and around Tengchong section of Gaoligongshan National Nature Reserve, Yunnan Province, China, 2014–2018.

Date	Survey areas*
24–30.iv.2014	2, 5, 7, 9
24–29.ix.2014	6, 9, 10
7–13.xii.2014	5, 6, 7, 10
10–15.iii.2015	8, 9
16–22.v.2015	7, 10
17–19.vii.2015	9, 10, 11
3–8.x.2015	5, 7, 10
14–16.x.2015	Binlang River and Longchuan River
27–29.xi.2015	Binlang River and Longchuan River
20–22.iii.2016	2, 3, 6
8–12.v.2016	2, 3, 4, 6, 9, 10
24–27.xi.2016	9, 10
20–22.ii.2017	1
24–26.iv.2017	10
4–10.v.2017	7, 10
25–26.vi.2017	4
21–25.xi.2017	10
24–26.v.2018	4, 5, 6, 9, 10

* Location numbers follows Figure 1.

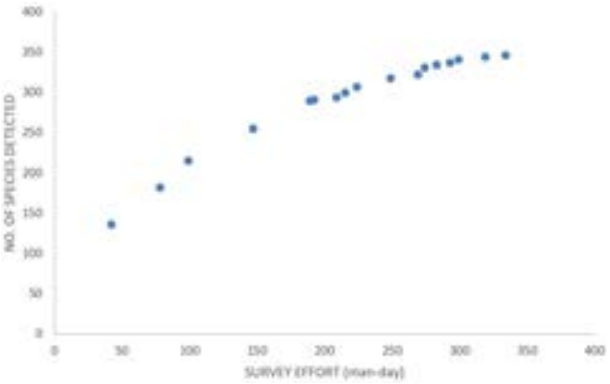

Figure 2. Detectability curve of our bird survey in and around Tengchong Section of Gaoligongshan National Nature Reserve, Yunnan Province, China, April 2014–May 2018.

richness of babblers. A total of 54 species of babblers were recorded during the survey period, this finding also consolidates the designation of GLGS as the center of speciation for Asian babblers (Wu et al. 2014).

Species accounts for selected species

The annotated list below gives details of significant records, including species of conservation significance and those with range extensions.

Sclater's Monal *Lophophorus sclateri*

Listed as Vulnerable by the IUCN Red List, also legally protected in China. Recorded in bamboo-rhododendron thickets above 3,000m in Datang and Qushi sections. One male was recorded at 3,160m in Qushi section on 2 May 2018 (Image 1a). Sclater's Monal was mainly found in subalpine-alpine habitats and migrates to lower altitude in winter (Han et al. 2004; Luo et al. 2004). The inaccessibility of its preferred habitats may contribute to the low encounter rate. Previous study reported Sclater's Monal from all sections in TC-GLGS along the mountain ridge (Han et al. 2004), but according to local interviews poaching may have decimated some subpopulations in suitable habitats.

Temminck's Tragopan *Tragopan temminckii*

Legally protected in China. Regularly recorded in mid to high-altitude moist evergreen broadleaf forest by both direct observations and camera traps in Qushi, Datang and Zizhi sections. Up to three individuals recorded together by camera trap in Qushi on 21 December 2014.

Mrs Hume's Pheasant *Syrmaticus humiae*

Listed as Near Threatened by the IUCN Red List, also legally protected in China. Recorded by camera traps from Datang and Qushi sections. A pair was observed crossing a quiet country road in an orchard-secondary forest mosaic at 1,700m at Dahaoping section. Birds were frequently seen by a reserve outpost at Qushi section since 2017. Interviews with local villagers suggest Mrs Hume's Pheasant is resilient to some degree of hunting and habitat degradation, and is usually found in disturbed habitats in lower elevations outside the reserve boundary. Its distribution range in Yunnan is restricted (Han 1997) and its habits make it vulnerable to habitat loss and poaching.

Lady Amherst's Pheasant *Chrysolophus amherstiae*

Legally protected in China. Camera-trapped in Datang section on 3 May 2016 and pair and singles were observed in Zizhi sections on 21 May 2015 and 21 August 2016 (Image 1b), respectively. Feathers of a male were collected in Zhengding section on 10 March 2015. Local villagers regard this species to be common in lower elevations around 2,000m and, as with Mrs Hume's Pheasant, prefer habitat mosaic of secondary growth.

Hodgson's Frogmouth *Batrachostomus hodgsoni*

Legally protected in China. One record in moist evergreen broadleaf forest in Zizhi Section on 11 May

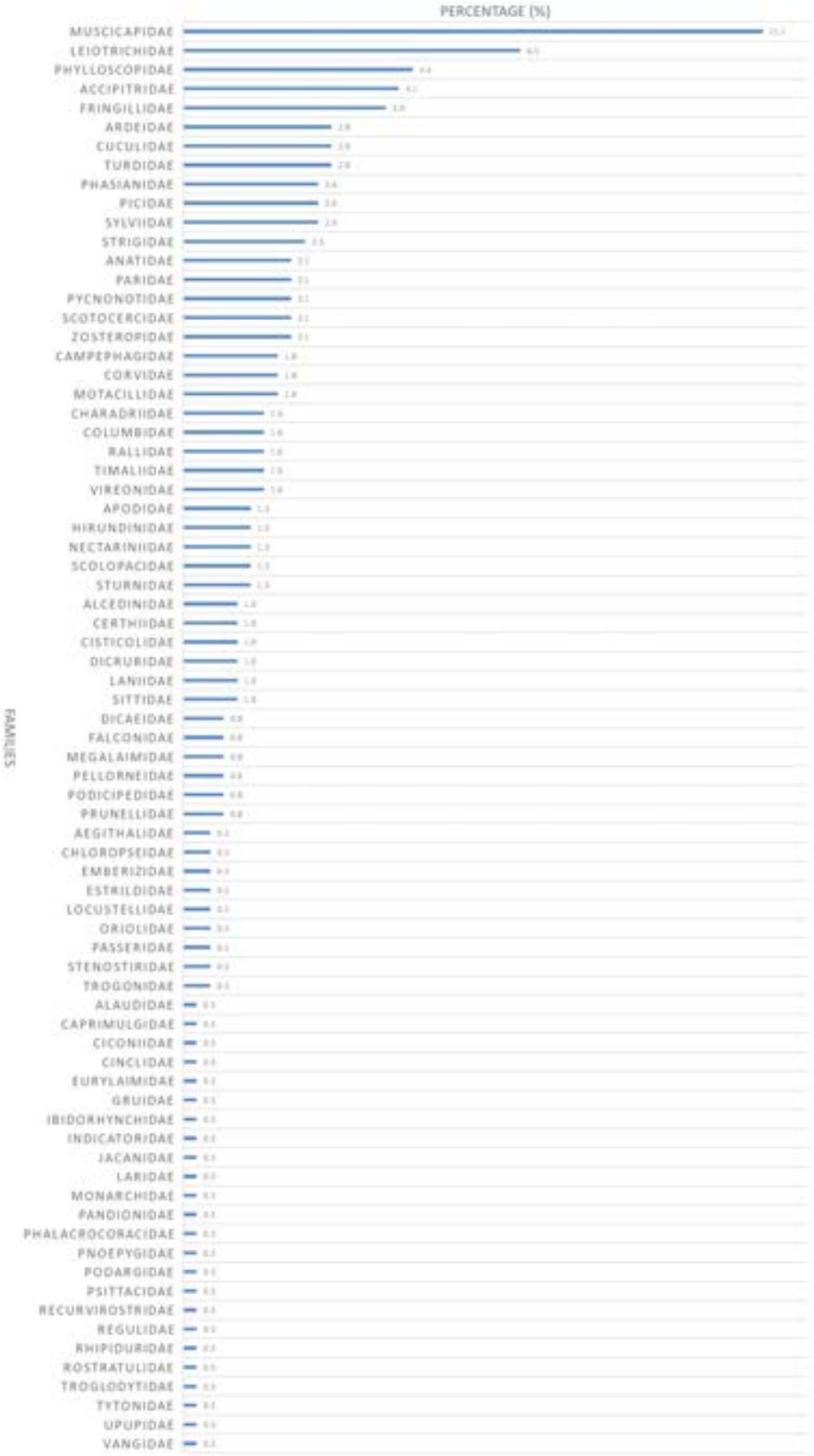

Figure 3. Taxonomic families recorded during our bird survey in and around Tengchong section of Gaoligongshan National Nature Reserve, Yunnan Province, China, April 2014-May 2018.

2016. The characteristic call of this species was recorded at 23.46h at 2,330m in moist evergreen broadleaf forest, which is higher than its normal elevation range at 300m to 1,900m (Holyoak 2018), it represented the northernmost record for China and the first record for TC-GLGS.

Asian Emerald Cuckoo *Chrysococcyx maculatus*

Recorded in Zhengding, Dahaoping, Qushi sections and Longchuan River protected riparian forest. This species may be a breeding visitor to Tengchong and courtship behaviours were observed in Qushi (28 April 2014) and Longchuan River protected riparian forest (10 May 2016).

Ibisbill *Ibidorhyncha struthersii*

Winter visitor recorded regularly in Zizhi section along an open stony river (11 December 2014, Image 1c; 28 November 2015). Seven individuals recorded in Jietou section on 18 February 2018. First record for TC-GLGS.

Northern Lapwing *Vanellus vanellus*

Listed as Near Threatened by the IUCN Red List. Winter visitor, a group of six individuals was spotted in Zizhi section on 12 December 2014. First record for TC-GLGS.

River Lapwing *Vanellus duvaucelii*

Listed as Near Threatened by the IUCN Red List. Recorded in a reservoir 8km north of Tengchong Town on 28 November 2015, also recorded in Jietou on 20 February 2018 (Image 1d). First record for TC-GLGS.

Himalayan Griffon *Gyps himalayensis*

Listed as Near Threatened by the IUCN Red List, also legally protected in China. The sighting of three high-flying birds at Qushi section over the main spine on 10 December 2014 is a first record for TC-GLGS. Noted by Liang et al. (2015) in nearby Lushui County.

Black Eagle *Ictinaetus malaiensis*

Legally protected in China. Regularly recorded in all sections of TC-GLGS. It is worth noting there was only one previous record from TC-GLGS (Yang et al. 1995). This forest-dependent species was historically rarely recorded in China, but are becoming regularly sighted in some provinces, despite the ongoing degradation of forest landscape outside protected areas. The apparent rarity of Black Eagle in China in the past was attributed to the species being overlooked or under-reported (Zhu et al. 2014).

Ward's Trogon *Harpactes wardi*

Listed as Near Threatened by the IUCN Red List. This elusive, forest-interior species is nowhere common, but audio and photographic records from Zizhi (19 May 2015), Datang (7 May 2016, 18 May 2018) and Jietou sections (8 April 2018) confirmed its presence in TC-GLGS. All records were from mid-montane moist evergreen broadleaf forest between 2,100m and 2,800m.

Yellow-rumped Honeyguide *Indicator xanthonotus*

Listed as Near Threatened by the IUCN Red List. Recorded at Qushi (28 April 2014) and Datang sections (13 March 2015, Image 1e) near cliffs in mid-montane moist evergreen broadleaf forest at 2,100–2,200 m. New record for TC-GLGS. Though not included in the GLGS list compiled by Dumbacher et al. (2011), specimens were collected from nearby Lushui County (Yang et al. 1995).

Grey-headed Parakeet *Psittacula finschii*

Listed as Near Threatened by the IUCN Red List, also legally protected in China. Population and distribution range of this species has declined in China in recent decades. One and three birds were observed/photographed at Datang section on 26 June 2017 and 6 June 2018, respectively. A flock of more than 50 individuals was found feeding on pine cones along the Longchuan River at 1,350m at Dahaoping on 25 June 2017. It appears to be nomadic and visit Tengchong only in the summer months, as records are few but many villages reported the species.

Fire-tailed Myzornis *Myzornis pyrrhoura*

Fire-tailed Myzornis breeds in high-altitude bamboo-rhododendron forest (Liang et al. 2017) and migrate to lower elevations in winter. Birds were often seen at 3,160m at Qushi section (Image 1f). This species was also encountered twice in Zizhi section: at 2,900m on 20 May 2015 in subalpine hemlock-rhododendron mixed forest and in moist evergreen broadleaf forest at 2,480m on 25 Nov 2017. On the latter occasion, it was seen feeding on moss-covered tree trunk, aggressively chasing off a Green-tailed Sunbird *Aethopyga nipalensis* from the feeding site. First record for TC-GLGS.

Bar-winged Wren-babbler *Spelaeornis troglodytoides* Two individuals were observed in thick undergrowth of moist evergreen broadleaf forest at 2,740m at Zizhi section on 22 November 2017.

Slender-billed Scimitar-babbler *Pomatorhinus superciliaris*

Recorded at 2,900m in Zizhi section on 29 September

Image 1. Birds recorded in the Tengchong Section of Gaoligongshan National Nature Reserve in 2014–2018. a— Sclater's Monal *Lophophorus sclateri* | b—Lady Amherst's Pheasant *Chrysolophus amherstiae* | c— Ibisbill *Ibidorhyncha struthersii* | d—River Lapwing *Vanellus duvaucelii* | e—Yellow-rumped Honeyguide *Indicator xanthonotus* | f— Fire-tailed Myzornis *Myzornis pyrrhoura* | g— Slender-billed Scimitar-babbler *Pomatorhinus superciliaris* | h— Himalayan Cutia *Cutia nipalensis*.

2014 and 8 May 2017. Ten birds were seen at 2,150m in Qushi section on 16 March 2018 (Image 1g).

Yellow-throated Fulvetta *Schoeniparus cinereus*

Recorded at Jietou section on 11 March 2015. Stotz (2003) also recorded this species in Datang section.

Himalayan Cutia *Cutia nipalensis*

A party of seven was observed feeding on nectar of the tree *Rhodoleia forrestii* at 2,100m in Datang section on 13 March 2015 (Image 1h). The species was frequently seen at 2,150m in Qushi section.

Yunnan Nuthatch *Sitta yunnanensis*

Listed as Near Threatened by the IUCN Red List. This Chinese endemic was recorded in Jietou section on 10 March 2015.

Purple Cochoa *Cochoa purpurea*

One sub-adult recorded in Zizhi section at 2,900m on 7 Oct 2015 in subalpine hemlock-rhododendron mixed forest. First record for TC-GLGS.

Common Chaffinch *Fringilla coelebs*

One individual photographed in subalpine bamboo-rhododendron thickets at 3,287m on 13 November 2016 at Qushi section, which represented the first record of this species in Yunnan (Zheng et al. 2017).

DISCUSSION

The vast expanse of mid-montane moist evergreen broadleaf forest protected by TC-GLGS harbours the highest bird species richness with the highest conservation value; a pattern consistent with a study conducted in the adjacent Lushui section of Gaoligongshan National Nature Reserve (Liang et al. 2015). In the nearby Hkakabo Razi region of northern Kachin State, Myanmar, Rappole et al. (2011) recorded 413 bird species at elevations ranging from 500 to 3,000 m. While our bird list of 387 species from TC-GLGS is comparable in species richness, it is obvious our current bird list lacks many species/groups typical of lower elevations; for example, the more tropical galliformes, raptors, woodpeckers and hornbills recorded from the 1,000–2,000-m hill forest belt in Rappole et al. (2011) are missing from TC-GLGS. In Tengchong, most forests below 2,200m are excluded from the current protected area network; the under-representation of lower elevation habitats undermines the potential of Tengchong to support a full community of avifauna, to the detriment of threatened species which prefer lower elevations such as Mrs Hume's Pheasant and River Lapwing. At altitudes above 2,800m, upland species like Sclater's Monal *Lophophorus sclateri* and Fire-tailed Myzornis *Myzornis pyrrhoura* face less direct threats from anthropogenic activities due to the remoteness of their habitats and the fact that high elevation areas are also the core zone of the Reserve. Climate change, however, will likely disrupt the altitudinal zonation of montane communities. The possible range contractions induced by climate change will put high altitude species under tremendous pressure (Gasner et al. 2010; Flousek et al. 2015). The current bird species richness and populations need to be monitored closely to predict the impacts of climate change on the bird fauna of GLGS.

TC-GLGS have a long history of human habitation, the inevitable habitat degradation as well as rampant hunting in the past all contributed to the loss of some biodiversity elements. The nature reserve network is, currently, the most important approach in protecting natural forests and biodiversity in Yunnan; however, it should be noted that the existing protected area system cannot effectively preserve all sites of conservation significance. Although large areas of intact mid- to upper-montane forests are currently protected, most lowland areas are devoted to settlements and agriculture. The rapidly growing human population continues to put pressure on the low-elevation ecosystems and biodiversity.

Despite the intensity of our field surveys, some species of conservation significance were not recorded by us: Yellow-breasted Bunting *Emberiza aureola* was a winter visitor to TC-GLGS and noted as "common" by Tang et al. (1996). It has been up listed to Critically Endangered in 2017 because of the rapid decline of its global population (BirdLife International 2017b). Absence of this species during surveys may reflect its current conservation status, but may also reflect our lack of survey coverage in farmland habitat; a dedicated survey should be conducted in the future to gather more information about the status of Yellow-breasted Bunting as well as other bunting species in Tengchong, as the group as a whole is under sharp decline (Kamp et al. 2015). Golden Eagle *Aquila chrysaetos* were once observed in large numbers (Rothschild 1926), but its population dropped rapidly since the 1960s (Yang et al. 1995). Red-headed Vulture *Sarcogyps calvus* was reported from Tengchong by Yang et al. (1995), but has not been reported in Yunnan since the 1980s. Global population of the Red-headed Vulture has been in precipitous decline, and is listed as Critically Endangered

(Birdlife International 2017c). A juvenile White-bellied Heron *Ardea insignis* was found in nearby Lushui County, around 20km north of Tengchong, in 2014 (Han et al. 2015), suggesting Tengchong could be a potential distribution area for this Critically Endangered species. We have organized target surveys covering suitable habitats in major river basins in Tengchong, but no White-bellied Heron was encountered despite positive feedbacks by interviews and good habitats available. The Green Peafowl *Pavo muticus* occurred in Tengchong before the 1980s (Cheng 1987), but has not been recorded since (Wen et al. 1995); we found no trace of the species during the survey, nor any local reports.

CONCLUSIONS

With 387 documented avian taxa in our survey, TC-GLGS has immense bird species richness, especially for a temperate region. It is an important site for the preservation of Asian montane forest birds, and an integral part of the larger eastern Himalaya region that is a center of bird endemism and evolution (Dumbacher et al. 2011; Renner & Rappole 2011).

More conservation effort should be allocated to lower elevations below 2,000m, which face intensive anthropogenic pressure for land use change, and is largely outside the reserve boundaries. The secondary forests and wetlands at lower elevations could increase landscape diversity and partially offset species loss from primary forests (Wang et al. 2016). There should be active collaboration with the local communities in developing restoration projects to connect these habitat fragments with TC-GLGS, which is in line with the Chinese government's "Ecological Civilization" goal (Xi 2017). With support from ecological compensation project like "Mechanism of Compensation for Ecological Protection" and other restoration projects, these pockets of low-elevation forests in community-owned land could provide "stepping stones" for the recovering wildlife population in the region (Hua et al. 2017).

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Appendix 1. Birds recorded from Tengchong section of Gaoligongshan, Yunnan Province, China, 2014–2018.

Conservation Status: 1 = IUCN Red List status, 2 = China Red List status (EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient), 3 = National Key Protected Wild Animals status (I = Class I, II = Class II).

First Record: YN = First record for Yunnan, TC = First record for Tengchong;

Survey Locations: A = Heshun Wetland, B = Laifengshan National Forest Park, C = Beihai Marsh, D = Protected Riparian Forest, E = Zhengding, F = Dahaoping, G = Qushi, H = Jietou, I = Datang, J = Zizhi, K = Fanshanchu State-owned Forest, L = Other sites in Tengchong.

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Hill Partridge	*Arborophila torqueola*	LC	LC	-	-	G,H,I,J,L
Rufous-throated Partridge	*Arborophila rufogularis*	LC	LC	-	TC	D,F
Mountain Bamboo-partridge	*Bambusicola fytchii*	LC	LC	-	-	E,G,I,J
Sclater's Monal	*Lophophorus sclateri*	VU	EN	I	-	G
Temminck's Tragopan	*Tragopan temminckii*	LC	NT	II	-	G,I,J
Blood Pheasant	*Ithaginis cruentus*	LC	NT	II	TC	I
Mrs Hume's Pheasant	*Syrmaticus humiae*	NT	VU	I	-	F,G,I
Lady Amherst's Pheasant	*Chrysolophus amherstiae*	LC	NT	II	-	I,J,L
Common Pheasant	*Phasianus colchicus*	LC	LC	-	-	E,J,L
Silver Pheasant	*Lophura nycthemera*	LC	LC	II	-	E,F,H,I,J,L
Ruddy Shelduck	*Tadorna ferruginea*	LC	LC	-	-	A,C,J,L
Common Pochard	*Aythya ferina*	VU	LC	-	TC	C
Ferruginous Duck	*Aythya nyroca*	NT	NT	-	TC	C
Garganey	*Spatula querquedula*	LC	LC	-	-	C
Gadwall	*Mareca strepera*	LC	LC	-	TC	C
Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	-	-	-	A,C,J,L
Mallard	*Anas platyrhynchos*	LC	LC	-	TC	J,L
Common Teal	*Anas crecca*	LC	LC	-	-	C
Little Grebe	*Tachybaptus ruficollis*	LC	LC	-	-	A,L
Great Crested Grebe	*Podiceps cristatus*	LC	LC	-	TC	L
Black-necked Grebe	*Podiceps nigricollis*	LC	LC	-	TC	L
Speckled Woodpigeon	*Columba hodgsonii*	LC	LC	-	-	G,J
Ashy Woodpigeon	*Columba pulchricollis*	LC	LC	-	TC	I
Oriental Turtle-dove	*Streptopelia orientalis*	LC	LC	-	-	B,D,F,H,I,J,L
Red Turtle-dove	*Streptopelia tranquebarica*	LC	LC	-	-	I
Eastern Spotted Dove	*Spilopelia chinensis*	LC	LC	-	-	H,I,J,L
Wedge-tailed Green-pigeon	*Treron sphenurus*	LC	NT	II	-	G,I,J
Hodgson's Frogmouth	*Batrachostomus hodgsoni*	LC	DD	II	TC	J
Grey Nightjar	*Caprimulgus jotaka*	LC	-	II	-	F,G,J
White-throated Needletail	*Hirundapus caudacutus*	LC	LC	-	-	J
Himalayan Swiftlet	*Aerodramus brevirostris*	LC	NT	-	-	G,I,J,K
Asian Palm-swift	*Cypsiurus balasiensis*	LC	LC	-	-	J,L
Pacific Swift	*Apus pacificus*	LC	LC	-	TC	E,G,H,J
House Swift	*Apus nipalensis*	LC	LC	-	-	B,D,H,L
Green-billed Malkoha	*Phaenicophaeus tristis*	LC	LC	-	-	D,E,F
Western Koel	*Eudynamys scolopaceus*	LC	LC	-	-	G,I,J
Asian Emerald Cuckoo	*Chrysococcyx maculatus*	LC	NT	-	-	D,E,G
Plaintive Cuckoo	*Cacomantis merulinus*	LC	LC	-	-	G,J
Fork-tailed Drongo-cuckoo	*Surniculus dicruroides*	LC	LC	-	-	D,F,J

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Large Hawk-cuckoo	*Hierococcyx sparverioides*	LC	LC	-	-	B,D,E,F,G,H,I,J,L
Whistling Hawk-cuckoo	*Hierococcyx nisicolor*	LC	LC	-	TC	D
Indian Cuckoo	*Cuculus micropterus*	LC	LC	-	TC	D,G,J
Common Cuckoo	*Cuculus canorus*	LC	LC	-	-	D,E,F,G,I,J
Oriental Cuckoo	*Cuculus saturatus*	LC	LC	-	-	D,G,I,J
Lesser Cuckoo	*Cuculus poliocephalus*	LC	LC	-	-	G,J
Ruddy-breasted Crake	*Zapornia fusca*	LC	NT	-	-	L
Black-tailed Crake	*Zapornia bicolor*	LC	LC	II	-	F,J
White-breasted Waterhen	*Amaurornis phoenicurus*	LC	LC	-	-	A,C,D,H,I,J
Purple Swamphen	*Porphyrio porphyrio*	LC	VU	-	-	C
Common Moorhen	*Gallinula chloropus*	LC	LC	-	-	A,C,L
Common Coot	*Fulica atra*	LC	LC	-	TC	J,L
Common Crane	*Grus grus*	LC	NT	II	TC	J,L
Black Stork	*Ciconia nigra*	LC	VU	I	-	J,L
Yellow Bittern	*Ixobrychus sinensis*	LC	LC	-	TC	C
Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	LC	-	-	I,L
Black-crowned Night-heron	*Nycticorax nycticorax*	LC	LC	-	-	L
Green-backed Heron	*Butorides striata*	LC	LC	-	-	A,L
Chinese Pond-heron	*Ardeola bacchus*	LC	LC	-	-	A,J,L
Cattle Egret	*Bubulcus ibis*	LC	LC	-	-	C,D,E,H,J,K,L
Grey Heron	*Ardea cinerea*	LC	LC	-	TC	L
Purple Heron	*Ardea purpurea*	LC	LC	-	TC	C
Great White Egret	*Ardea alba*	LC	LC	-	TC	C,D
Intermediate Egret	*Ardea intermedia*	LC	LC	-	TC	C,J
Little Egret	*Egretta garzetta*	LC	LC	-	-	C,D,I,J,L
Great Cormorant	*Phalacrocorax carbo*	LC	LC	-	-	A,J,L
Ibisbill	*Ibidorhyncha struthersii*	LC	NT	-	TC	H,J
Black-winged Stilt	*Himantopus himantopus*	LC	LC	-	-	L
Long-billed Plover	*Charadrius placidus*	LC	NT	-	-	J
Little Ringed Plover	*Charadrius dubius*	LC	LC	-	TC	L
Northern Lapwing	*Vanellus vanellus*	NT	LC	-	TC	J
River Lapwing	*Vanellus duvaucelii*	NT	NT	-	TC	L,H
Grey-headed Lapwing	*Vanellus cinereus*	LC	LC	-	-	J,L
Red-wattled Lapwing	*Vanellus indicus*	LC	DD	-	-	L
Greater Painted-snipe	*Rostratula benghalensis*	LC	LC	-	-	L
Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	NT	-	TC	C
Eurasian Woodcock	*Scolopax rusticola*	LC	LC	-	-	F,J
Common Snipe	*Gallinago gallinago*	LC	LC	-	TC	L
Red-necked Phalarope	*Phalaropus lobatus*	LC	LC	-	TC	L
Common Sandpiper	*Actitis hypoleucos*	LC	LC	-	-	J,L
Green Sandpiper	*Tringa ochropus*	LC	LC	-	-	H,J,L
Black-headed Gull	*Larus ridibundus*	LC	LC	-	TC	L
Eastern Grass-owl	*Tyto longimembris*	LC	DD	-	TC	G,L
Collared Owlet	*Glaucidium brodiei*	LC	LC	II	TC	E,F,H,I,J,L

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Asian Barred Owlet	*Glaucidium cuculoides*	LC	LC	II	TC	D,F,H,J
Collared Scops-owl	*Otus lettia*	LC	LC	II	-	F,G
Mountain Scops-owl	*Otus spilocephalus*	LC	NT	II	TC	F,I,J,L
Oriental Scops-owl	*Otus sunia*	LC	LC	II	TC	J
Brown Wood-owl	*Strix leptogrammica*	LC	NT	II	-	B,G,J
Himalayan Owl	*Strix nivicolum*	LC	-	II	-	F,H,J
Spot-bellied Eagle-owl	*Bubo nipalensis*	LC	NT	II	TC	I
Tawny Fish-owl	*Ketupa flavipes*	LC	EN	II	TC	I
Osprey	*Pandion haliaetus*	LC	NT	II	TC	J
Black-winged Kite	*Elanus caeruleus*	LC	NT	II	-	F,H,L
Oriental Honey-buzzard	*Pernis ptilorhynchus*	LC	NT	II	-	D,F,G,I,J
Jerdon's Baza	*Aviceda jerdoni*	LC	NT	II	TC	G
Crested Serpent-eagle	*Spilornis cheela*	LC	NT	II	-	D,F,H,I,J
Himalayan Griffon	*Gyps himalayensis*	NT	NT	II	TC	G
Mountain Hawk-eagle	*Nisaetus nipalensis*	LC	NT	II	-	G,J
Black Eagle	*Ictinaetus malaiensis*	LC	VU	II	-	E,F,G,H,I,J,K,L
Bonelli's Eagle	*Aquila fasciata*	LC	VU	II	TC	I
Hen Harrier	*Circus cyaneus*	LC	NT	II	-	J,L
Pied Harrier	*Circus melanoleucos*	LC	NT	II	-	C,H
Crested Goshawk	*Accipiter trivirgatus*	LC	NT	II	-	B,D,F,L
Besra	*Accipiter virgatus*	LC	LC	II	-	G,H,I
Northern Goshawk	*Accipiter gentilis*	LC	NT	II	TC	G
Black Kite	*Milvus migrans*	LC	LC	II	-	L
Grey-faced Buzzard	*Butastur indicus*	LC	NT	II	TC	G,J
Himalayan Buzzard	*Buteo refectus*	LC	-	II	-	E,H,J,L
Red-headed Trogon	*Harpactes erythrocephalus*	LC	NT	-	-	I,J
Ward's Trogon	*Harpactes wardi*	NT	NT	-	TC	H,I,J
Common Hoopoe	*Upupa epops*	LC	LC	-	-	F,J
Common Kingfisher	*Alcedo atthis*	LC	LC	-	-	A,H,I,J,L
Crested Kingfisher	*Megaceryle lugubris*	LC	LC	-	-	G
White-breasted Kingfisher	*Halcyon smyrnensis*	LC	LC	-	-	L
Black-capped Kingfisher	*Halcyon pileata*	LC	LC	-	-	I
Great Barbet	*Psilopogon virens*	LC	LC	-	TC	B,D,E,F,G,H,I,J,K,L
Golden-throated Barbet	*Psilopogon franklinii*	LC	DD	-	-	B,D,E,F,G,H,I,J,K
Blue-throated Barbet	*Psilopogon asiaticus*	LC	DD	-	-	D,E,F,G,H
Yellow-rumped Honeyguide	*Indicator xanthonotus*	NT	NT	-	TC	G,I
Eurasian Wryneck	*Jynx torquilla*	LC	LC	-	TC	L
Bay Woodpecker	*Blythipicus pyrrhotis*	LC	LC	-	-	E,F,G,H,I,J
Greater Yellownape	*Chrysophlegma flavinucha*	LC	EN	-	TC	G,I,J
Grey-faced Woodpecker	*Picus canus*	LC	LC	-	-	J
Grey-capped Woodpecker	*Picoides canicapillus*	LC	LC	-	-	B,G,I,J
Crimson-breasted Woodpecker	*Dryobates pernyii*	LC	-	-	-	G,I,J
Rufous-bellied Woodpecker	*Dendrocopos hyperythrus*	LC	LC	-	TC	J
Stripe-breasted Woodpecker	*Dendrocopos atratus*	LC	DD	-	TC	J

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Darjeeling Woodpecker	*Dendrocopos darjellensis*	LC	LC	-	-	I,J,L
Great Spotted Woodpecker	*Dendrocopos major*	LC	LC	-	-	G,I,J
Common Kestrel	*Falco tinnunculus*	LC	LC	II	-	H,J,L
Eurasian Hobby	*Falco subbuteo*	LC	LC	II	-	G
Peregrine Falcon	*Falco peregrinus*	LC	NT	II	TC	G,L
Grey-headed Parakeet	*Psittacula finschii*	NT	DD	II	-	D,I
Long-tailed Broadbill	*Psarisomus dalhousiae*	LC	NT	II	TC	D
Maroon Oriole	*Oriolus traillii*	LC	NT	-	-	D,G,I,L
Slender-billed Oriole	*Oriolus tenuirostris*	LC	DD	-	-	B,E
Black-headed Shrike-babbler	*Pteruthius rufiventer*	LC	DD	-	TC	H,I,J
White-browed Shrike-babbler	*Pteruthius aeralatus*	LC	LC	-	-	B,D,E,F,G,H,I,J
Green Shrike-babbler	*Pteruthius xanthochlorus*	LC	NT	-	TC	D,G,I,J
Black-eared Shrike-babbler	*Pteruthius melanotis*	LC	DD	-	-	G,I
Chestnut-fronted Shrike-babbler	*Pteruthius aenobarbus*	LC	DD	-	TC	J
White-bellied Erpornis	*Erpornis zantholeuca*	LC	LC	-	-	D,F,G,I,J
Grey-chinned Minivet	*Pericrocotus solaris*	LC	LC	-	-	F,G,H,I,K,L
Short-billed Minivet	*Pericrocotus brevirostris*	LC	LC	-	-	D,E,F,G,I,J,L
Long-tailed Minivet	*Pericrocotus ethologus*	LC	LC	-	-	F,H,J
Scarlet Minivet	*Pericrocotus flammeus*	LC	LC	-	-	B,D,E,F,G,I,J
Rosy Minivet	*Pericrocotus roseus*	LC	LC	-	-	F
Large Cuckoo-shrike	*Coracina javensis*	LC	LC	-	-	B,J
Black-winged Cuckoo-shrike	*Lalage melaschistos*	LC	LC	-	-	D,I
Bar-winged Flycatcher-shrike	*Hemipus picatus*	LC	DD	-	TC	D,G,H
White-throated Fantail	*Rhipidura albicollis*	LC	LC	-	-	D,E,F,G,H,I,J,K
Black Drongo	*Dicrurus macrocercus*	LC	LC	-	-	D,E,G,I,J,L
Ashy Drongo	*Dicrurus leucophaeus*	LC	LC	-	-	B,D,E,F,G,I,J,L
Bronzed Drongo	*Dicrurus aeneus*	LC	LC	-	-	D,J,L
Hair-crested Drongo	*Dicrurus hottentottus*	LC	LC	-	-	G
Oriental Paradise-flycatcher	*Terpsiphone affinis*	LC	NT	-	-	D
Brown Shrike	*Lanius cristatus*	LC	LC	-	-	F,J
Burmese Shrike	*Lanius collurioides*	LC	NT	-	-	C
Long-tailed Shrike	*Lanius schach*	LC	LC	-	-	B,C,D,F,G,H,I,J,K,L
Grey-backed Shrike	*Lanius tephronotus*	LC	LC	-	-	E,G,H,I,J
Grey Treepie	*Dendrocitta formosae*	LC	LC	-	-	D,F,L
Yellow-billed Blue Magpie	*Urocissa flavirostris*	LC	LC	-	-	J
Red-billed Blue Magpie	*Urocissa erythroryncha*	LC	LC	-	-	D,F,G,H,I,J,L
Eurasian Jay	*Garrulus glandarius*	LC	LC	-	TC	B,J
Eurasian Magpie	*Pica pica*	LC	LC	-	-	E,G,H,J,L
Southern Nutcracker	*Nucifraga hemispila*	LC	LC	-	-	J
Large-billed Crow	*Corvus macrorhynchos*	LC	LC	-	-	C,E,G,H,I,J,L
Yellow-bellied Fairy-fantail	*Chelidorhynx hypoxanthus*	LC	LC	-	-	B,E,F,G,H,I,J,L
Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	LC	LC	-	-	B,D,F,G,H,I,J,K,L
Fire-capped Tit	*Cephalopyrus flammiceps*	LC	LC	-	-	E,H
Yellow-browed Tit	*Sylviparus modestus*	LC	LC	-	-	G,H,I,J,L

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Sultan Tit	*Melanochlora sultanea*	LC	DD	-	TC	D
Coal Tit	*Periparus ater*	LC	LC	-	TC	H,J
Grey-crested Tit	*Lophophanes dichrous*	LC	LC	-	TC	J
Green-backed Tit	*Parus monticolus*	LC	LC	-	-	B,D,E,F,G,H,I,J,K,L
Great Tit	*Parus major*	LC	LC	-	-	A,B,D,F,G,H,I,J,L
Yellow-cheeked Tit	*Machlolophus spilonotus*	LC	LC	-	-	D,E,G,I,J,L
Oriental Skylark	*Alauda gulgula*	LC	LC	-	-	C,E,F
Zitting Cisticola	*Cisticola juncidis*	LC	LC	-	-	C
Hill Prinia	*Prinia superciliaris*	LC	LC	-	-	D,F,G,I
Plain Prinia	*Prinia inornata*	LC	LC	-	-	C
Common Tailorbird	*Orthotomus sutorius*	LC	LC	-	TC	D,I
Pygmy Cupwing	*Pnoepyga pusilla*	LC	LC	-	-	E,F,G,I,J,L
Russet Grasshopper-warbler	*Locustella mandelli*	LC	LC	-	TC	J
Striated Grassbird	*Megalurus palustris*	LC	LC	-	-	C
Asian House Martin	*Delichon dasypus*	LC	LC	-	TC	F,G,I,J,L
Nepal House Martin	*Delichon nipalense*	LC	LC	-	-	G,J
Red-rumped Swallow	*Cecropis daurica*	LC	LC	-	-	D,F,H,L
Barn Swallow	*Hirundo rustica*	LC	LC	-	-	B,D,F,G,H,I,J,L
Asian Plain Martin	*Riparia chinensis*	LC	LC	-	TC	D,J,L
Ashy Bulbul	*Hemixos flavala*	LC	LC	-	TC	D
Mountain Bulbul	*Ixos mcclellandii*	LC	LC	-	-	B,D,E,F,G,I,J,K,L
Black Bulbul	*Hypsipetes leucocephalus*	LC	LC	-	-	B,D,E,G,H,I,J,K,L
Crested Finchbill	*Spizixos canifrons*	LC	LC	-	-	B,D,E,F,G,H,I,K,L
Striated Bulbul	*Pycnonotus striatus*	LC	LC	-	-	E,G,I,L
Brown-breasted Bulbul	*Pycnonotus xanthorrhous*	LC	LC	-	-	B,D,E,F,G,H,I,J,L
Red-vented Bulbul	*Pycnonotus cafer*	LC	LC	-	-	B,D,E,G,L
Flavescent Bulbul	*Pycnonotus flavescens*	LC	NT	-	TC	D,F,G,H
Yellow-browed Warbler	*Phylloscopus inornatus*	LC	LC	-	-	B,H,J
Sichuan Leaf-warbler	*Phylloscopus forresti*	LC	LC	-	TC	J
Buff-barred Warbler	*Phylloscopus pulcher*	LC	LC	-	-	G,H,I,J
Ashy-throated Warbler	*Phylloscopus maculipennis*	LC	LC	-	-	B,F,G,H,I,J
Dusky Warbler	*Phylloscopus fuscatus*	LC	LC	-	-	J,L
Buff-throated Warbler	*Phylloscopus subaffinis*	LC	LC	-	-	F,I,J,L
Tickell's Leaf-warbler	*Phylloscopus subaffinis*	LC	LC	-	-	I
Yellow-streaked Warbler	*Phylloscopus armandii*	LC	LC	-	-	G
White-spectacled Warbler	*Phylloscopus intermedius*	LC	LC	-	TC	F,G,I,J
Grey-cheeked Warbler	*Phylloscopus poliogenys*	LC	LC	-	-	I,J
Grey-crowned Warbler	*Phylloscopus tephrocephalus*	LC	LC	-	-	G,J
Bianchi's Warbler	*Phylloscopus valentini*	LC	LC	-	-	H,J
Chestnut-crowned Warbler	*Phylloscopus castaniceps*	LC	LC	-	-	E,I,J,L
Greenish Warbler	*Phylloscopus trochiloides*	LC	LC	-	-	H
Large-billed Leaf-warbler	*Phylloscopus magnirostris*	LC	LC	-	TC	J
Blyth's Leaf-warbler	*Phylloscopus reguloides*	LC	LC	-	TC	B,D,E,F,G,H,I,J
White-tailed Leaf-warbler	*Phylloscopus intensior*	LC	LC	-	-	E,F,I,J

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Grey-bellied Tesia	*Tesia cyaniventer*	LC	LC	-	-	G,I,J
Grey-sided Bush-warbler	*Cettia brunnifrons*	LC	LC	-	-	G
Chestnut-headed Tesia	*Cettia castaneocoronata*	LC	LC	-	TC	G,I,J
Black-faced Warbler	*Abroscopus schisticeps*	LC	LC	-	-	E,G,H,I,J,K
Mountain Tailorbird	*Phyllergates cucullatus*	LC	LC	-	-	E,G,I,J
Broad-billed Warbler	*Tickellia hodgsoni*	LC	LC	-	TC	G
Brownish-flanked Bush-warbler	*Horornis fortipes*	LC	LC	-	-	C,D,F,G,H,I,J,L
Aberrant Bush-warbler	*Horornis flavolivaceus*	LC	LC	-	-	G,J
Black-throated Tit	*Aegithalos concinnus*	LC	LC	-	-	B,D,E,F,G,H,I,J,L
Black-browed Tit	*Aegithalos bonvaloti*	LC	LC	-	-	E,G,I,J
Fire-tailed Myzornis	*Myzornis pyrrhoura*	LC	NT	-	TC	G,J
Golden-breasted Fulvetta	*Lioparus chrysotis*	LC	LC	-	-	G,H
White-browed Fulvetta	*Fulvetta vinipectus*	LC	LC	-	-	G,H,I,J
Manipur Fulvetta	*Fulvetta manipurensis*	LC	-	-	TC	E,G,I,J,L
Spectacled Fulvetta	*Fulvetta ruficapilla*	LC	LC	-	-	I,J
Spot-breasted Parrotbill	*Paradoxornis guttaticollis*	LC	LC	-	-	D,E,I
Brown Parrotbill	*Cholornis unicolor*	LC	LC	-	TC	G,H,J,L
Fulvous Parrotbill	*Suthora fulvifrons*	LC	LC	-	-	G,H
Black-throated Parrotbill	*Suthora nipalensis*	LC	DD	-	-	E,G,J,L
Brown-winged Parrotbill	*Sinosuthora brunnea*	LC	LC	-	-	B,D,E,F,G,H,I,J
White-collared Yuhina	*Yuhina diademata*	LC	LC	-	-	F,G,H,I,J
Striated Yuhina	*Yuhina castaniceps*	LC	LC	-	TC	D,I
Stripe-throated Yuhina	*Yuhina gularis*	LC	LC	-	-	E,F,G,H,I,J,L
Whiskered Yuhina	*Yuhina flavicollis*	LC	LC	-	-	B,D,E,F,G,I,J,K,L
Rufous-vented Yuhina	*Yuhina occipitalis*	LC	LC	-	-	E,F,G,H,I,J,L
Chestnut-flanked White-eye	*Zosterops erythropleurus*	LC	LC	-	TC	E,G
Japanese White-eye	*Zosterops japonicus*	LC	LC	-	-	F,G,H,J,L
Oriental White-eye	*Zosterops palpebrosus*	LC	LC	-	-	D,E,F,H,I,J
Bar-winged Wren-babbler	*Spelaeornis troglodytoides*	LC	LC	-	-	J
Grey-bellied Wren-babbler	*Spelaeornis reptatus*	LC	-	-	-	G
Slender-billed Scimitar-babbler	*Pomatorhinus superciliaris*	LC	NT	-	-	G,J
Streak-breasted Scimitar-babbler	*Pomatorhinus ruficollis*	LC	LC	-	-	D,E,F,G,H,I,J,L
Black-streaked Scimitar-babbler	*Erythrogenys gravivox*	LC	-	-	-	D,F,G,H,I,J,L
Rufous-capped Babbler	*Cyanoderma ruficeps*	LC	LC	-	-	D,E,F,G,H,I,J,K,L
Rusty-capped Fulvetta	*Schoeniparus dubius*	LC	LC	-	-	D,E,F,G,H,I,J,L
Yellow-throated Fulvetta	*Schoeniparus cinereus*	LC	LC	-	-	H
Rufous-winged Fulvetta	*Schoeniparus castaneceps*	LC	LC	-	-	B,E,G,H,I,J,K,L
Grey-cheeked Fulvetta	*Alcippe morrisonia*	LC	LC	-	-	B,D,E,F,G,H,I,J,L
Striated Laughingthrush	*Grammatoptila striata*	LC	LC	-	TC	I,J
Himalayan Cutia	*Cutia nipalensis*	LC	LC	-	-	G,I
Spotted Laughingthrush	*Garrulax ocellatus*	LC	NT	-	TC	L
Western Moustached Laughingthrush	*Garrulax cineraceus*	LC	LC	-	-	D
White-browed Laughingthrush	*Garrulax sannio*	LC	LC	-	-	B,D,F,G,I,J,L
Black-throated Laughingthrush	*Garrulax chinensis*	LC	LC	-	TC	G

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Chinese Babax	*Garrulax lanceolatus*	LC	LC	-	-	E,I,J,K,L
White-throated Laughingthrush	*Garrulax albogularis*	LC	LC	-	-	J
Grey-sided Laughingthrush	*Garrulax caerulatus*	LC	LC	-	-	E
Scaly Laughingthrush	*Trochalopteron subunicolor*	LC	LC	-	-	I
Blue-winged Laughingthrush	*Trochalopteron squamatum*	LC	LC	-	TC	G
Black-faced Laughingthrush	*Trochalopteron affine*	LC	LC	-	-	G,J
Red-tailed Laughingthrush	*Trochalopteron milnei*	LC	LC	-	-	I,J
Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	LC	LC	-	-	E,F,G,J,L
Beautiful Sibia	*Heterophasia pulchella*	LC	LC	-	-	E,G,H,I,J,L
Black-headed Sibia	*Heterophasia desgodinsi*	LC	-	-	-	B,D,F,G,H,I,J
Silver-eared Mesia	*Leiothrix argentauris*	LC	NT	-	TC	B,D,E,F,I
Red-billed Leiothrix	*Leiothrix lutea*	LC	LC	-	-	B,E,I,J
Red-tailed Minla	*Minla ignotincta*	LC	LC	-	-	B,E,F,G,H,I,J,K,L
Scarlet-faced Liocichla	*Liocichla ripponi*	LC	NT	-	TC	B,F
Streak-throated Barwing	*Sibia waldeni*	LC	LC	-	-	G,H,I,J
Blue-winged Minla	*Siva cyanouroptera*	LC	LC	-	-	A,B,D,F,G,H,I,J
Bar-throated Minla	*Chrysominla strigula*	LC	LC	-	-	B,E,F,G,H,I,J,L
Rusty-fronted Barwing	*Actinodura egertoni*	LC	LC	-	-	E,F,G,I
Rusty-flanked Treecreeper	*Certhia nipalensis*	LC	LC	-	TC	G,H,J
Manipur Treecreeper	*Certhia manipurensis*	LC	LC	-	-	J
Bar-tailed Treecreeper	*Certhia himalayana*	LC	LC	-	TC	J
Hodgson's Treecreeper	*Certhia hodgsoni*	LC	-	-	TC	J
Chestnut-vented Nuthatch	*Sitta nagaensis*	LC	LC	-	-	B,E,F,G,H,I,J,L
White-tailed Nuthatch	*Sitta himalayensis*	LC	NT	-	-	G,H,I,J
Yunnan Nuthatch	*Sitta yunnanensis*	NT	VU	-	-	H
Wallcreeper	*Tichodroma muraria*	LC	LC	-	-	I
Northern Wren	*Troglodytes troglodytes*	LC	LC	-	TC	H,J
Brown Dipper	*Cinclus pallasii*	LC	LC	-	-	I,J
Black-collared Starling	*Gracupica nigricollis*	LC	LC	-	-	C,H
Chestnut-tailed Starling	*Sturnia malabarica*	LC	LC	-	-	L
White-cheeked Starling	*Spodiopsar cineraceus*	LC	LC	-	TC	A
Collared Myna	*Acridotheres albocinctus*	LC	LC	-	-	A
Crested Myna	*Acridotheres cristatellus*	LC	LC	-	-	A,C,E
Long-tailed Thrush	*Zoothera dixoni*	LC	LC	-	TC	I
Himalayan Forest Thrush	*Zoothera salimalii*	LC	LC	-	TC	G,H
Dark-sided Thrush	*Zoothera marginata*	LC	LC	-	TC	L
Scaly Thrush	*Zoothera dauma*	LC	LC	-	-	F,G
Purple Cochoa	*Cochoa purpurea*	LC	LC	-	TC	J
Eurasian Blackbird	*Turdus merula*	LC	LC	-	TC	D,E,H,L
Grey-winged Blackbird	*Turdus boulboul*	LC	LC	-	TC	L
Black-breasted Thrush	*Turdus dissimilis*	LC	NT	-	-	B,D,H,K
Eyebrowed Thrush	*Turdus obscurus*	LC	LC	-	-	F,I,L
Chestnut Thrush	*Turdus rubrocanus*	LC	LC	-	TC	G
Oriental Magpie-robin	*Copsychus saularis*	LC	LC	-	-	B,D,E,G,H,J,L

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Dark-sided Flycatcher	*Muscicapa sibirica*	LC	LC	-	-	F,G,I,J
Ferruginous Flycatcher	*Muscicapa ferruginea*	LC	LC	-	-	G,I,J,K
Brown-breasted Flycatcher	*Muscicapa muttui*	LC	LC	-	TC	B
Rufous-bellied Niltava	*Niltava sundara*	LC	LC	-	-	G,I,J
Small Niltava	*Niltava macgrigoriae*	LC	LC	-	TC	G,J
Large Vivid Niltava	*Niltava oatesi*	LC	LC	-	TC	I
Fujian Niltava	*Niltava davidi*	LC	LC	-	TC	G,J
Large Niltava	*Niltava grandis*	LC	LC	-	-	B,I
Verditer Flycatcher	*Eumyias thalassinus*	LC	LC	-	-	B,D,E,F,G,I,J
Pale Blue-flycatcher	*Cyornis unicolor*	LC	LC	-	-	I,J
Hill Blue-flycatcher	*Cyornis banyumas*	LC	LC	-	-	D,G
Lesser Shortwing	*Brachypteryx leucophris*	LC	LC	-	-	I,J
Himalayan Shortwing	*Brachypteryx cruralis*	LC	LC	-	-	B,G,J
Indian Blue Robin	*Larvivora brunnea*	LC	LC	-	-	B
Siberian Rubythroat	*Calliope calliope*	LC	LC	-	-	F,I
White-tailed Blue Robin	*Myiomela leucura*	LC	LC	-	-	E,J
Himalayan Bush-robin	*Tarsiger rufilatus*	LC	-	-	TC	B,G,H,I,J,L
White-browed Bush-robin	*Tarsiger indicus*	LC	LC	-	TC	F,I
Golden Bush-robin	*Tarsiger chrysaeus*	LC	LC	-	-	G,H,J
Little Forktail	*Enicurus scouleri*	LC	LC	-	-	G,H,I,J
Slaty-backed Forktail	*Enicurus schistaceus*	LC	LC	-	-	D,I,J,L
White-crowned Forktail	*Enicurus leschenaulti*	LC	-	-	TC	D,E,H,I
Spotted Forktail	*Enicurus maculatus*	LC	LC	-	-	D,G,I,J,L
Blue Whistling-thrush	*Myophonus caeruleus*	LC	LC	-	-	D,G,H,I,J,K
Slaty-backed Flycatcher	*Ficedula erithacus*	LC	LC	-	-	G,H,I,J
Slaty-blue Flycatcher	*Ficedula tricolor*	LC	LC	-	TC	B,F,J
Snowy-browed Flycatcher	*Ficedula hyperythra*	LC	LC	-	-	E,G,J
Pygmy Blue-flycatcher	*Ficedula hodgsoni*	LC	LC	-	-	G,J
Rufous-gorgeted Flycatcher	*Ficedula strophiata*	LC	LC	-	-	G,H,J
Sapphire Flycatcher	*Ficedula sapphira*	LC	LC	-	-	J
Little Pied Flycatcher	*Ficedula westermanni*	LC	LC	-	-	B,D,F,G,I,J,L
Red-throated Flycatcher	*Ficedula albicilla*	LC	LC	-	-	F,G,I
Blue-fronted Redstart	*Phoenicurus frontalis*	LC	LC	-	-	B,E,G,H,I,J,L
White-capped Water-redstart	*Phoenicurus leucocephalus*	LC	LC	-	-	D,G,H,I,J,L
Plumbeous Water-redstart	*Phoenicurus fuliginosus*	LC	LC	-	-	D,E,G,H,I,J,K
Daurian Redstart	*Phoenicurus auroreus*	LC	LC	-	-	B,F,H,I,L
Hodgson's Redstart	*Phoenicurus hodgsoni*	LC	LC	-	-	L
Chestnut-bellied Rock-thrush	*Monticola rufiventris*	LC	LC	-	-	F,H,I,J
Blue Rock-thrush	*Monticola solitarius*	LC	LC	-	-	J
Grey Bushchat	*Saxicola ferreus*	LC	LC	-	-	B,D,E,F,G,H,I,J,L
Pied Bushchat	*Saxicola caprata*	LC	LC	-	-	D,H
Common Stonechat	*Saxicola torquatus*	LC	LC	-	-	C,D,E,F,G,H,I,J,L
Goldcrest	*Regulus regulus*	LC	LC	-	TC	F,I
Orange-bellied Leafbird	*Chloropsis hardwickii*	LC	LC	-	-	D,F,G,H,I

Common name	Scientific name	Conservation status			First record	Survey locations
		1	2	3		
Blue-winged Leafbird	*Chloropsis moluccensis*	LC	LC	-	TC	D
Yellow-bellied Flowerpecker	*Dicaeum melanozanthum*	LC	LC	-	-	E,G,I,J
Plain Flowerpecker	*Dicaeum minullum*	LC	LC	-	-	E,L
Fire-breasted Flowerpecker	*Dicaeum ignipectus*	LC	LC	-	-	D,E,F,G,H,I,J,K,L
Streaked Spiderhunter	*Arachnothera magna*	LC	LC	-	-	B
Fire-tailed Sunbird	*Aethopyga ignicauda*	LC	LC	-	-	E,G,H,I,J,L
Black-throated Sunbird	*Aethopyga saturata*	LC	LC	-	-	D,F
Green-tailed Sunbird	*Aethopyga nipalensis*	LC	LC	-	-	B,F,G,H,I,J,L
Gould's Sunbird	*Aethopyga gouldiae*	LC	LC	-	-	E,F,G,H,I,J,L
Alpine Accentor	*Prunella collaris*	LC	LC	-	TC	G
Maroon-backed Accentor	*Prunella immaculata*	LC	LC	-	-	L
Rufous-breasted Accentor	*Prunella strophiata*	LC	LC	-	TC	G,H,L
White-rumped Munia	*Lonchura striata*	LC	LC	-	TC	H
Scaly-breasted Munia	*Lonchura punctulata*	LC	LC	-	-	E
Russet Sparrow	*Passer cinnamomeus*	LC	LC	-	-	C,D,E,G,H,I,J,K,L
Eurasian Tree Sparrow	*Passer montanus*	LC	LC	-	-	H,J,L
Olive-backed Pipit	*Anthus hodgsoni*	LC	LC	-	-	F,H,I,J
Rosy Pipit	*Anthus roseatus*	LC	LC	-	-	C
Paddyfield Pipit	*Anthus rufulus*	LC	LC	-	-	L
Grey Wagtail	*Motacilla cinerea*	LC	LC	-	-	E,F,I,J,L
Citrine Wagtail	*Motacilla citreola*	LC	LC	-	-	A,C
Eastern Yellow Wagtail	*Motacilla tschutschensis*	LC	LC	-	-	C,J
White Wagtail	*Motacilla alba*	LC	LC	-	-	B,C,D,E,F,G,I,J,K,L
Common Chaffinch	*Fringilla coelebs*	LC	LC	-	YN	G
Brambling	*Fringilla montifringilla*	LC	LC	-	TC	H,I,J
Spot-winged Grosbeak	*Mycerobas melanozanthos*	LC	LC	-	-	J
Common Rosefinch	*Carpodacus erythrinus*	LC	LC	-	-	G,J
Scarlet Finch	*Carpodacus sipahi*	LC	LC	-	-	H
Vinaceous Rosefinch	*Carpodacus vinaceus*	LC	LC	-	TC	G
Crimson-browed Finch	*Carpodacus subhimachalus*	LC	LC	-	TC	G
Brown Bullfinch	*Pyrrhula nipalensis*	LC	LC	-	-	F,H,J
Grey-headed Bullfinch	*Pyrrhula erythaca*	LC	LC	-	TC	G
Gold-naped Finch	*Pyrrhoplectes epauletta*	LC	LC	-	TC	E
Dark-breasted Rosefinch	*Procarduelis nipalensis*	LC	LC	-	TC	J,L
Plain Mountain-finch	*Leucosticte nemoricola*	LC	LC	-	TC	G
Black-headed Greenfinch	*Chloris ambigua*	LC	LC	-	-	C,D,E,F,G,H,I,J
Red Crossbill	*Loxia curvirostra*	LC	LC	-	TC	B,F,G,J
Tibetan Siskin	*Spinus thibetanus*	LC	NT	-	TC	L
Yellow-throated Bunting	*Emberiza elegans*	LC	LC	-	-	H,K
Little Bunting	*Emberiza pusilla*	LC	LC	-	-	E,F,H,I,J,L

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PLATINUM
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A report on the herpetofauna of Tengchong Section of Gaoligongshan National Nature Reserve, China

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Abstract: We present the results from a series of herpetological surveys conducted in the Tengchong Section of Gaoligongshan National Nature Reserve, Yunnan Province, China between April 2014 and November 2018. A total of 59 species of amphibians and reptiles (one salamander, 30 batrachians, four lizards, and 24 snakes) were recorded during the surveys including three newly described amphibian species and 17 new records for Tengchong, 10 of which also represent new generic records for the area. Natural history notes of some little-known species are presented. Our survey results clearly demonstrate that the herpetofauna diversity of this mountain range is still underestimated and warrants further systematic study.

Keywords: Amphibians, ecology, new record, new species, reptiles, species accounts, Yunnan.

Chinese 摘要： 2014 年 4 月至 2018 年 11 月期间，我们对中国云南省高黎贡山国家级自然保护区腾冲辖区内的两栖爬行动物多样性进行野外调查。本次调查共记录 59 种两栖爬行动物，包括有尾类 1 种，无尾类 30 种，蜥蜴类 4 种及蛇类 24 种，其中 3 种两栖动物为此次调查所发现的科学新种，17 种为腾冲地区首次记录的物种。当中 10 种更是腾冲地区的属级新纪录。根据野外调查的数据，本文亦提供部分罕见物种的基础生态学资料。本次调查结果显示高黎贡山地区的两栖爬行动物多样性仍然被低估，尚待进一步的深入调查。

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Author contribution: J-HY: conceived and designed the biodiversity survey, conducted field surveys,analyzed the data, contributed reagents/materials/analysis tools, prepared figures and/ortables, authored or reviewed drafts of the paper, approved the final draft. X-YH: conceived and designed the biodiversity survey, conducted field surveys. J-FY: conducted field surveys, contributed reagents/materials/analysis tools. S-PY: conducted field surveys, contributed reagents/materials/analysis tools. X-CZ: conducted field surveys, contributed reagents/materials/analysis tools. BP-LC: conceived and designed the biodiversity survey, conducted field surveys, authored or reviewed drafts of the paper.

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INTRODUCTION

The Gaoligongshan Mountains (hereafter GLGS) is a sub-range at the southwestern end of the Hengduan Mountains, lying along the west bank of the Nujiang River (The Salween) in the western part of Yunnan Province, China. GLGS is renowned for its unique geography and significant biodiversity (Stattersfield et al. 1998; Chaplin 2005; Dumbacher et al. 2011). The first herpetofauna research of GLGS dates back to the 1860s when western zoologist John Anderson explored the region (Anderson 1876, 1878). Subsequent herpetological surveys were conducted from time to time by Chinese herpetologists, yielding a number of new species endemic to the region (Zhao & Yang 1997; Stotz et al. 2003; Yang & Rao 2008; Fei et al. 2009; Chan & Bi 2016).

The Tengchong Section of Gaoligongshan National Nature Reserve (hereafter TC-GLGS) refers to the reserve area within the Tengchong county-level District, geographically located on the western slope of southern GLGS draining the Irrawaddy River (24.933–25.833 ^{0}N). For more details of the geography and ecology of Tengchong and the nature reserve, readers should refer to Chan et al. (2019, this special issue). In April 2014, a biodiversity survey team, led by Kadoorie Farm and Botanic Garden, started to conduct a biodiversity inventory of TC-GLGS. We herein provide a report on the herpetofauna of TC-GLGS based on our fieldwork.

MATERIALS AND METHODS

From April 2014 to November 2018, we conducted a series of herpetological surveys in the following 10 sites in or adjacent to TC-GLGS: Site 1: Nankang; Site 2: Xiaodifang; Site 3: Dahaoping; Site 4: Hujianglin (the protected riparian forest along Longchuan River); Site 5: Linjiapu; Site 6: Tiantaishan; Site 7: Xiaotianhe; Site 8: Dahetou; Site 9: Dazhuba; and Site 10: Cizhuhe (see Fig. 1). For detailed information on survey sites see Table 1. We followed the taxonomic treatments of Fei et al. (2009) and Frost (2018) for amphibians, and Zhao et al. (1998, 1999) and Uetz et al. (2018) for reptiles. Some voucher specimens are temporarily kept at the herpetology collection of Kadoorie Farm and Botanic Garden, Hong Kong [KFBG] for further studies, and others are deposited at the Museum of Biology, Sun Yat-sen University, Guangzhou [SYS]. For the identification of species, references used include Yang (1991), Zhao et al. (1998, 1999), Fei et al. (2005, 2009, 2012), Zhao (2006), Yang & Rao (2008), Guo & Deng (2009), Fei & Ye (2016), Yang et al. (2016a, 2016b), Yang & Huang (2019).

RESULTS

In total, we documented the presence of 59 species of amphibians and reptiles in TC-GLGS, including one salamander, 30 batrachians, four lizards and 24 snakes; voucher specimens were collected for all but 12 species (see Appendix 1 for the list of voucher specimens). *Leptobrachium tengchongense*, *Leptolalax tengchongensis*, and *Scutiger tengchongensis* were revealed to be new species described by our team (Yang et al. 2016a,b; Yang & Huang 2019). A further 17 species have not been previously reported in TC-GLGS (Xue 1995; Yang & Rao 2008), and 10 genera were new records for the area. A species checklist of herpetofauna based on our survey is provided in Table 2. Voucher photographs were taken for all species recorded, a selection of species are illustrated below (Images 1–7). In the following, selected species of special interest are dealt with in detail, including newly described species, globally threatened species, unidentified species, and those with taxonomic issues, and where our field data provided additional information on natural history of little-known species.

Remarks

***Tylototriton shanjing* (Image 1a)**

This is the only tailed amphibian known from Tengchong. It was found at three sites during the surveys but is believed to be more widespread, because outside breeding season it disperses into forests, which makes detection difficult. From April to June adults congregate to mate in clear puddles and pools in forest as well as nearby farmland below 2,400m. The taxonomic chaos between *Tylototriton shanjing* and its sister-taxon *T. verrucosus* is still not fully resolved (Nishikawa et al. 2014; Khatiwada et al. 2015), and the distribution boundary between these two species is not determined (Fei et al. 2012; Fei & Ye 2016). In this paper, we retain the validity of *T. shanjing* and regard the population in Tengchong as *T. shanjing* following Fei et al. (2012). It is collected as a traditional medicine in most of its range, and is listed as Near Threatened in the IUCN Red List.

***Bufo tuberospinius* (Image 1d)**

Compared with its sympatric congener *B. gargarizans*, this toad species is more common in montane forest habitats up to 2,700m throughout TC-GLGS. It is associated with small streams where adults

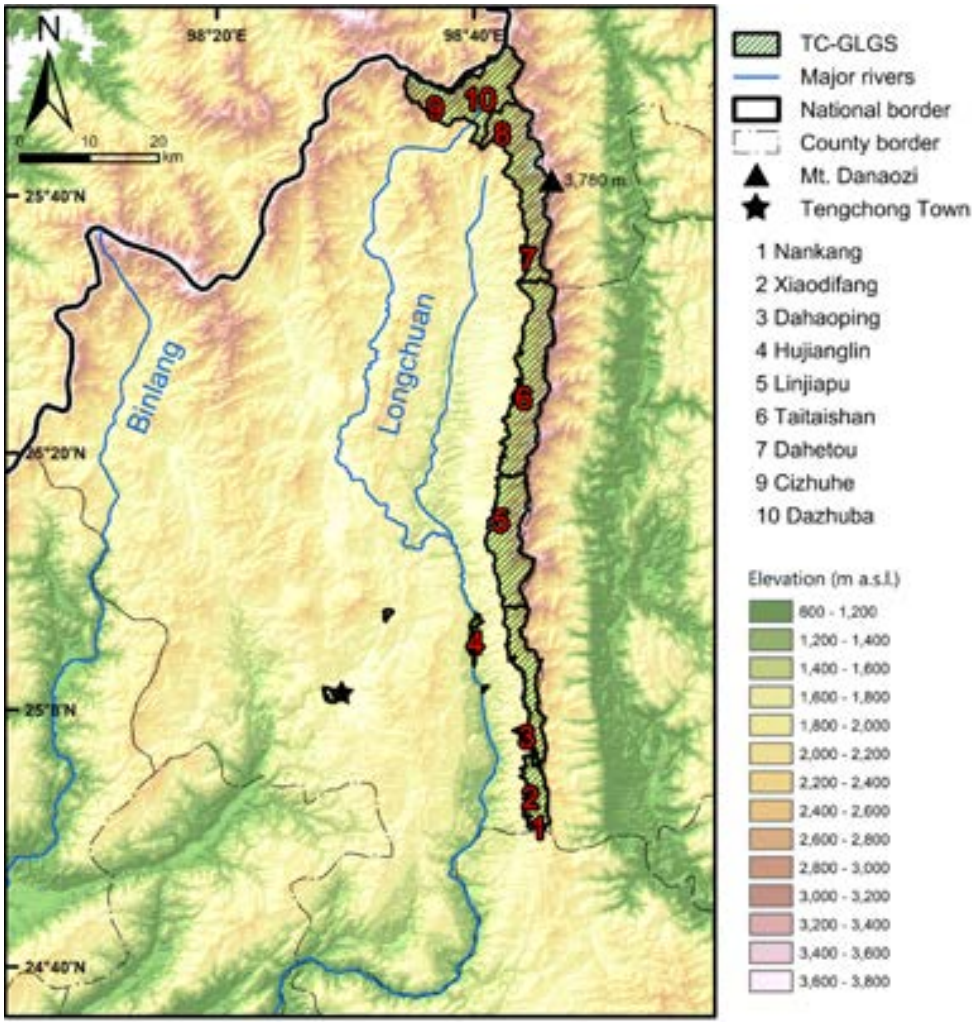

Figure 1. Map of Tengchong, Yunnan Province, China, showing the surveyed localities in this study.

breed and lay eggs in pool sections in between April and July. There has been much debate for the validity of *B. tuberospinius* since its description; while some researchers insisted *B. tuberospinius* is a valid taxon (Yang et al. 1996; Yang & Rao 2008), others regarded it as a synonym of *B. burmanus* distributed in northeastern Myanmar (Fei et al. 2005, 2009, 2012). This has not been fully resolved to date, thus in this paper we retain the validity of *B. tuberospinius* following Frost (2018).

Leptobrachium huashen **(Image 2b)**

This species is found in the southern portion of TC-GLGS. Representatives of the genus *Leptobrachium* from TC-GLGS were previously regarded as *L. chapaensis* (Yang 1991; Xue 1995; Yang & Rao 2008), but recent morphological and molecular research has shown that the population consists of two distinct species, namely *L. huashen* in the south and the newly-described *L. tengchongense* from the northern portion (Fei et al. 2005; Rao & Wilkinson 2008; Yang et al. 2016b).

Leptobrachium tengchongense **(Image 2c)**

This is a new species discovered by our team, which occurs in the northern portion of TC-GLGS between 2,200–2,500 m (Yang et al. 2016b). According to our fieldwork the two species of *Leptobrachium* from TC-GLGS, *L. huashen* and *L. tengchongense*, are allopatric but their ecological niches, distribution limits and contact zone require further investigation. *L. tengchongense* can be easily distinguished from *L. huashen* by having a bicolored iris with upper parts light blue, while the iris is uniformly dark brown in *L. huashen*; the black bands on dorsal surfaces of the limbs are relatively wider in *L. tengchongense* than in *L. huashen* (Yang et al. 2016b).

***Leptolalax tengchongensis* (Image 2d)**

This species was described during a recent survey (Yang et al. 2016a). *Leptolalax tengchongensis* is characterized by having dorsal skin scattered with fine, reddish tubercles; almost entirely black tympanum; large black blotches present on flanks; iris not bicolored, uniform dark brown and scattered with minute, coppery reticulations. *Leptolalax tengchongensis* was found along a clear-water rocky stream and nearby seepage in well-preserved montane moist evergreen broadleaf forest at 2,100m at Site 5; male calls were heard during the April and May surveys.

***Leptolalax* sp. (Image 2f)**

This taxon was recorded along clear-water rocky streams at Sites 3 and 5. At Site 3 male calls were heard in March when night time air temperature was ca. 3°C. At Site 5, this species was sympatric with *L. tengchongensis*, but can be easily distinguished by the male advertisement calls (peak frequency of male calls 4.1–4.3 kHz in *Leptolalax* sp. while 4.5–4.8 kHz in *L. tengchongensis*; each call contains 4–6 notes in *Leptolalax* sp. while consisting of only two notes in *L. tengchongensis* (Jian-Huan Yang, unpublished data, 10 April 2019.) and morphology: *L. tengchongensis* has a uniform dark brown iris in life, while *Leptolalax* sp. has a bi-colored iris with orange-yellow upper half and silvery white lower half. Further molecular and morphological studies are needed to clarify the taxonomic status of *Leptolalax* sp.

***Leptolalax* cf. *ventripunctatus* (Image 2e)**

This species is temporarily allocated to *L. ventripunctatus* by having longitudinal skin folds on dorsum; irregular black spots present on venter; dermal fringes on toes narrow; flank with distinct black spots; and a bicolored iris with orange-yellow upper half and silvery white lower half (Fei et al. 2009; Yang et al. 2018); however, its peak frequency of male calls (6.8–7.1 kHz) is remarkably higher than those of *L. ventripunctatus* from Yingjiang county (6.1–6.4 kHz; see Yang et al. 2018). Due to the great morphological similarity of *Leptolalax* species (Rowley et al. 2015), further molecular analysis is needed in order to obtain the accurate identification. This is the first record of this species for Tengchong while the two congeneric species *L. tengchongensis* and *Leptolalax* sp. were recorded in high-altitude montane areas above 2,100m in TC-GLGS, *Leptolalax* cf. *ventripunctatus* was recorded at 1,360m with subtropical climate/biome at Site 4.

Table 1. Survey localities and dates in Tengchong Section of Gaoligongshan National Nature Reserve for this study, sorted by latitude from south to north.

Site no.	Location	Elevation covered (m)	Survey dates
Site 1	Nankang	2,180	24–25.iv.2014 13–14.ix.2018
Site 2	Xiaodifang	2,150–2,400	10.iii.2015
Site 3	Dahaoping	2,020–2,400	23–24.ix.2014 11–12.iii.2015
			15–17.v.2015 27–28.vii.2015 22–23.v.2018
Site 4	Hujianglin	1,360	9.v.2016 24–26.vi.2017
Site 5	Linjiapu	1,900–3,000	28–30.iv.2014 9–10.xii.2014 15–17.v.2015
Site 6	Tiantaishan	1,850–2,300	29–30.vii.2015
Site 7	Xiaotianhe	2,000–3,100	22–23.vi.2017
Site 8	Dahetou	2,000–2,300	26–27.iv.2014 13–14.iii.2015 17–18.iii.2016 24.vii.2017 23–4.iii.2018 24–25.v.2018
Site9	Dazhuba	2,070–2,200	20–21.v.2015
Site 10	Cizhuhe	2,050–2,920	26–28.ix.2014 11–12.xii.2014 18–19.v.2015 31.vii.–1.viii.2015 20–21.iii.2016 10–11.v.2016

***Megophrys* cf. *minor* (Image 2g)**

This small-sized *Megophrys* species appears to be very common throughout TC-GLGS, and was recorded from all surveyed sites between 2,000–2,300 m. The cryptic behavior of this species makes visual detection a real challenge, but male calls were commonly heard along small streams and seepages in well-preserved forests at 1,900–2,300 m between April and September. In view of the taxonomic chaos of small-sized *Megophrys* in southern China (Chen et al. 2017), we cannot easily assign this species to any known species on the basis of morphology. Further study incorporating molecular, morphological and acoustic methods is needed to solve this problem. In this paper, we temporarily allocate this species to *Megophrys minor* (see also Xue 1995; Yang & Rao 2008; Fei et al. 2009).

***Oreolalax* sp. (Image 3a)**

A sub-adult and a juvenile were collected from Site 8 in May 2015. Subsequent molecular study revealed a sister relationship to *Oreolalax jingdongensis* in the 16S rRNA gene fragment, but *Oreolalax* sp. still presents a certain degree of genetic divergence (Jian-Huan Yang,

Image 1. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—*Tylototriton shanjing* from Site 1 | b—adult male *Bombina maxima* from Site 10 | c—a pair of *Bufo gargarizans* in amplexus from Site 10 | d—*Bufo tuberospinius* from Site 9 | e—*Duttaphrynus melanosticus* from Site 4 | f—an adult male *Nanorana yunnanensis* from Site 5 | g—a pair of *Fejervarya multistriata* in amplexus from Site 4 | h—a pair of *Hyla annectans* in amplexus from Site 10.

Image 2. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—an adult *Brachytarsophrys feae* from Site 3 | b—an adult male *Leptobrachium huashen* from Site 5 | c—adult male holotype SYS a004603 of *Leptobrachium tengchongense* from Site 8 | d—adult male holotype SYS a004600 of *Leptolalax tengchongensis* from Site 5 | e—an adult male *Leptolalax ventripunctatus* from Site 4 | f—an adult male *Leptolalax* sp. from Site 3 | g—*Megophrys* cf. *minor* from Site 3 | h—an adult male *Megophrys glandulosa* from Site 5.

unpublished data, 10 April 2019.). Morphological comparisons are not possible as adult specimens with secondary sexual characteristics are lacking, which is essential for species identification in this genus. Adult specimens are needed to clarify its taxonomic status. *Oreolalax* sp. is a new record for Tengchong.

***Scutiger tengchongsnsis* (Image 3b)**

This species was described by our team during a previous survey (Yang & Huang 2019). *S. tengchongensis* is very distinct from local anurans by dorsum having large conical-shaped and longitudinal tubercles covered by numerous tiny black spines; adult males have a pair of pectoral glands and a pair of axillary glands present on the chest, which are covered by dense tiny black spines; adult males have inner three fingers with black nuptial spines (Yang & Huang 2019). It was found in streamlets and surrounding areas along the main ridge at 3,000m close to Site 7, which represents the southernmost distribution limit of the genus *Scutiger* worldwide. Previous southernmost locality known for the genus was in Fugong County of middle-GLGS, 145km north of Site 7 (Fei & Ye 2016).

***Amolops bellulus* (Image 3d)**

This torrent frog was found in large rocky streams in well-preserved forest at elevations between 2100–2350 m, and currently is only recorded in the northernmost portion of TC-GLGS at sites 8 and 10. This species can be easily distinguished from other stream frogs by dorsum yellowish-brown above; lower flanks olive-green or blueish-green; upper lips light brown and unspotted. Adults were usually found perching on rocks and streamside bushes during surveys in May and June. This species is to date only recorded from GLGS in Lushui County and Tengchong City (Yang & Rao 2008; Fei et al. 2012). Due to the lack of information about its distribution, population and ecology, it is listed as Data Deficient in the IUCN Red List.

***Amolops jinjiangensis* (Image 3e)**

A new record for Tengchong, this species is rarely recorded in TC-GLGS and has been only found twice from Site 7 in August and October 2018. During the survey in October, females were found being gravid and males had distinct nuptial pads on fingers, suggesting they may be breeding at that season. Molecular analyses revealed this population to be identical with *Amolops jinjiangensis*: there was no genetic divergence in the 16S rRNA gene fragment between our specimens and a sequence of *A. jinjiangensis* from the Genbank database (Genbank No. EF453741). The TC-GLGS population represents a new distribution record of this rarely known species and is far away from its known distribution areas in north-western Yunnan Province and adjoining areas in Sichuan Province (Fei et al. 2009). *A. jinjiangensis* is now listed as Vulnerable in the IUCN Red.

***Odorrana graminea* (Image 4a)**

A new record for Tengchong, this large stream frog is widely distributed in southern China and very common in stream areas (Fei et al. 2009); however, this species was only found at Site 4 (ca. 1400m), although intensive surveys at other sites (mostly above 2000m) have been made, suggesting that it may be restricted to relatively low altitude forest areas.

***Polypedates braueri* (Image 4c)**

Recent molecular studies suggested that the species in the *Polypedates leucomystax* complex from Tengchong, which was previously treated as *P. megacephalus* (Yang & Rao 2008; Fei et al. 2009), is actually *P. braueri* (Kuraishi et al. 2013; Pan et al. 2013).

***Rhacophorus puerensis* (Image 4d, 4e)**

This species was recorded from the southernmost and northernmost portions of TC-GLGS at Sites 1, 2 and 10 at 2,100–2,880 m elevation, suggesting that it is widely distributed in TC-GLGS. During the breeding season from late April to May, male calls were heard from the ground in puddle and grassland at forest edge, and eggs were laid in foam nests in soft mud around still water. Due to the lack of information about its distribution, population and ecology, it is listed as Data Deficient in the IUCN Red List.

***Gracixalus* sp. (Image 4h)**

This is the first record of the genus *Gracixalus* from GLGS (Fei et al. 2009; Fei & Ye 2016). Male calls of this species were widely recorded from south to north in TC-GLGS during surveys between April to July. The frogs were very difficult to collect, however, because all males were calling from the upper layers of small trees/shrubs ca. 3m from above the ground. Only one pair (one calling male and one gravid female) was found together inside a small tree hole from Site 3 in May 2018. Subsequent molecular study revealed a sister relationship to *Gracixalus tianlinensis* from northwestern Guangxi in the 16S rRNA gene fragment, but *Gracixalus* sp. still presents a certain degree of genetic divergence (Jian-Huan Yang, unpublished data, 10 April 2019). Detailed integrative taxonomical studies incorporating

Table 2. Amphibians and reptiles recorded in Tengchong Section of Gaoligongshan National Nature Reserve, 2014–2018. For site details refer to Table 1.

Taxon	Chinese common name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
AMPHIBIA											
Bombinatoridae											
Bombina maxima (Boulenger, 1905)*	大蹼铃蟾*										X
Bufonidae											
Bufo gargarizans Cantor, 1842*	中华蟾蜍*								X		X
Bufo tuberospinius (Yang, Liu & Rao, 1996)	疣棘溪蟾			X		X		X	X	X	X
Duttaphrynus melanosticus (Schneider, 1799)	黑眶蟾蜍			X	X						
Dicroglossidae											
Fejervarya multistriata (Hallowell, 1861)	泽蛙				X			X			
Nanorana yunnanensis (Anderson, 1879)	双团棘胸蛙		X	X		X	X	X	X	X	X
Hylidae											
Hyla annectans (Jerdon, 1870)	华西雨蛙				X		X	X	X	X	X
Megophryidae											
Brachytarsophrys feae (Boulenger, 1887)	费氏短腿蟾			X							
Leptobrachium huashen Fei & Ye, 2005	华深拟髭蟾			X		X					
Leptobrachium tengchongense Yang, Wang & Chan, 2016**	腾冲拟髭蟾**							X	X		X
Leptolalax tengchongensis Yang, Wang, Chen & Rao, 2016**	腾冲掌突蟾**					X					
Leptolalax cf. *ventripunctatus* Fei, Ye & Li, 1990*	腹斑掌突蟾*				X						
Leptolalax sp.*	掌突蟾属一种*			X		X					
Megophrys glandulosa Fei, Ye & Huang, 1990	腺角蟾			X	X	X		X	X	X	X
Megophrys cf. *minor* Stejneger, 1926	小角蟾（暂定）		X	X		X	X	X	X	X	X
Oreolalax sp.*	齿蟾属一种*							X	X		X
Scutiger tengchongensis Yang & Huang, 2019**	腾冲齿突蟾**							X			
Microhylidae											
Microhyla fissipes Boulenger, 1884	饰纹姬蛙			X	X						
Ranidae											
Amolops bellulus Liu, Yang, Ferraris & Matsui, 2000	丽湍蛙								X		X
Amolops jingjiangensis Su, Yang & Li, 1986*	金江湍蛙*								X		
Amolops viridimaculatus (Jiang, 1983)	绿点湍蛙			X		X		X	X		
Babina pleuraden (Boulenger, 1904)	滇蛙	X	X	X		X	X	X	X		X
Odorrana andersonii (Boulenger, 1882)	云南臭蛙		X		X	X		X	X	X	X
Odorrana graminea (Boulenger, 1900)*	大绿臭蛙*				X						
Rana chaochiaoensis Liu, 1946	昭觉林蛙			X		X		X	X		X
Rhacophoridae											
Gracixalus sp.*	纤树蛙属一种*			X					X	X	X
Polypedates braueri (Vogt, 1911)	布氏树蛙			X	X		X	X	X	X	X
Rhacophorus burmanus (Andersson, 1939)	缅甸树蛙			X		X			X	X	X
Rhacophorus puerensis (He, 1999)	普洱树蛙	X	X								X
Rhacophorus rhodopus Liu & Hu, 1960	红蹼树蛙			X	X			X	X		
Salamandridae											
Tylototriton shanjing Nussbaum, Brodie & Yang, 1995	红瘰疣螈	X		X							X

Taxon	Chinese common name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
REPTILIA											
Agamidae											
Japalura yunnanensis Anderson, 1878	云南攀蜥	X		X		X		X			
Pseudocalotes kakhienensis (Anderson, 1879)	蚌西拟树蜥							X			
Scincidae											
Scincella doriae (Boulenger, 1887)*	长肢滑蜥*	X		X							
Sphenomorphus indicus (Gray, 1853)	印度蜓蜥	X					X	X			
Colubroidea											
Archelaphe bella (Stanley, 1917)*	方花小头蛇*			X					X		
Coelognathus radiatus (Boie, 1827)	三索锦蛇				X						
Elaphe carinata (Günther, 1864)	王锦蛇						X	X	X		
Hebius octolineatum (Boulenger, 1904)	八线腹链蛇								X	X	X
Hebius modestum (Günther, 1875)	腹斑腹链蛇								X	X	
Lycodon fasciatus (Anderson, 1879)	双全链蛇			X					X		
Lycodon cf. *septentrionalis* (Günther, 1875)*	白链蛇*								X		
Oreocryptophis porphyraceus (Cantor, 1839)	紫灰锦蛇			X					X		
Orthriophis taeniurus (Cope, 1861)	黑眉锦蛇			X				X	X		
Psammodynastes pulverulentus (Boie, 1827)	紫砂蛇				X						
Pseudoxenodon macrops (Blyth, 1855)	大眼斜鳞蛇			X				X	X		X
Ptyas nigromarginata (Blyth, 1854)	黑线乌梢蛇				X						
Rhabdophis leonardi (Wall, 1923)	缅甸颈槽蛇			X		X		X	X	X	X
Rhabdophis himalayanus (Günther, 1864)*	喜山颈槽蛇*				X						
Rhabdophis subminiatus (Schlegel, 1837)	红脖颈槽蛇				X						
Sibynophis collaris (Gray, 1853)	黑领剑蛇								X		
Elapidae											
Bungarus multicinctus Blyth, 1861	银环蛇			X							
Ophiophagus hannah (Cantor, 1836)*	眼镜王蛇*				X						
Sinomicrurus kelloggi (Pope, 1928)*	福建丽纹蛇*			X							
Pareatidae											
Pareas sp.*	钝头蛇属一种*									X	
Pareas nigriceps Guo & Deng, 2009*	黑顶钝头蛇*			X							
Viperidae											
Ovophis monticola (Günther, 1864)	山烙铁头			X		X	X	X	X	X	X
Protobothrops jerdonii (Günther, 1875)*	菜花烙铁头*			X				X		X	
Trimeresurus yunnanensis Schmidt, 1925	云南竹叶青					X		X	X		

Remarks: Species distribution is based on our own field data, and do not represent true distribution range of these species in Tengchong Section of Gaoligongshan National Nature Reserve.
* represents newly recorded species for Tengchong (refers to Xue 1995; Yang & Rao 2008); ** represents new species discovered during the surveys.

morphological, molecular and acoustic data is underway in order to clarify its taxonomic status.

***Lycodon fasciatus* (Image 6a)**

One sub-adult specimen was collected from Site 7 in October 2018, which matches the diagnosis of *Lycodon fasciatus* by having one small preocular; loreal elongate, not in contact with eye on left side while in narrow contact with eye on right side; temporals: 2+3; supralabials eight, 2nd to 4th ones touching the eye; dorsal scale rows 17:17:15, keeled on dorsal rows 7–9; solid black above with 34 and 16 transverse pinkish-brown bands (in 2–3 scales wide) on body and tail respectively; ventrals 195; and subcaudals 86, paired (Zhao et al. 1999; Zhao 2006).

***Lycodon* cf. *septentrionalis* (Image 6b)**

A new record for Tengchong. One adult female specimen (snout-vent length 955mm, tail length 210mm) was collected from Site 7 in Oct 2018, which matches the diagnosis of *Lycodon septentrionalis* by having one preocular; loreal not in contact with eye; temporals: 2+2; supralabials seven, 3rd and 4th ones touching the eye; dorsal scale rows 17:17:15, smooth throughout the body (however, versus feebly keeled in the original description); ventrals 221; subcaudals 74, paired; solid black above with 29 and 13 narrow white transverse bands on body and tail respectively (Zhao et al. 1999; Zhao 2006).

***Rhabdophis himalayanus* (Image 7a)**

A new record for Tengchong. A single juvenile specimen (snout-vent length 256mm, tail length 78mm) was collected from Site 4 at 1,360m in June 2017, which matches the diagnosis of *Rhabdophis himalayanus* by having one preocular, postoculars three; temporals: 2+2, supralabials 8/8, 4th and 5th touching the eye; dorsal scale rows 19:19:17; ventrals 163; subcaudals 82, paired; two distinct narrow orange yellow transverse bands at nuchal region, narrow and short dark brown transverse bands present on dorsum of body (Zhao 2006). In China, this rare species was previously only known from southeastern Tibet and Gongshan County in northern GLGS (Zhao et al. 1999; Zhao 2006).

Ophiophagus hannah

A new record for Tengchong. Three adults were encountered at Site 4 at 1,360m between 13.00h and 16.00h on 9 May 2017. Intensive surveys at other sites failed to detect this large-sized species, suggesting that it may be restricted to relatively low altitude forest areas in Tengchong. Despite its wide distribution range worldwide, the King Cobra faces great pressures from habitat loss and over-exploitation (Stuart et al. 2012), and it is now listed as Vulnerable in the IUCN Red List.

***Sinomicrurus kelloggi* (Image 7c)**

This is the first record of the genus *Sinomicrurus* from GLGS. A photo of an individual of *Sinomicrurus* species was taken by a TC-GLGS warden at 2,020m from Site 3, but the specimen was not collected. The snake matches the diagnosis of *Sinomicrurus kelloggi* by having reddish-brown dorsum and narrow transverse cross-bars above body and tail, an inverted V shape of creamy white band present on head (Zhao et al. 1998; Zhao 2006). It is the third record of the species from Yunnan Province (Yang & Rao 2008; Sun et al. 2015).

***Pareas nigriceps* (Image 7e)**

This is a new generic record for GLGS. A single individual was recorded at Site 3 in May 2015, found at night on shrub in old-growth forest at 2,050m. *Pareas nigriceps* is a newly-described snake species from adjacent Xiaoheishan in Longling County, with the type locality reported as 24.83671°N, 98.76185°E (2,067m) (Guo & Deng 2009). Our record represents the second documented locality for the species, and a slight northern range expansion. Brief measurements and scalation characters of the specimen: SYS r001222, SVL: 525.9mm; tail length: 133.1mm. Supralabials 7/7, 7th elongate and largest; infralabials 7/7; preocular one; subocular one; postocular absent; temporals: 1+2; ventrals 184; subcaudals 73, paired; dorsal scale rows 15:15:15, dorsal five rows slightly keeled; vertebrate scale slightly enlarged. Due to the lack of information on distribution, status and ecology of this recently described species, it is listed as Data Deficient in the IUCN Red List.

***Pareas* sp. (Image 7d)**

A single specimen was collected from Site 9 which cannot be allocated to any known species in the genus. Brief measurements and scalation characters of the specimen: nasal one; loreal touching the eye; prefrontal touching the eye; subocular and postocular fused; infralabials seven; anterior temporals two, posterior temporials three; 11 middle rows of dorsal scales keeled at mid-body; vertebral scales not enlarged; ventral scales 173; subcaudals 62, paired. More specimens and genetic analyses are needed to clarify the taxonomic status of this taxon.

Image 3. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—an subadult of *Oreolalax* sp. from Site 9 | b—adult male hototype SYS a005793 of *Scutiger tengchongensis* from Site 7 | c—*Microhyla fissipes* from Site 3 | d—an adult male *Amolops bellulus* from Site 10 | e—an adult female *Amolops jinjiangensis* from Site 8 | f—*Amolops viridimaculatus* from Site 5 | g—*Babina pleuraden* from Site 3 | h—*Odorrana andersonii* from Site 9.

Image 4. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—an adult female *Odorrana graminea* from Site 4 | b—*Rana chaochiaoensis* from Site 7 | c—an adult male *Polypedates braueri* from Site 10 | d —an adult male *Rhacophorus rhodopus* from Site 3 | e—an adult male *Rhacophorus rhodopus* from Site 7, note the coloration variation on dorsum in life | f—an adult male *Rhacophorus burmanus* from Site 10 | g—a pair of *Rhacophorus puerensis* from Site 9 | h—an adult male *Gracixalus* sp. from Site 3.

Image 5. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—an adult female *Japalura yunnanensis* from Site 1 | b—*Pseudocalotes kakhienensis* from Site 7 | c—an adult *Scincella doriae* from Site 3 | d—*Sphenomorphus indicus* from Site 6 | e—*Archelaphe bella* from Site 8 | f—*Elaphe carinata* from Site 6 | g—*Hebius octolineatum* from Site 10 | h—*Hebius modestum* from Site 7.

Image 6. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—*Lycodon fasciatus* from Site 7 | b—*Lycodon septentrionalis* from Site 7 | c—*Oreocryptophis porphyraceus* from Site 7 | d—freshly-killed *Orthriophis taeniurus* from Site 3 | e—*Psammodynastes pulverulentus* from Site 4 | f—an adult *Pseudoxenodon macrops* from Site 3 | g—a juvenile *Pseudoxenodon macrops* from Site 8, noted the coloration variation | h—*Rhabdophis leonardi* from Site 8.

Image 7. Herpetofauna recorded in the Tengchong Section of Gaoligongshan National Nature Reserve from 2014–2018. For site details refer to Table 1: a—a juvenile *Rhabdophis himalayanus* from Site 4 | b—*Sibynophis collaris* from Site 8 | c—*Sinomicrurus kelloggi* from Site 3 | d—*Pareas* sp. from Site 9 | e—*Pareas nigriceps* from Site 3 | f—*Ovophis monticola* from Site 5 | g—an adult *Protobothrops jerdonii* from Site 9 digesting large prey | h—*Trimeresurus yunnanensis* from Site 5.

DISCUSSION

Our survey greatly enhances our understanding of the herpetofauna diversity of TC-GLGS, with discoveries of at least three species new to science and a series of new regional records, including 10 new generic records. A number of collected species are yet to be thoroughly identified due to the lack of specimen series, and some of these may prove to be new when more collections or genetic data become available in the future. Information for most recorded species can also be found in Chan & Bi (2016). Since we focused our efforts on well-protected montane forests at the elevation band between 1900m and 3000m (see table 1), a number of herpetofauna previously recorded from Tengchong (Xue 1995; Zhao & Yang 1997; Yang & Rao 2008) were not detected during our survey: *Hoplobatrachus rugulosus* (Wiegmann), *Microhyla heymonsi* Vogt, *Hemidactylus bowringii* (Gray), *Hemiphyllodactylus yunnanensis* (Boulenger), *Acanthosaura lepidogaster* (Cuvier), *Calotes emma* Gray, *Calotes jerdoni* Günther, *Sphenomorphus incognitus* (Thompson), *S. maculatus* (Blyth), *Ahaetulla prasina* (Boie), *Atretium yunnanensis* Anderson, *Plagiopholis blakewayi* Boulenger, *Ptyas korros* (Schlegel), *P. mucosa* (Linnaeus), *Naja kaouthia* Lesson, and *Trimeresurus albolabris* Gray. Most of these missing species occur at lower elevations and/or in disturbed habitats, where we invested little survey effort. Further surveys in these habitats are needed to ascertain the current status and distribution of these species. Our results clearly highlight the fact that the herpetofauna of GLGS remains imperfectly studied and its diversity is undoubtedly underestimated. Future herpetological expeditions will probably uncover more exciting findings in TC-GLGS, especially in higher altitude habitats of the reserve.

The natural forests of Gaoligongshan National Nature Reserve have been well protected, and we found few anthropogenic activities which are threatening the survival of amphibians and reptiles, however, local populations of certain large-sized frogs are being suppressed by over-collecting for human consumption, in particular *Nanorana yunnanensis* which fetches high prices (USD 30–40 per kilogram) in local markets; its wild population has declined dramatically and is now listed as Endangered in the IUCN Red List. Our interviews also revealed that local people opportunistically collect large "rat snakes" from the genera *Elaphe* and *Orthriophis* for consumption. Education outreach targeting this issue is called for if populations of the affected species are to recover to a natural level.

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Appendix 1. Voucher specimens collected during the survey. See materials and methods for museum abbreviations.

Bombina maxima: SYS a003798–3800, coll. 18 May 2015, from Site 10 by Jian-Huan Yang (JHY, hereafter); KFBG 14446–14447, coll. 18 May 2015, from Site 10 by JHY.
Bufo tuberospinius: SYS a003811, coll. 17 May 2015, from Site 3 by Jian Wang (JW, hereafter); KFBG 14350, coll. 27 July 2015, from Site 3 by JHY.
Duttaphrynus melanosticus: KFBG 14457, coll. 25 June 2017, from Site 4 by JHY.
Nanorana yunnanensis: SYS a003763, coll. 18 May 2015, from Site 5 by JHY; SYS a003796, coll. 17 May 2015, from Site 3 by JW; SYS a003843–3844, coll. 18 May 2015, from Site 10 by JHY; KFBG 14117, coll. 13 March 2015, from Site 8 by JHY.
Hyla annectans: SYS a003816–3818, coll. 22 May 2015, from Site 10 by JHY.
Leptobrachium huashen: SYS a003751–3752, coll. 15 May 2015, from Site 5 by JHY; SYS a003779–3781, coll. 17 May 2015, from Site 3 by JW; KFBG 14301–14302, coll. 15 May 2015, from Site 5 by JHY.
Leptobrachium tengchongense: SYS a004603, coll. 13 March 2015, SYS a004623–4627, coll. 17–18 March 2016, from Site 8, by YJH; SYS a004628–4632, coll. 20–21 March 2016, from Site 10, by JHY.
Leptolalax tengchongensis: SYS a004956, coll. on 29 April 2014, SYS a004957–4602, coll. on 16 May 2015, from Site 5, by JHY
Leptolalax* cf. *ventripunctatus: KFBG 14462–14464, coll. 25 June 2017, from Site 4 by JHY.
***Leptolalax* sp.**: KFBG 14111–14115, coll. on 11 March 2015, from site 3 by JHY; KFBG 14295–14296, coll. on 15 May 2015, from Site 5 by JHY.
Megophrys glandulosa: SYS a003757–3758, SYS a003762, coll. 15 May 2015, from site 5 by JHY; SYS a003792–3795, coll. 17 May 2015, from Site 3 by JW.
Megophrys* cf. *minor: SYS a003755, SYS a00376–3761, SYS a003767, coll. 15 May 2015, from Site 5 by JHY; SYS a003782–3798, coll. 17 May 2015, from Site 3 by JW; SYS a003821–3827, SYS a003837–3839, coll. 18 May 2015, from Site 10 by JHY.
***Oreolalax* sp.**: KFBG 14356–14357, coll. 18 May 2015, from Site 10 by JHY.
Scutiger tengchongensis: SYS a005793–5797, coll. on 22 June 2017, from Site 7, by JHY and Shen-Pin Yang (SPY).
Microhyla fissipes: KFBG 14354, coll. 17 July 2015, from Site 3 by JHY; KFBG 14465, coll. 9 May 2016, from Site 4 by JHY.
Amolops bellulus: KFBG 14425–14427, coll. 11 May 2016, from Site 10 by JHY.
Amolops jinjiangensis: KFBG 14561–14567, coll. 20 October 2017, from Site 8, by SPY.
Amolops viridimaculatus: SYS a003753–3754, coll. 15 May 2015, from Site 5 by JHY; SYS a003797, SYS a003812–3813, coll. 17 May 2015, from Site 3 by JW.
Babina pleuraden: SYS a003775–3778, coll. 17 May 2015, from Site 3 by JW.
Odorrana andersoni: SYS a003820, SYS a003831–3834, coll. 18 May 2015, from Site 10 by JHY.
Odorrana graminea: KFBG 14429, coll. 9 May 2016, from Site 4 by JHY.
Rana chaochiaoensis: SYS a003819, coll. 18 May 2015, from Site 10 by JHY; KFBG 14460–14461, 29 April 2014, from Site 5 by JHY.
***Gracixalus* sp.**: KFBG 14558–15559, coll. 22 May 2018, from Site 3 by JHY.
Polypedates braueri: SYS a003770, SYS a003774, SYS a003814–3815 coll. 17 May 2015, from Site 3 by JW; SYS a003835–3836, SYS a003841–3842, coll. 18 May 2015, from Site 10 by JHY.
Rhacophorus rhodopus: KFBG 14352--14353, coll. 27 July 2015, from Site 3 by JHY.
Rhacophorus burmanus: SYS a003764, coll. 15 May 2015, from Site 5 by JHY; SYS a003829–3830, SYS a003840, coll. 18 May 2015, from Site 10 by JHY.
Rhacophorus puerensis: SYS a003771–3772, coll. 17 May 2015, from Site 3 by JW.
Tylototriton shanjing: SYS a003768–3769, coll. 17 May 2015, from Site 3 by JW.
Japalura yunnanensis: SYS r001215, coll. 15 May 2015, from site 5 by JHY; SYS r001220, coll. 17 May 2015, from Site 3 by JW; KFBG 14389–14390, coll. 15 May 2015, from Site 5 by JHY.
Pseudocalotes kakhienensis: KFBG 14391–14392, coll. February 2018, from Site 7 by SPY.
Scincella doriae: KFBG 14361, coll. 24 April 2014, from Site 1 by JHY; KFBG 14362, coll. 17 May 2015, from Site 3 by JW.
Sphenomorphus indicus: KFBG 14459, coll. February 2018, from Site 7 by SPY.
Archelaphe bella: KFBG 14466–14467, coll. 23 May 2018, from Site 3 by JHY.
Hebius octolineatum: SYS r001223, coll. 18 May 2015, from Site 10 by JHY; SYS r001225, coll. 20 May 2015, from Site 9 by JHY.
***Hebius modestum*:** KFBG 14557, coll. 11 May 2018, from Site 7 by SPY.
***Lycodon fasciatus*:** KFBG 14578, coll. 22 October 2018, from Site 7 by SPY.
Lycodon* cf. *septentrionalis: KFBG 14579, coll. 22 October 2018, from Site 7 by SPY.
Oreocryptophis porphyraceus: KFBG 14576, coll. 13 July 2018, from Site 7 by SPY.
Psammodynastes pulverulentus: KFBG 14456, coll. 25 June 2017, from Site 4 by JHY.
Pseudoxenodon macrops: KFBG 14450, coll. June 2017, from Site 3 by Philip Lo; KFBG 14451, coll. 13 March 2015, from Site 7 by JHY.
Rhabdophis leonardi: SYS r001221, Dahaoping; SYS r001224, Site 9; KFBG 14344, coll. September 2014, from Site 8 by JHY; KFBG 14345, coll. 20 May 2015, from Site 9 by JHY; KFBG 14346, coll. 27 April 2014, from Site 8 by JHY; KFBG 14347, coll. 17 May 2015, from Site 10 by JHY; KFBG 14348, coll. on 19 July 2015, from Site 8 by JHY.
Rhabdophis himalayanus: KFBG 14458, coll. 25 June 2017, from Site 4 by JHY.
***Pareas* sp.**: KFBG 14360, coll. 20 May 2015, from Site 9 by JHY
Pareas nigriceps: SYS r001222, coll. 17 May 2015, from Site 3 by JW.
Ovophis monticola: SYS r001217, coll. 15 May 2015, from Site 5 by JHY.
Protobothrops jerdonii: SYS r001218, coll. 17 May 2015, from Site 3 by JW.
***Trimeresurus yunnanensis*:** SYS r001216, coll. 15 May 2015, from Site 5 by JHY.

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A preliminary report on butterfly fauna (Insecta: Lepidoptera) of Tengchong Section of Gaoligongshan National Nature Reserve, China

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Abstract: The butterfly fauna of Tengchong Section of Gaoligongshan National Nature Reserve, western Yunnan, China was investigated during a series of field surveys conducted between April 2014 and May 2018. A total of 216 butterfly species were recorded (Hesperiidae 41, Papilionidae 20, Pieridae 21, Lycaenidae 45, and Nymphalidae 89), of which 179 represent new records for Tengchong. Significant findings include paratype materials of a recently described genus and a subspecies, respectively, as well as three national and five provincial new records. Several obscure species were rediscovered during the survey, including two taxa that have not been recorded since their descriptions, *Celaenorrhinus morena* Evans, 1949 and *Thoressa pedla pedla* (Evans, 1956). The result of the survey is presented herein with notes on some little-known species. Additionally, past records on Tengchong butterfly fauna were reviewed and a name is treated as *nomen nudum*.

Keywords: Eastern Himalaya, Hengduan Mountains, Kachin, Myanmar, national new records, western Yunnan.

Chinese 摘要： 在 2014 年 4 月至 2018 年 5 月期间，对中国云南西部高黎贡山国家级自然保护区腾冲片区的蝶类进行了一系列调查，共记录蝶类 216 种（弄蝶科 41 种；凤蝶科 20 种；粉蝶科 21 种；灰蝶科 45 种；蛱蝶科 89 种），其中包括腾冲市新记录 179 种。本调查其他重要发现包括采集到 1 个新近被描述的属和亚种的副模式标本，以及 3 个中国和 5 个云南省新记录种 / 亚种。在调查中还重新发现了一些鲜为人知的物种，包括 2 个自正式描述以来未再被记录的分类单元，即摩星弄蝶 *Celaenorrhinus morena* Evans, 1949 和侏儒陀弄蝶指名亚种 *Thoressa pedla pedla* (Evans, 1956)。本报告列出了详细的调查结果，并对其中一些重要物种进行深入探讨。此外，本报告还回顾了腾冲蝴蝶的历史纪录，并将 1 个学名处理为裸名 (*nomen nudum*)。

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Author contribution: YFLP conceived, designed and performed the analysis, and wrote the paper. Both authors collected and contributed data.

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INTRODUCTION

Gaoligongshan (hereafter GLGS) is a mountain range that runs north-south along the border between Kachin State (Myanmar) and western Yunnan (China). GLGS part of the Hengduan Mountains of southwestern China, and is well known for rich and unique biodiversity. The southern part of GLGS was designated a nature reserve in 1986 and recognized as a biosphere reserve in 2000 (UNESCO 2007), and the Tengchong section is located on the western slope of the reserve. For administrative and geographic details see Chan et al. (2019, this issue).

Tengchong was the first area in GLGS to be explored by western zoologists, when British zoologist John Anderson made a collecting expedition in Daying River and Tengchong of western Yunnan in 1868. One-hundred-and-eighteen butterfly species were collected during the expedition, including three new species described by Atkinson (1871) (Anderson 1878). Since detailed locality information was not provided in Anderson's report, it is not possible to distinguish Tengchong material from the rest of his collection. Following Anderson's exploration, a number of naturalists visited GLGS in the early 20th Century, but their works contributed little to the knowledge of butterfly fauna of the region.

Starting from the 1970s, GLGS has been frequently visited by Chinese and Japanese entomologists. The exceptionally high species richness of butterflies was gradually revealed with the description of a number of new taxa (e.g., Yoshino 1995, 1997, 1999, 2008; Huang 2001, 2002, 2003). Most efforts were focused on the Nujiang (Salween River) Valley on the eastern slope of the mountain range, and the butterfly fauna of Tengchong on the western slope of GLGS received less attention and was not comprehensively documented. It was only briefly investigated during the Yunnan forest pest survey from 1979 to 1982 organized by the Yunnan Provincial Department of Forestry, which listed 482 butterfly species for Yunnan Province, of which 32 were recorded from Tengchong (Lee & Cao 1987). The discovery of *Neorina neosinica* Lee, 1985, an astonishing satyrid butterfly, was perhaps the most notable finding in Tengchong from that study. Lee (1995) & Xue (1995) basically adopted the information in Lee & Cao (1987).

Since 2000, several more butterfly species were added to the Tengchong list following taxonomic works on particular groups. Three skipper species of the genus *Thoressa* were reported in Tengchong in a study of the tribe Aeromachini from China (Huang 2009). Meanwhile, Xue (2009) listed four additional skipper species from the same area in a study of Chinese Hesperiidae. Lang & Duan (2016) described a new *Lethe* species from Tengchong. A further seven satyrid butterfly species from the subtribe Lethina were reported in Tengchong by Lang (2017). By 2017, 51 species of butterfly were documented for Tengchong, which likely underestimated the rich biodiversity of this area. To update this information, a series of joint biodiversity surveys were organized by Kadoorie Farm and Botanic Garden (KFBG) and the Tengchong Bureau of Gaoligongshan National Nature Reserve during 2014–2018. The survey results for butterfly fauna are presented herein, with a checklist and notes on selected species of special interest.

METHODS

Study areas

Surveys were conducted primarily in the Tengchong Section of Gaoligongshan National Nature Reserve (hereafter TC-GLGS) including all six management sections (from south to north: Zhengding, Dahaoping, Qushi, Jietou, Datang and Zizhi). In addition, lower-elevation forests of Laifengshan National Forest Park and the protected riparian forest along Longchuan River were also surveyed. Fieldwork covered elevations between 1,300m and 2,800m and was conducted during March to October, which is expected to cover the flight periods of most butterfly species in the region. A total of 57.5 man-days were spent from April 2014 to May 2018; survey details are shown in Table 1. For detail information on geography, vegetation and habitat of the study area, please refer to Chan et al. (2019, this issue).

Survey methods

Daytime surveys were conducted in a variety of habitats when weather conditions were favourable for butterfly activity (non-rainy, temperature >20°C) along roads and major forest trails throughout the study areas, using standard 42cm diameter insect nets to collect adult butterflies (superfamily Papilionoidea), particular attention was paid at mud-puddling sites and spots of nectar source. Some individuals were retained as voucher materials or for identification purpose. Duplicate material that could be readily identified in the field was released immediately after recording. Larvae were also recorded opportunistically by examination of potential host plants. Verified photo records of important species taken by other members of KFBG and TC-GLGS were also included in the list.

Table 1. Survey sites and dates of this study (southern Tengchong includes Zhengding, Dahaoping and Qushi sections of TC-GLGS; northern Tengchong includes Jietou, Datang and Zizhi sections of TC-GLGS).

Date	Survey sites	Man-day
April 2014	Southern Tengchong, northern Tengchong, Laifengshan	4.5
September 2014	Southern Tengchong, northern Tengchong	6.0
May 2015	Southern Tengchong, northern Tengchong	10.0
July–August 2015	Southern Tengchong, northern Tengchong, Laifengshan	18.0
March 2016	Northern Tengchong	1.0
May 2016	Northern Tengchong, Longchuan River	4.0
June 2017	Southern Tengchong, northern Tengchong, Laifengshan, Longchuan River	11.0
May 2018	Northern Tengchong	3.0

Identification

Voucher materials were pinned and mounted in laboratory and a temporary catalogue number was assigned for each pinned specimen. A variety of references were used for identification (e.g., Evans 1949; Eliot & Kawazoe 1983; Chiba & Tsukiyama 1996; Koiwaya 2007; Huang 2009; Lang 2012, 2017; Wu & Hsu 2017). Higher classification arrangement follows Hsu et al. (2017). For species groups that are difficult to identify superficially, such as members of the family Hesperiidae and the genus *Ypthima*, male genitalia were also examined by dissection following the protocol of Hsu (2015).

RESULTS

Butterfly species richness

A total of 216 butterfly species were recorded in the survey, and these species belong to five families: Hesperiidae (41 species); Papilionidae (20 species); Pieridae (21 species); Lycaenidae (45 species); and Nymphalidae (89 species). Of the recorded species, 179 species were hitherto undocumented for Tengchong County. Some of the materials collected from the present study have been illustrated in Wu & Hsu (2017), and live adult photographs of selected species are illustrated by Lo (2016). A list of the butterfly species collected in the present survey is provided in Appendix 1. For reference purpose, a list of butterflies that were recorded in Tengchong in earlier studies but absent in the present survey is listed in Appendix 2.

Regarding species richness at genus level, the most speciose genus was *Lethe* (Nymphalidae) with 16 species recorded in the study area. *Papilio* (Papilionidae) and *Neptis* (Nymphalidae) were the second and third richest genera represented by nine and eight species, respectively. In addition, 10 genera in which at least four species each were recorded in the present survey (Table 2).

Conservation status

Two species, *Troides aeacus* and *Bhutanitis lidderdalii* (Papilionidae), are listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), meaning that international trade is regulated. The global conservation status of most Tengchong species have not been evaluated by the IUCN Red List of Threatened Species (2017) except *Troides aeacus* (Papilionidae), *Ancema ctesia*, and *Dodona eugenes* (Lycaenidae), which are listed as Near Threatened (NT). Meanwhile, seven and 20 species have been evaluated as Vulnerable (VU) and Near Threatened (NT), respectively, by the China Species Red List (Wang & Xie 2005). None of the butterfly species from Tengchong are included in the Lists of Wildlife under Special State Protection (conventionally known as China State Key Protected Animal List in literature, e.g., Smith & Xie 2008), which is in need of revision.

Notable findings

One-hundred-and-seventy-nine species are new records for Tengchong. Many of these species are known from adjacent areas and their occurrence in Tengchong was expected. Nevertheless, substantial range extensions of some taxa were observed, including three national and six provincial new records, and several rare and obscure species were rediscovered. Detailed information of these, and notes on other species of special interest, are provided in the following species accounts.

Selected species accounts

Celaenorrhinus morena Evans, 1949 (Image 1)

New species record for China

This is an obscure species that has not been recorded since its original description. The records in Igarashi & Fukuda (2000) and Gogoi (2013) were misidentifications of other species, probably *C. leucocera* (Kollar, [1844]). The male genital structure of the Tengchong materials agrees with the description and illustration in Evans (1949). This species was previously only known from India's Naga Hills, Manipur, and Sikkim (Evans 1949);

Table 2. The 13 most speciose butterfly genera and their associated habitat preference in Tengchong, Yunnan Province, China.

Higher classification	Genus	Number of species	% of total recorded species	Habitat association
Nymphalidae: Satyrinae	*Lethe*	16	7.41%	Forest
Papilionidae: Papilioninae	*Papilio*	9	4.17%	Forest
Nymphalidae: Limenitidinae	*Neptis*	8	3.70%	Forest
Nymphalidae: Satyrinae	*Ypthima*	7	3.24%	Forest
Lycaenidae: Riodininae	*Dodona*	6	2.78%	Forest
Nymphalidae: Satyrinae	*Neope*	5	2.31%	Forest
Pieridae: Pierinae	*Pieris*	5	2.31%	Open
Hesperiidae: Hesperiinae	*Thoressa*	5	2.31%	Forest
Lycaenidae: Lycaeninae	*Chrysozephyrus*	4	1.85%	Forest
Nymphalidae: Satyrinae	*Mycalesis*	4	1.85%	Forest
Nymphalidae: Limenitidinae	*Euthalia*	4	1.85%	Forest
Lycaenidae: Lycaeninae	*Heliophorus*	4	1.85%	Open
Papilionidae: Papilioninae	*Byasa*	4	1.85%	Forest

the present discovery suggests that *C. morena* may also occur in similar habitat of northern Myanmar. A univoltine species was recorded only in July and August. Adults have typical behavior of the genus and often occur concurrently with *C. ratna nujiangensis* Huang, 2001.

***Ochlodes brahma* (Moore, 1878) (Image 2)**

New species record for China

This is primarily a Himalayan species with a disjunct population in northern Thailand (Chiba & Tsukiyama 1996). The present discovery fills the distribution gap of the species.

***Thoressa pedla pedla* (Evans, 1956) (Image 3)**

This taxon was described based on a unique male collected in Yunnan by well-known British botanist George Forrest in 1918 without detailed locality information (Evans 1956). This mysterious skipper was rediscovered recently in Tengchong by two different groups (Huang & Wang 2016; Lo 2016). A univoltine species which only occurs in May. Males are swift flyers and often gather at puddles with other congeneric species.

***Tsukiyamaia albimacula* Zhu, Chiba & Wu, 2016 (Image 4)**

A species of a recently established monotypic genus, described by materials from northern Myanmar, GLGS and northern Vietnam (Zhu et al. 2016). One of the males collected from the present survey in TC-GLGS was designated as a paratype. Males are active under strong sunlight, often fly swiftly close to the ground and gather at puddles.

***Polytremis gotama* Sugiyama, 1999 (Image 5)**

This is a poorly known skipper species that was thought to be confined to the east of the upper Mekong River (also known as Lancangjiang in China) in northwestern Yunnan (Sugiyama 1999; Fan 2006; Xue 2009; Zhu 2012). The result of this study extends the range of this rare species to the Irrawaddy Basin on the western slopes of GLGS. Males fly close to the ground and frequently perch on blades of tall grasses.

***Graphium mandarinus stilwelli* Cotton & Hu, 2018 (Image 6)**

A recently described taxon from western Yunnan and northern Myanmar (Hu et al. 2018). Two of the males collected in the present survey in Tengchong were designated as part of the paratypes. It is a univoltine species occurring in May.

***Dodona kaolinkon* Yoshino, 1999 (Image 7)**

Another poorly known species confined to GLGS. All previous records were restricted to the Nujiang Valley on the eastern slope (Yoshino 1999) and the materials collected in the present study represent the first record on the western slope of GLGS in the Irrawaddy Basin. It is a bivoltine species with adults being recorded in May and September. Males often fly with congeneric species along forest paths, settling on ground for long periods or puddling on moist surfaces in groups.

Image 1. *Celaenorrhinus morena* Evans, 1949. © Yik Fui Philip Lo.

Image 2. *Ochlodes brahma* (Moore, 1878). © Yik Fui Philip Lo.

Image 3. *Thoressa pedla pedla* (Evans, 1956). © Yik Fui Philip Lo.

Image 4. *Tsukiyamaia albimacula* Zhu, Chiba & Wu, 2016. © Yik Fui Philip Lo.

Image 5. *Polytremis gotama* Sugiyama, 1999. © Yik Fui Philip Lo.

Image 6. *Graphium mandarinus stilwelli* Cotton & Hu, 2018. © Yik Fui Philip Lo.

Image 7. *Dodona kaolinkon* Yoshino, 1999. © Yik Fui Philip Lo.

Image 8. *Oreolyce vardhana nepalica* (Forster, 1980). © Yik Fui Philip Lo.

***Oreolyce vardhana nepalica* (Forster, 1980) (Image 8)**

This taxon was once considered a Nepal endemic (Eliot & Kawazoe 1983) until Huang (2003) reported its presence in China, based on a single female collected on the eastern slope of GLGS. Three males collected in northern Tengchong in this study represent the second record in China and an adult of Chinese material is illustrated here for the first time.

***Heliophorus tamu kala* Tytler, 1912 (Image 9)**

New species record for Yunnan Province

A Himalayan species distributed from Nepal to northern Myanmar (Yago 2002). The presence of this species in China was first reported by Evans (1915) from southeastern Tibet (Motuo area). Three males collected in this study represent the easternmost global distribution and the first record of the species in Yunnan Province of China.

***Chrysozephyrus vittatus phoopan* Koiwaya, 2002 (Image 10)**

New subspecies record for China

The single male from Tengchong agrees well with ssp. *phoopan*, a taxon previously only known from northern Laos (Koiwaya 2007). The other subspecies known to occur in China, originally described as ssp. *yamanakai* Fujioka, 2003 upon materials from Sichuan, was synonymized with *akikoae* Morita, 2002 by Koiwaya (2007).

***Lethe brisanda* de Nicéville, 1886 (Image 11)**

New species record for Yunnan Province

All previous records of this species in China were restricted to the Motuo area of southeastern Tibet (Evans 1915; Huang 2000; Lang 2017; Wu 2017). The male collected in the present survey was the first reliable record of this species in Yunnan. The Yunnan material illustrated in Chou (1994) (as *L. insana brisanda*) was actually a misidentification of another undetermined taxon.

***Lethe tengchongensis* Lang, 2016 (Image 12)**

This is a recently described species endemic to Tengchong (Lang & Duan 2016, present study). A univoltine species which occurs only from August to September. They often fly near understorey bamboo growth and have typical behavior of the genus.

***Neorina neosinica* Lee, 1985 (Image 16)**

With Tengchong as the type locality, this obscure species, apart from its original description (Lee 1985), has only been recorded twice in Laos (D' Abrera 1985: two males) and Vietnam (Monastyrskii 2005: 1 male). No specimen was collected in the present survey and the record is based on an unequivocal photograph taken in southern Tengchong at an elevation of 1,900m in June 2018.

***Neorina hilda* Westwood, [1850] (Image 13)**

New species record for Yunnan Province

An eastern Himalayan species, recorded in southeastern Tibet (Motuo area) by Evans (1915). It was also found in Kachin State of northern Myanmar recently (Shizuya et al. 2005a). The males collected in the present study are the first record of this species in Yunnan Province. A univoltine species which occurs in summer, and is rare throughout its range.

***Symbrenthia doni* Tytler, 1940 (Image 14)**

New species record for Yunnan Province

This Himalayan species was formerly regarded as a subspecies of *S. brabira*, a widespread Oriental species, and all previous Chinese records were confined to southeastern Tibet (Motuo area) (Huang 1998: as *S. dalailama*; Lang, 2012). The material collected in this study represents the first record of this species in Yunnan Province and the easternmost distribution of the species.

***Kallima knyvettii* de Nicéville, 1886 (Image 15)**

New species record for Yunnan Province

There was confusion on the true identity of the *Kallima* with blue bands on wings in China and two names, *knyvettii* de Nicéville, 1886 and *alompra* Moore, 1879 have been adopted in earlier studies (e.g., Huang 2000; Lang 2012) with all records restricted to southeastern Tibet (Motuo area). Küppers (2015) clarified that the "blue" *Kallima* in southeastern Tibet should be called *K. knyvettii*, while *K. alompra* is a junior synonym of *K. horsfieldii* (Kollar, 1844) which has not been recorded in China. The male collected in present study is the first Chinese record outside Tibet.

DISCUSSION

The primary purpose of the present study is to assess the species richness of butterfly fauna in TG-GLGS. Survey effort was uneven at different sites which prevents rigorous comparison of species assemblages or relative species diversity along latitude and altitude. In general, the survey sites along the main ridge of GLGS support

Image 9. *Heliophorus tamu kala* Tytler, 1912. © Yik Fui Philip Lo.

Image 10. *Chrysozephyrus vittatus phoopan* Koiwaya, 2002. © Yik Fui Philip Lo.

Image 11. *Lethe brisanda* de Nicéville, 1886. © Yik Fui Philip Lo.

Image 12. *Lethe tengchongensis* Lang, 2016. © Yik Fui Philip Lo.

Image 13. *Neorina hilda* Westwood, [1850]. © Yik Fui Philip Lo.

Image 14. *Symbrenthia doni* Tytler, 1940. © Yik Fui Philip Lo.

more butterfly species than the enclaves, probably due to differences in habitat quality and altitude range.

Although the results of this survey have expanded the species list of Tengchong butterflies by over three-fold, it should not be treated as a comprehensive inventory of the butterfly fauna of the area. The flight period of adult butterflies in TG-GLGS is characterized by pronounced seasonality which complicates survey efficiency. In fact, more than one-third of the recorded species appear to have univoltine populations in Tengchong that can only be observed in well-defined, usually short, periods of a year. With succession of butterfly assemblages throughout the warmer seasons, many species may have been overlooked in this survey. Such activity pattern increases the difficulty to assess the true species richness of GLGS because considerable survey effort will be needed in order to cover the flight seasons of all butterfly species. Another limitation of the present

Image 15. *Kallima knyvettii* de Nicéville, 1886. © Yu Feng Hsu.

Image 16. *Neorina neosinica* Lee, 1985. © Zheng Bi.

survey was that habitats at higher altitude (>2,800m) were not covered because of accessibility constraints. To improve the completeness of the butterfly inventory, future fieldwork should be conducted during periods not covered by this survey, and sampling of the butterfly communities in sub-alpine habitats is necessary.

Given its high elevation, Tengchong has a more temperate climatic pattern than subtropical lowland at similar latitude. Species assemblage of Tengchong butterflies also show similar tendency as it is dominated by Oriental montane species intermixed with some Palearctic representatives. Meanwhile, a few tropical species also penetrate into the area; they are either restricted to lower elevations at the protected riparian forest along Longchuan River, or are well-known migrants (e.g., *Appias* spp. & *Catopsilia pomona*) which probably stray from the Irrawaddy lowlands.

Geographically, GLGS can be considered as an

Table 3. Examples of TC-GLGS butterfly taxa confined to the western slope of GLGS and eastern Himalaya.

Scientific name	Sources
Hesperiidae	
Celaenorrhinus morena Evans, 1949	Evans 1949
Sebastonyma dolopia medoensis Lee, 1979	Huang 2009
Lycaenidae	
Heliophorus tamu (Kollar, 1844)	Huang 2000; Yago 2002
Nymphalidae	
Lethe brisanda de Nicéville, 1886	Lang 2016
Neorina hilda Westwood, [1850]	Huang 2000
Symbrenthia doni Tytler, 1940	Huang 1998; Lang 2012
Kallima knyvettii de Nicéville, 1886	Lang 2012; Küppers 2015

eastern extension of the Himalaya and its western slope is categorized as part of the Himalayan southern slope region (Zhao 1986). Although majority of Tengchong butterflies are typical northern Indochina-southwestern China fauna, the present study reveals that it supports a number of taxa that are confined to the western slope of GLGS and eastern Himalaya, but absent in the rest of China (Table 3). Tengchong therefore represents the eastern distribution limit for many species of their global ranges.

TC-GLGS supports a large number of forest-associated and shade-loving species (Table 2), indicating the area supports intact forest habitat. Many areas with old-growth forest in TC-GLGS have extensive understorey of dwarf bamboo, mainly in the genus *Fargesia* (Xue, 1995). Exceptionally high diversity of the subfamily Satyrinae is noteworthy, especially the genus *Lethe*, which is bamboo-associated and the most speciose genus of the area (16 species, Table 2), including the Tengchong endemic *L. tengchongensis*. A similar pattern was also observed in neighbouring Kachin State of northern Myanmar (Shizuya et al. 2005a,b). The tribe Aeromachini of the Hesperiidae family is another bamboo-associated group that has high species richness in the study areas, comprising five genera and 11 species, including one endemic subspecies (*Thoressa pedla pedla*), which is not unexpected as the Hengduan Mountains is recognized as one of the centers of speciation for the tribe (Huang 2009). Tengchong is also home to many rare and obscure species, some are already mentioned in the species account in the present paper, which further demonstrated the importance of TC-GLGS in conserving the unique biodiversity of the region.

With only 29 of the Tengchong species evaluated, existing international and national conservation assessments (Wang & Xie 2005; The IUCN Red List of Threatened Species 2017) are insufficient to reflect the current conservation status of butterflies in Tengchong. To identify special conservation needs for Tengchong butterflies, especially those with highly restricted distribution range, it is recommended to invest targeted efforts to assess their current status. It should be noted that there have been considerable taxonomic changes on those evaluated species since the last assessment of the China Species Red List in 2005, assessment updates following these taxonomic changes are necessary. Meanwhile, according to the definition proposed by Collins & Morris (1985), *Bhutanitis lidderdalii* and several other members of Papilionidae occurring in Tengchong are potential targets of "low volume/ high value" trade. These large and showy butterflies are popular items among collectors and over-collecting is a potential threat. Although no sign of commercial harvesting was detected in the study areas during the survey, any unauthorized collecting activity should be closely monitored and regulated by the authority.

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Appendix 1. Butterflies recorded during the present survey in Tengchong Section of Gaoligongshan National Nature Reserve.

Locations: STC = Zhengding, Dahaoping and Qushi sections of TC-GLGS; NTC = Jietou, Datang and Zizhi sections of TC-GLGS; LFS = Laifengshan National Forest Park; RPF = Protected riparian forest along Longchuan River; OS = Other sites.

Notes: Historical records: 1 = Lee & Cao 1987, 2 = Lee 1995, 3 = Xue 1995, 4 = Huang 2009, 5 = Xue 2009, 6 = Lang, 2017; Conservation status: cLC = Least Concern in China Species Red List, cVU = Vulnerable in China Species Red List; LC = Least Concern in IUCN Red List; CITES II = The Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendix II.

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
HESPERIIDAE															
Coeliadinae															
Hasora vitta indica Evans, 1932	√	√						√		√					
Hasora taminatus bhavara Fruhstorfer, 1911	√	√						√			√				
Hasora anura anura de Nicéville, 1889		√					√		√	√	√	√			
Choaspes benjaminii japonicus (Murray, 1875)	√	√									√	√			
Pyrginae															
Coladenia maeniata Oberthür, 1896		√							√						p.1309, fig.18
Capila pieridoides pieridoides Moore, 1878		√									√				
Gerosis sinica narada (Moore, 1884)		√									√				p.1318, fig.15
Gerosis phisara rex Evans, 1949		√							√		√				p.1318, fig.14
Pyrgus maculatus thibetanus (Oberthur, 1891)	√							√							
Celaenorrhinus ratna nujiangensis Huang, 2001	√	√									√	√		cNT	
Celaenorrhinus morena Evans, 1949		√							√		√			New to China	
Celaenorrhinus tibetana (Mabille, 1876)		√								√					
Satarupa zulla ouvrardi Oberthur, 1921		√									√				p.1327, fig.05
Pseudocoladenia dan fabia (Evans,1949)			√								√				
Pseudocoladenia festa (Evans, 1949)	√	√									√	√			
Heteropterinae															
Barca bicolor (Oberthür, 1896)	√	√							√						
Carterocephalus alcinoides Lee, 1962	√	√								√		√			
Hesperiinae															
Ochlodes brahma (Moore, 1878)	√							√						New to China	
Ochlodes thibetana (Oberthür, 1886)		√								√	√				p.1401, fig.11-12
Ochlodes bouddha (Mabille, 1876)		√								√					
Notocrypta feisthamelii alysos (Moore, 1865)	√	√						√	√			√			
Notocrypta curvifascia curvifascia Felder 1862			√							√					

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Erionota torus Evans, 1941			√								√				
Halpe sp. 1		√									√				
Halpe sp. 2		√									√				
Sovia separata magna (Evans, 1932)		√									√				p.1358, fig.13
Sovia grahami miliaohuae Huang, 2003		√									√				p.1358, fig.09
Aeromachus catocyanea amplifascia Huang, 2003		√									√				p.1354, fig.03
Thoressa pedla pedla (Evans, 1956)		√							√						p.1365, fig.03
Thoressa gupta nujiangensis Huang, 2003	√	√		√					√					4	
Thoressa pandita (de Niceville, 1885)	√	√							√		√			4	p.1361, fig.15
Thoressa serena (Evans, 1937)	√	√							√					4 5	
Thoressa baileyi (South, 1914)		√							√						
Sebastonyma dolopia medoensis Lee, 1979		√									√				p.1356, fig.59
Tsukiyamaia albimacula Zhu, Chiba & Wu, 2016	√	√						√	√						p.1428, fig.05
Polytremis cf. *micropunctata* Huang, 2003		√									√				
Polytremis gotama Sugiyama, 1999		√									√				p.1433, fig.12
Polytremis eltola eltola (Hewitson, 1869)		√	√								√			5	
Parnara batta Evans, 1949		√								√					
Parnara bada (Moore, 1878)			√								√				
Potanthus trachala tytleri (Evans, 1914)			√	√					√		√				
PAPILIONIDAE															
Parnassiinae															
Bhutanitis lidderdalii spinosa Stichel, 1907	√	√										√		cVU, CITES II	
Papilioninae															
Troides aeacus aeacus (C. & R. Felder, 1860)		√									√			cNT, LC ,CITES II	
Byasa plutonius tytleri Evans, 1923	√							√	√					cVU	p.54, fig.07
Byasa polyeuctes polyeuctes (Doubleday, 1842)	√	√							√		√	√			p.60, fig.20
Byasa dasarada ouvrardi (Oberthur, 1920)		√							√						p.66, fig.05
Byasa latreillei ticona (Tytler, 1939)	√	√							√	√				cVU	p.69, fig.12
Papilio agestor agestor Gray, 1831	√	√						√	√						p.80, fig.07
Papilio bootes mindoni Tytler, 1939	√	√							√	√					p.125, fig.22; p.126, fig.23-24
Papilio helenus helenus Linnaeus, 1758		√		√				√	√						

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Papilio protenor protenor Cramer, 1775				√					√						
Papilio xuthus Linnaeus, 1767		√					√					√		1 2 3	
Papilio arcturus arcturus Westwood, 1842	√	√							√		√	√		cNT	p.161, fig.05
Papilio bianor gladiator Fruhstorfer, [1902]	√	√						√	√		√	√		1 2 3	p.136, fig.09-10; p.137, fig.11
Papilio krishna thawgawa Tytler, 1939		√							√	√	√				p.163, fig.09
Papilio machaon verityi Fruhstorfer, 1907		√							√						
Lamproptera meges indistincta (Tytler, 1912)				√						√				cNT	
Graphium cloanthus cloanthus Westwood, 1841		√						√	√		√				p.185, fig.09
Graphium sarpedon sarpedon Linnaeus, 1758		√									√				
Graphium mandarinus stilwelli Cotton & Hu, 2018		√							√						p.212, fig.03
Meandrusa lachinus aribbas (Fruhstorfer, 1909)		√									√				p.230, fig.12
PIERIDAE															
Pierinae															
Delias belladonna hedybia Jordan, 1925	√	√		√	√			√	√	√		√	√		p.343, fig.15-16
Delias berinda cooperi Tytler, 1939				√					√						
Delias sanaca perspicua Fruhstorfer, 1910	√	√		√					√	√	√				
Aporia agathon bifurcata Tytler, 1939	√	√						√	√	√				1 2 3	p.395, fig.09-10
Aporia harrietae paracraea (de Nicéville, 1900)	√	√						√	√	√					p.390, fig.11
Aporia goutellei (Oberthur, 1886)		√							√						
Prioneris thestylis thestylis (Doubleday, 1842)	√		√					√						cNT	p.362, fig.08
Pieris brassicae nepalensis Gray, 1846	√	√						√	√	√				1 2 3	
Pieris rapae yunnana Mell, 1943	√	√						√	√	√	√			1 2 3	
Pieris canidia indica Evans, 1926	√	√		√				√	√		√	√			
Pieris extansa bhutya Talbot, 1939	√	√							√	√	√				
Pieris melete melete Ménétriés, 1857	√	√	√	√			√	√	√	√	√				
Pontina edusa praeclara Fruhstorfer, 1910					√				√						
Appias pandione lagela (Moore, [1879])		√									√				
Appias galba (Wallace, 1867)			√								√				
Coliadinae															
Catopsilia pomona pomona (Fabricius, 1775)	√	√						√	√					1 2 3	
Eurema blanda silhetana (Wallace, 1867)		√							√			√			

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Eurema laeta sikkima (Moore, 1906)	√	√	√							√	√	√		3	
Eurema hecabe (Linnaeus, 1758)				√	√				√				√	1 2 3	
Dercas lycorias lycorias Doubleday, 1842		√							√		√				
Calias fieldii fieldii Ménétriés, 1855	√	√			√			√	√		√	√			p.301, fig.15
LYCAENIDAE															
Riodininae															
Zemeros flegyas flegyas (Cramer, [1780])			√	√				√	√						
Dodona ouida ouida Moore, 1865	√	√						√	√	√	√	√			
Dodona eugenes Bates, 1867	√	√							√	√	√	√		LC	
Dodona egeon egeon Westwood, 1851	√	√						√	√					cNT	
Dodona dipoea Hewitson, 1866	√	√						√	√	√		√		1 2 3	p.1034, fig.19-20
Dodona adonira ssp.	√	√	√						√		√	√		cNT	
Dodona kaolinkon Yoshino, 1999		√							√			√			p.1033, fig.12-13
Stiboges nymphidia nymphidia Butler, 1876	√								√						
Abisara freda daliensis Sugiyama, 1992	√							√	√					cNT	p.1024, fig.02-03
Abisara fylla (Westwood, 1851)		√		√					√		√				
Abisara neophron Hewitson, 1861		√							√						
Curetinae															
Curetis acuta naga Evans, 1954		√									√			1 2 3 (as *bulis*)	
Lycaeninae															
Zizina emelina thibetensis (Poujade, 1885)		√	√						√	√	√				
Zizeeria maha maha (Kollar,[1844])		√									√				
Everes huegelii dipora (Moore,1865)	√	√						√				√			
Lampides boeticus (Linnaeus, 1767)	√		√	√			√	√	√	√				1 2 3	
Udara dilectus dilectus (Moore, 1879)	√	√		√				√	√	√	√	√			
Udara albocaerulea albocaerulea (Moore, 1879)	√	√							√	√	√	√			
Celatoxia marginata marginata (de Nicéville, [1884])	√	√		√				√		√	√	√			p.1244, fig.11
Monodontides musina musinoides (Swinhoe, 1910)	√	√							√		√	√			
Celastrina argiolus iynteana (de Nicéville, 1884)	√	√						√							
Celastrina lavendularis (Moore, 1877)		√									√				
Celastrina oreas yunnana Eliot & Kawazoé, 1983		√							√	√	√	√			p.1250, fig.03-04

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Oreolyce vardhana nepalica (Forster, 1980)		√							√						
Orthomiella pontis rovorea (Fruhstorfer, 1918)		√					√		√						
Catochrysops strabo strabo (Fabricius, 1793)		√		√				√	√						
Acytolepis puspa gisca (Fruhstorfer, 1910)	√	√		√					√	√		√			
Jamides bochus bochus (Stoll, [1782])	√	√						√		√					
Prosotas sp.		√									√				
Prosotas dubiosa indica (Evans, [1925])				√					√						
Heliophorus eventa Fruhstorfer, 1918	√	√	√					√	√	√	√	√			
Heliophorus brahma mogoka Evans, 1932	√	√	√					√	√	√	√	√			
Heliophorus ila pseudonexus Eliot, 1963			√								√				
Heliophorus tamu kala Tytler, 1912		√							√					New to Yunnan	p.1213, fig.30
Chrysozephyrus kirbariensis machimurai (Koiwaya, 2002)		√							√			√			p.1119, fig.50
Chrysozephyrus paona paona (Tytler, 1915)		√								√					
Chrysozephyrus vittatus phoopan Koiwaya, 2002		√								√				New to China	
Chrysozephyrus duma (Hewitson, 1869)		√								√					
Cheritrella truncipennis de Nicéville, 1887	√							√							
Sinthusa virgo (Elwes, 1887)		√							√	√					p.1182, fig. 14-15
Sinthusa rayata Riley, 1939		√							√						
Chliaria kina kina (Hewitson, 1869)		√							√	√	√	√			
Rapala sp.		√										√			
Ancema ctesia ctesia (Hewitson, 1865)		√							√					LC	
Maneca bhotea bhotea (Moore, 1884)	√											√			
NYMPHALIDAE															
Danainae															
Parantica sita sita (Kollar, [1844])	√	√						√	√	√	√	√			
Parantica aglea melanoides Moore, 1883	√											√			
Euploea mulciber mulciber (Cramer, [1777])	√	√		√					√		√	√		3	
Satyrinae															
Melanitis leda leda (Linnaeus, 1758)			√									√			p.434, fig.04
Lethe sura (Doubleday, [1849])	√								√	√		√		2, cNT	p.443, fig.11
Lethe goalpara gana Talbot, 1947	√	√										√		6	p.456, fig.20

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Lethe ocellata ocellata (Poujade, 1885)	√											√		cNT	
Lethe neofaciata Lee, 1985	√								√						
Lethe sidonis (Hewitson, 1863)	√	√								√		√		6, cVU	
Lethe maitrya thawgawa Tytler, 1939		√									√			2, cNT	p.493, fig.08
Lethe kanjupkula burmana Tytler, 1939	√								√			√			
Lethe nicetas Hewitson, 1863		√							√						
Lethe verma sintica Fruhstorfer, 1911	√								√						
Lethe hyrania dinarbas (Hewitson, 1863)	√	√						√	√			√		6	
Lethe brisanda de Nicéville, 1886		√								√				New to Yunnan	
Lethe oculatissima (Poujade, 1885)		√								√				cNT	
Lethe serbonis pallida Tytler, 1939		√									√	√		6, cVU	
Lethe tengchongensis Lang, 2016		√									√	√		6	p.489, fig.05-06
Lethe luteofasciata (Poujade, 1884)		√							√					1 2 3, cNT	
Lethe andersoni (Atkinson, 1871)		√							√		√	√		cNT	
Chonala praeusta burmana Tytler, 1939		√									√	√		cNT	
Neope muirheadii muirheadii (C. & R. Felder, 1862)					√				√					1 2 3	
Neope armandii khasiana Moore, 1881	√	√						√	√					6	
Neope yama kinpingensis Lee, 1962	√	√							√	√	√			1 2 3	
Neope oberthueri qiqia Huang, 2002	√	√							√	√	√				
Neope ramosa Leech, 1890	√	√							√		√				
Neorina neosinica Lee, 1985	√									√				1 2 3	
Neorina hilda Westwood, [1850]		√									√			New to Yunnan	
Callerebia polyphemus annadina Watkins, 1927	√	√									√				
Orinoma damaris damaris Gray, 1846	√											√			p.517, fig.01
Rhaphicera satrica kabrua (Tytler, 1939)		√									√			cVU	p.515, fig.05
Mycalesis francisca sanatana Moore, 1857		√	√					√			√				
Mycalesis gotama charaka Moore, 1874				√						√					
Mycalesis misenus serica Leech, [1892]	√	√	√							√	√	√			p.541, fig.05
Mycalesis suaveolens konglua Tytler, 1939			√							√	√				
Ypthima conjuncta monticola Uemura & Koiwaya, 2000	√	√								√		√			
Ypthima sakra austeni (Moore, 1893)	√		√						√	√				cNT	

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Ypthima menpae Huang, 1999		√									√				
Ypthima persimilis Elwes & Edwards, 1893	√							√							
Ypthima confusa Shirôzu & Shima, 1977	√	√	√						√	√		√			
Ypthima frontierii Uémura & Monastyrskii, 2000	√	√	√					√	√	√		√			
Ypthima zodia Butler, 1871		√							√		√				p.591, fig.12
Calinaginae															
Calinaga davidis buphonas Oberthür, 1920		√							√						p.682, fig.08
Charaxinae															
Polyura narcaea thawgawa (Tytler, 1940)		√							√					1 2	
Polyura dolon grandis (Rothschild, 1899)	√	√			√				√						
Polyura athamas athamas (Drury, [1773])					√								√		
Cyrestinae															
Cyrestis thyodamas thyodamas Boisduval, 1846		√		√					√		√				
Heliconiinae															
Acraea issoria sordice (Fruhstorfer, 1914)	√	√							√		√	√		1 2 3	
Cethosia biblis biblis (Drury, [1773])	√	√			√							√	√		
Cirrochroa tyche mithila Moore, 1872	√		√	√				√	√	√					
Childrena childreni (Gray, 1831)		√		√					√			√		1 2 3	
Argyronome laodice rudra (Moore, [1858])		√								√	√	√			
Argyreus hyperbius hyperbius (Linnaeus, 1763)				√	√				√					1 2 3	
Issoria lathonia isaaea (Gray, 1846)		√							√						
Nymphalinae															
Vanessa cardui (Linnaeus, 1758)	√			√				√	√						
Vanessa indica indica (Herbst, 1794)	√	√	√		√			√	√		√	√	√		
Kaniska canace canace (Linnaeus, 1763)	√	√		√			√	√	√	√	√	√		1 2 3	
Symbrenthia doni Tytler, 1940	√	√						√	√		√			New to Yunnan	
Symbrenthia lilaea lilaea (Hewitson, 1864)		√			√							√	√		
Symbrenthia niphanda niphanda Moore, 1872		√							√	√	√	√			p.805, fig.01
Junonia orithya ocyale Hübner, [1819]		√		√	√			√	√			√		1 2 3	
Aglais urticae chinensis (Leech, 1892)	√	√			√				√	√	√	√		1 2 3	
Araschnia prorsoides prorsoides (Blanchard, 1871)	√	√					√	√	√	√	√	√			

Scientific name and higher classification	Location						Flight period (Month)							Notes	Illustrations in Wu & Hsu (2017)
	STC	NTC	LFS	RPF	OS		III	IV	V	VI	VII VIII	IX	X		
Kallima knyvettii de Nicéville, 1886		√									√			New to Yunnan	
Kallima inachus inachus Doyere, 1840	√											√			
Pseudergolis wedah wedah (Kollar, 1848)	√	√			√				√	√	√	√	√		
Stibochiona nicea nicea (Gray, 1846)	√	√							√						p.881, fig.06
Limenitinae															
Athyma opalina opalina (Kollar, [1844])	√	√							√	√	√	√			
Athyma jina jina Moore, [1858]		√			√				√				√		
Auzakia danava danava (Moore, [1858])		√								√	√				p.947, fig.09
Parasarpa zayla (Doubleday, [1848])		√									√				
Parasarpa dudu dudu (Doubleday, [1848])		√			√				√			√	√		
Sumalia daraxa daraxa (Doubleday, [1848])	√										√	√			
Neptis soma shania Evans, 1924	√	√						√	√		√	√			
Neptis ananta ochracea Evans, 1924		√		√					√	√		√			
Neptis cartica cartica Moore, 1872				√					√					cNT	
Neptis sappho astola Moore, 1872		√								√					
Neptis armandia ssp.	√	√							√	√	√				
Neptis dejeani Oberthür, 1894		√								√	√			cNT	
Neptis nemorum nemorum Oberthür, 1906		√								√				cVU	
Neptis themis theodora Oberthür, 1906		√								√					
Euthalia sakota Fruhstorfer, 1913		√									√				
Euthalia dubernardi Oberthür, 1907		√									√				
Euthalia nara nara (Moore, 1859)		√									√			1 2 3	p.919, fig.26
Euthalia franciae raja (C. & R. Felder, 1859)	√											√		cNT	
Apaturinae															
Hestina nama nama Doubleday, 1844					√								√	2	
Hestina persimilis persimilis Westwood, 1850					√								√		
Dilipa morgiana Westwood, 1850					√								√	cNT	
Libytheinae															
Libythea lepita lepita Moore, [1858]				√					√						

Appendix 2. Butterfly fauna of Tengchong County reported by earlier workers that were not found in the present study.

The butterfly fauna of Tengchong County has also been briefly investigated by different researchers and some of the species reported in their works were not detected during the present survey. These species are listed below with reference source and notes on selected taxa.

1. *Potanthus lydius* (Evans, 1934) — Xue 2009.
2. *Parnara guttata guttata* (Bremer & Grey, 1853) — Xue 2009.
3. *Byasa nevilli* (Wood-Mason, 1882) — Lee & Cao 1987; Xue 1995.
4. *Papilio paris paris* Linnaeus, 1758 — Xue 1995.
5. *Delias subnubila* Leech, 1893 — Lee & Cao 1987; Lee 1995; Xue 1995.
6. *Delias patrua* Leech, 1890 — Lee & Cao (1987); Xue (1995).

Delias lepida Lee, 1995, *nomen nudum*

The name *Delias lepida* Lee in Lee (1995) very likely referred to the record of this species because *D. patrua* was the only Tengchong species listed in Lee & Cao (1987) but absent in Lee (1995), and both records had identical field information (Tengchong, 1,780m). Perhaps the author intended to publish *lepida* formally, but no action was taken eventually. Since there was no description, reference nor indication accompanying the name *lepida*, it should be treated as a *nomen nudum*.

7. *Aporia larraldei* (Oberthür, 1876) — Lee & Cao (1987); Lee (1995); Xue (1995)
8. *Lethe siderea* Marshall, 1881 — Lang (2017).
9. *Lethe lanaris* Butler, 1877 — Lee & Cao (1987); Lee (1995); Xue (1995).
10. *Callarge sagitta* (Leech, 1890) — Wu & Hsu (2017)

Although most of the Tengchong records in Wu & Hsu (2017) originated from the present study, this species was an exception.

11. *Ypthima beautei* Oberthür, 1884 — Lee & Cao (1987); Lee (1995); Xue (1995);

It is likely that the records of *Y. beautei* in Tengchong were actually *Y. frontierii* Uémura & Monastyrskii, 2000, a recently described species, which is quite common in Tengchong.

12. *Ypthima chinensis* Leech, 1892 — Xue (1995).
13. *Neptis hylas* (Linnaeus, 1758) — Xue (1995).

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