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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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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

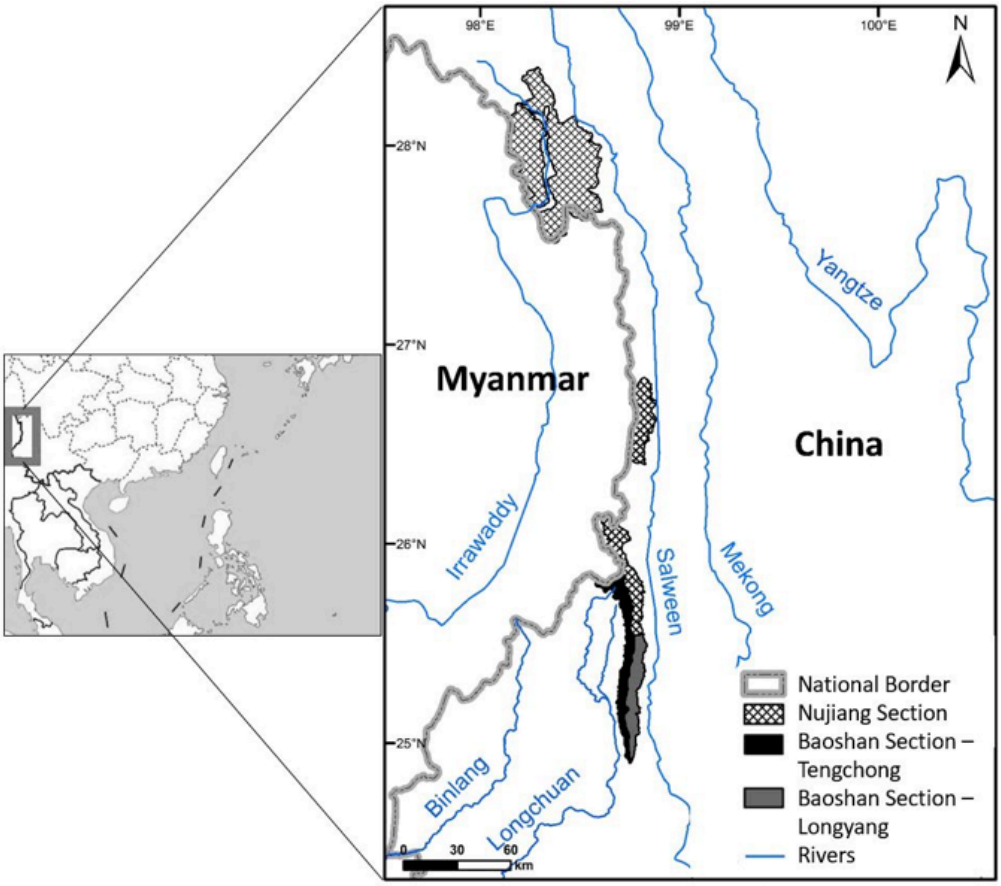

Figure 1. Gaoligongshan National Nature Reserve in Yunnan, China, with locations mentioned in the text.

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

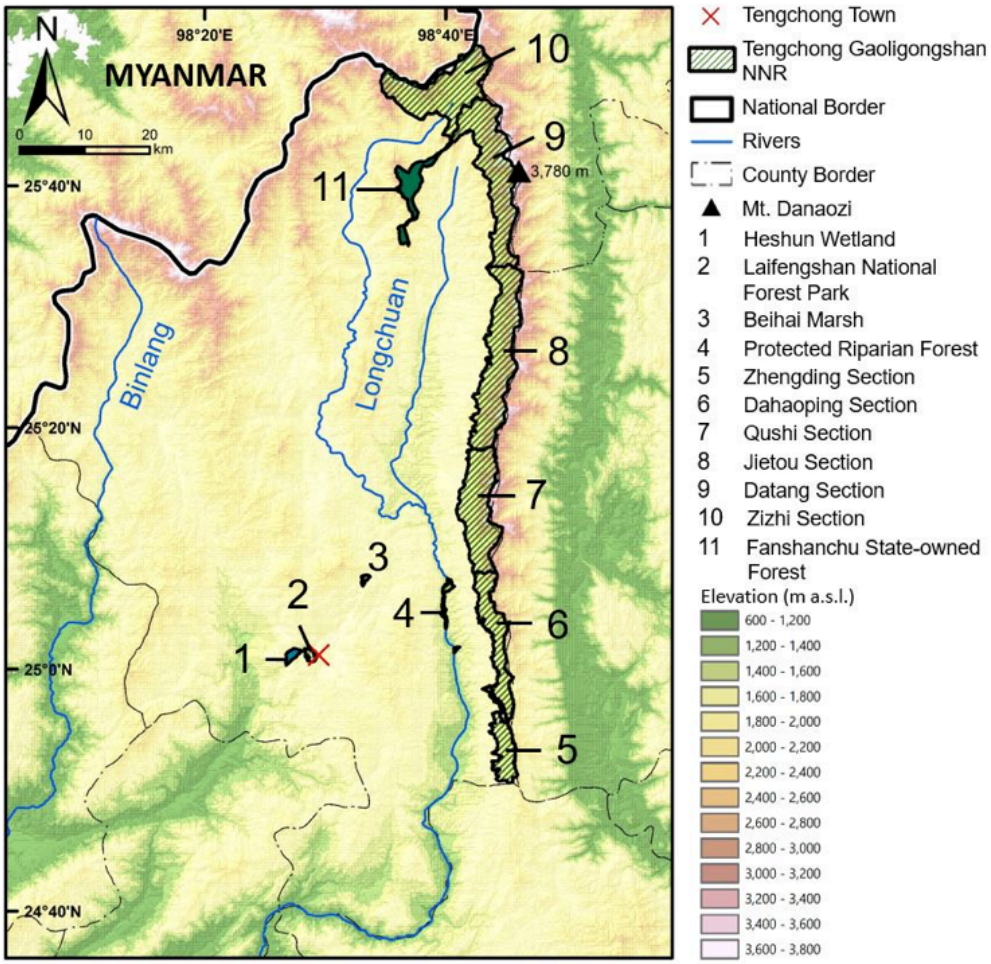

Figure 2. Tengchong in Yunnan, China, with survey locations mentioned in the text.

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.

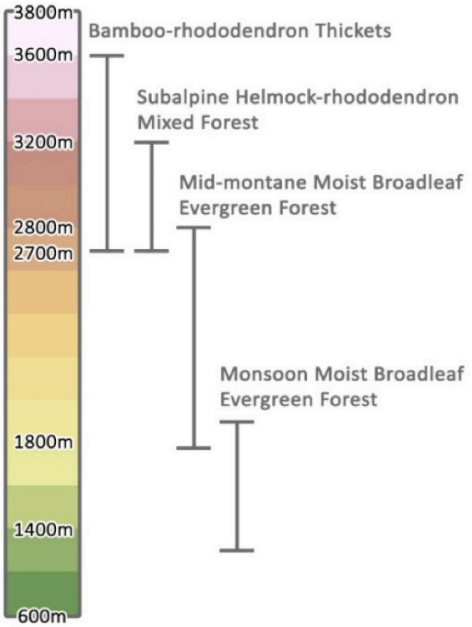

Figure 3. Altitude zonation of vegetation of Tengchong in Yunnan, China.

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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