

Cenozoic plant diversity of Yunnan: A review



Yongjiang Huang^{a, d}, Linbo Jia^{a, e}, Qiong Wang^b, Volker Mosbrugger^c,
Torsten Utescher^{c, f}, Tao Su^{b, d}, Zhekun Zhou^{a, b, *}

^a Key Laboratory for Plant Diversity and Biogeography of East Asia, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China

^b Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla 666303, China

^c Senckenberg Research Institute/BiK F (Loewe), Senckenberganlage 25, 60325 Frankfurt am Main, Germany

^d State Key Laboratory of Paleobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

^e Graduate University of the Chinese Academy of Sciences, Beijing 100049, China

^f Steinmann Institute, University of Bonn, Nussallee 8, 53115 Bonn, Germany

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ABSTRACT

Yunnan in southwestern China is renowned for its high plant diversity. To understand how this modern botanical richness formed, it is critical to investigate the past biodiversity throughout the geological time. In this review, we present a summary on plant diversity, floristics and climates in the Cenozoic of Yunnan and document their changes, by compiling published palaeobotanical sources. Our review demonstrates that thus far a total of 386 fossil species of ferns, gymnosperms and angiosperms belonging to 170 genera within 66 families have been reported from the Cenozoic, particularly the Neogene, of Yunnan. Angiosperms display the highest richness represented by 353 species grouped into 155 genera within 60 families, with Fagaceae, Fabaceae, Lauraceae and Juglandaceae being the most diversified. Most of the families and genera recorded as fossils still occur in Yunnan, but seven genera have disappeared, including *Berryophyllum*, *Cedrelopermum*, *Cedrus*, *Palaeocarya*, *Podocarpium*, *Sequoia* and *Wataria*. The regional extinction of these genera is commonly referred to an aridification of the dry season associated with Asian monsoon development. Floristic analyses indicate that in the late Miocene, Yunnan had three floristic regions: a northern subtropical floristic region in the northeast, a subtropical floristic region in the east, and a tropical floristic region in the southwest. In the late Pliocene, Yunnan saw two kinds of floristic regions: a subalpine floristic region in the northwest, and two subtropical floristic regions separately in the southwest and the eastern center. These floristic concepts are verified by results from our areal type analyses which suggest that in the Miocene southwestern Yunnan supported the most Pantropic elements, while in the Pliocene southwestern Yunnan had abundant Tropical Asia (Indo–Malaysia) type and East Asia and North America disjunct type that were absent from northwestern Yunnan. From the late Miocene to late Pliocene through to the present, floristic composition and vegetation types changed markedly, presumably in response to altitude changes and coeval global cooling. An integration of palaeoclimate data suggests that during the Neogene Yunnan was warmer and wetter than today. Moreover, northern Yunnan witnessed a pronounced temperature decline, while southern Yunnan experienced only moderate temperature changes. Summer precipitation was consistently higher than winter precipitation, suggesting a rainfall seasonality. This summary on palaeoclimates helps us to understand under what conditions plant diversity occurred and evolved in Yunnan throughout the Cenozoic.

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* Corresponding author. Key Laboratory for Plant Biodiversity and Biogeography of East Asia, Kunming Institute of Botany, Chinese Academy of Sciences, Lanhei Road 132#, Kunming 650201, Yunnan, China. Fax: +86 0871 65219932.

E-mail address: zhouzk@mail.kib.ac.cn (Z. Zhou).

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1. Introduction

Yunnan in southwestern China has long been recognized as a hotspot for plant diversity (Wu, 1988; López-Pujol et al., 2006, 2011; Ruth et al., 2008; Turkington and Harrower, 2016). It is

home to approximately 16,000 higher plant species grouped into more than 2300 genera within 244 families, representing 6% of the world's total diversity of higher plant species (Wu, 1979), even though the region accounts for only 4% of the Chinese land surface. Nearly half of these plant species are endemic to Yunnan. In addition, almost all ecosystem types within China, including tropical seasonal rain forest, evergreen broad-leaved forest, sclerophyllous evergreen broad-leaved forest, deciduous broad-leaved forest, both warm and cold temperate coniferous forests, dry and warm valley scrubs as well as subalpine and alpine scrubs can be found in Yunnan (Writing Group of Yunnan Vegetation, 1987). This high diversity of plant taxa and vegetation types qualifies Yunnan as an outstanding place for botanical research. Yunnan also exhibited exceptional botanical richness in the geological past as revealed by the rich fossil record. To date, around 20 megafossil floras are known from the Cenozoic of Yunnan, and hundreds of fossil species, covering ferns, gymnosperms and angiosperms, have been documented. A summary of past plant diversity based on palaeobotanical data affords a better understanding of the modern botanical richness in this region.

In the present review, we compile palaeobotanical data from literature to document plant diversity in Yunnan throughout the Cenozoic. Only fossil taxa represented by megafossils are considered, i.e., leaves, wood, fruits, seeds and flowers. Pollen records are not considered, because they can be transported to Yunnan from elsewhere and cannot be identified to a fine enough taxonomic resolution. We first briefly introduce the research history of palaeobotany in Yunnan, then present known fossil families, genera and species to depict the diversity of Cenozoic plants and ecosystems, and analyze the inferred floristic characters and changes. We also summarize the Neogene climate evolution in Yunnan and related extinction events exemplified for selected plant taxa. The present review aims to facilitate access to the rich palaeobotanical record of Yunnan for both palaeobotanists and botanists.

2. Research history of palaeobotany in Yunnan

As a montane region, Yunnan has more than 150 Cenozoic sedimentary basins, many of which have yielded Cenozoic strata that bear plant fossils (Ge and Li, 1999). The region archives at least 20 megafossil floras, ranging from the early Oligocene to late Pliocene (Fig. 1). However, these fossil floras rarely attracted attention before the beginning of the last century. In 1920, Colani reported the first plant fossils recovered from Miocene sediments along the former railway connecting Kunming and Hanoi (Colani, 1920), but interest was transient as no more palaeobotanical studies followed for the next 57 years. In 1978, several Chinese palaeobotanists, including Tao Jun-Rong, Guo Shuang-Xing and Li Hao-Ming, jointly published a monograph entitled “Cenozoic Plants of China” (Writing Group of the Cenozoic Plants of China, 1978). In that monograph, 301 plant fossil species, covering mosses, ferns, gymnosperms and angiosperms, were described systematically. Among them, 76 species came from five floras in Yunnan: the Oligocene Jinggu flora, the Miocene Duotan flora, the early Miocene Shuanghe flora, the late Miocene Xiaolongtan flora, and the late Pliocene Eryuan flora. In the 1980s, Tao and Chen (1983) described the late Miocene Bangmai flora, also known as the Lincang flora, from southwestern Yunnan which comprised 59 fossil species grouped into 48 genera within 28 families; Tao (1986) reported the late Pliocene Fudong flora from northwestern Yunnan which yielded 17 species grouped into four genera of three families. Unfortunately, published mostly in Chinese, these works have had limited international recognition.

During the last two decades, 10 Cenozoic megafossil floras from Yunnan have been studied as doctoral or master's research projects, e.g., the late Miocene Xianfeng flora, the late Pliocene Nanbanbang, Fudong, Longmen and Tuantian floras. A few are still being investigated for the subject of doctoral research, e.g., the middle Miocene Wenshan and Maguan floras (formerly dated as late Miocene, but recently moved to middle Miocene according to lake geochemical

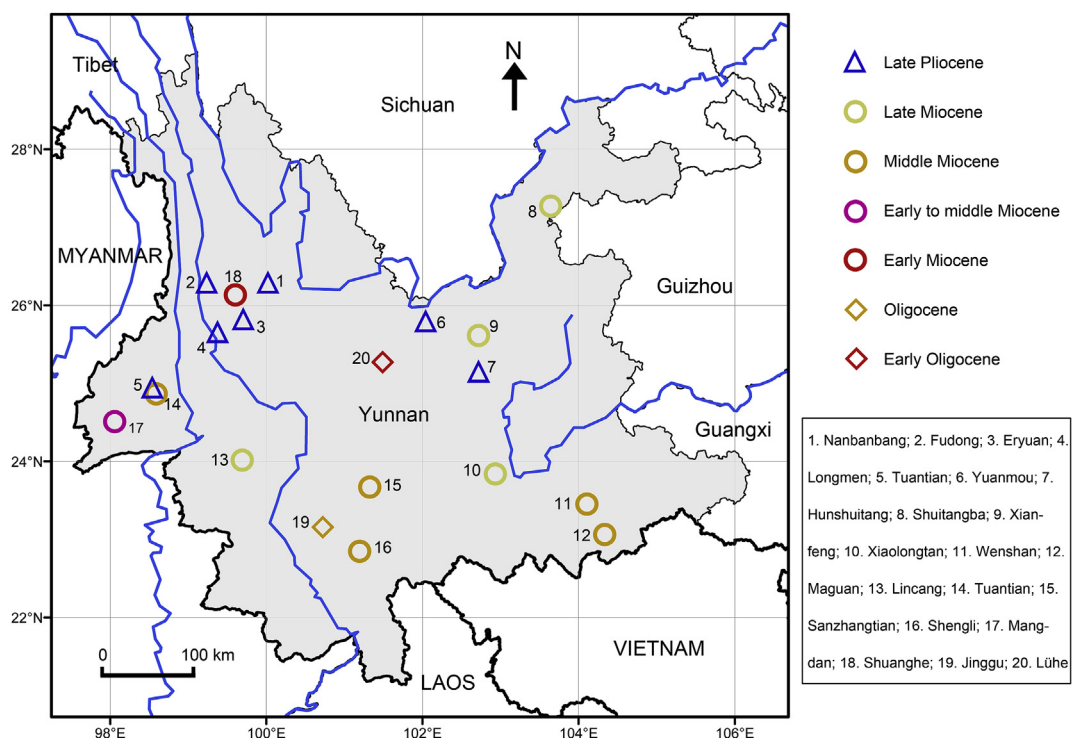


Fig. 1. Map showing the distribution of Cenozoic fossil floras in Yunnan, southwestern China.

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