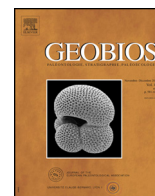




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Original article

## *Rubus* (Rosaceae) diversity in the late Pliocene of Yunnan, southwestern China<sup>☆</sup>



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### ABSTRACT

Yunnan, southwestern China, represents a modern biodiversity center for *Rubus* (Rosaceae). The history for this high modern diversity remains poorly known due to the lack of fossil evidence. In this report, fossil pyrenes of *Rubus* are taxonomically studied from the late Pliocene (Piacenzian) of Lanping County, northwestern Yunnan. These pyrenes show a greater morphological variation than that of extant *Rubus* pyrenes within the same species, indicating that they belong to different taxa of *Rubus*. Based on comparisons with both modern and other fossil species, our fossil pyrenes are assigned to five taxa, including a newly established one, *Rubus lanpingensis* nov. sp. These fossils suggest a somewhat high species diversity of *Rubus* in Lanping, a small area in northwestern Yunnan, during the late Pliocene. This provides the first fossil perspective for an understanding of the historical background of the modern *Rubus* diversity in a limited geographic area of Yunnan. The inferred palaeobiodiversity is probably associated with a large environmental heterogeneity in a limited area of Yunnan at that time.

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## 1. Introduction

Yunnan, located in the far southwest of China and bordered by the southeastern edge of the Qinghai-Tibet Plateau, has long been known as a hotspot for plant diversity (Wu, 1988; López-Pujol et al., 2006, 2011; Ruth et al., 2008). Many plant taxa have their highest species richness in this region, e.g., *Pedicularis* L. and *Rhododendron* L. In recent years, several studies have been carried out using molecular data to interpret the history of this high level of plant diversity (Chen et al., 2005; Wang et al., 2005; Chen et al., 2007), but few studies have been conducted based on fossil evidence which can more directly track the once-living species.

Within the subfamily Rosoideae (Rosaceae), *Rubus* L. is one of the numerous species-rich angiosperm genus in Yunnan (Gu et al.,

2000; Lu and Boufford, 2003). It consists of at least 750 species and hundreds of varieties (Jennings, 1988; Morden et al., 2003; Potter et al., 2007), of which about 107 species and 45 varieties occur in Yunnan (Gu et al., 2000; Lu and Boufford, 2003). This high diversity has long been recognized, especially by Chinese botanists (Wu, 1988; Gu et al., 2000). Moreover, several common species of *Rubus* coexist in some limited but geographically complex areas in Yunnan; e.g., about 15 species occur in Lanping County, a small area in northwestern Yunnan (Lu and Boufford, 2003). In contrast to this extant flourishing diversity, no *Rubus* fossil has been reported so far from Yunnan or surrounding areas, making it difficult to understand how such high diversity, even within a limited area, arose.

Herein we taxonomically describe fossil pyrenes of *Rubus* from the upper Pliocene strata of Lanping, northwestern Yunnan. These fossil pyrenes, encompassing a large morphological diversity, provide a unique insight into the past diversity of the genus in Yunnan, and thus help to understand the onset of its modern richness in this region. The intraspecific variation of pyrene morphology for modern *Rubus* is examined in order to determine

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whether the morphological variations observed in the fossils are of an intra- or interspecific nature. *Rubus* diversity and environmental heterogeneity in the late Pliocene of Yunnan are discussed.

## 2. Material and methods

### 2.1. Fossil material and observations

The fossil pyrenes were collected from Fudong Village in Lanping County, northwestern Yunnan, southwestern China (26°28'N, 99°26'E; 2740 m a.s.l.; Fig. 1). The fossil site contains 700 m thick lacustrine deposits (Tao, 1986). Within the upper units of the deposits are red claystone layers embedding carbonaceous layers that bear abundant plant remains mainly including fruits and seeds (Huang et al., 2012). The deposits of the fossil site belong to the Sanying Formation, which was determined as late Pliocene (Piacenzian) in age (Huang et al., 2012) based on various evidence such as lithostratigraphical and biostratigraphical correlations (WGRSY, 1978; Tao, 1986; Ge and Li, 1999), fossil mammals (Su et al., 2011), and magnetostratigraphical data (Li et al., 2013). The geological settings of the Sanying Formation were described previously according to the regional geological and lithostratigraphical survey (WGRSY, 1978; Tao, 1986; Huang et al., 2012).

In previous field and laboratory work, up to one thousand fossil fruits and seeds were extracted from the fossiliferous carbonaceous layers of the Sanying Formation (Huang et al., 2012, 2013). The fossils were cleaned using an ultrasonic cleaner (KO-50M) at a frequency of 40 KHz for 5–30 seconds in order to remove the clay particles adhering to their surface. They are stored in the fossil collection at the Key Laboratory for Plant Diversity and

Biogeography of East Asia, Kunming Institute of Botany, Chinese Academy of Sciences. A total of 25 pyrenes of *Rubus* were isolated from this existing fossil collection. The pyrenes were observed and photographed under a binocular microscope (Nikon SZX16). Their surface details were examined with a scanning electron microscope (SEM, KYKY-1000). All studied fossil specimens are deposited in the Herbarium of Kunming Institute of Botany.

### 2.2. Extant material and comparisons

Fourteen species of *Rubus* that occur today in southwestern China were examined in order to investigate the extant intraspecific variation of pyrene morphology. Among them, pyrenes of six species (*R. alexeterius* Focke, *R. fockeanus* Kurz., *R. fragarioides* Bertol., *R. lambertianus* Seringe, *R. lutescens* Franchet, and *R. xanthocarpus* Bureau et Franchet) were collected in the field in southwestern China, and those of the other eight species (*R. alpestris* Blume, *R. assamensis* Focke, *R. ellipticus* Smith in Rees, *R. idaopsis* Focke, *R. multibractea* H. Lévillé et Vaniot, *R. niveus* Thunberg, *R. paniculatus* Smith, and *R. pentagonus* Wallich ex Focke) were obtained from specimens housed in the Herbarium of Kunming Institute of Botany. For each species, at least 40 pyrenes from different specimens were observed morphologically.

## 3. Systematic paleobotany

Family Rosaceae Jussieu

Genus *Rubus* L.

*Rubus lanpingensis* Y.-J. Huang et Z.-K. Zhou nov. sp.

Figs. 2(1–8), 3(1–3)

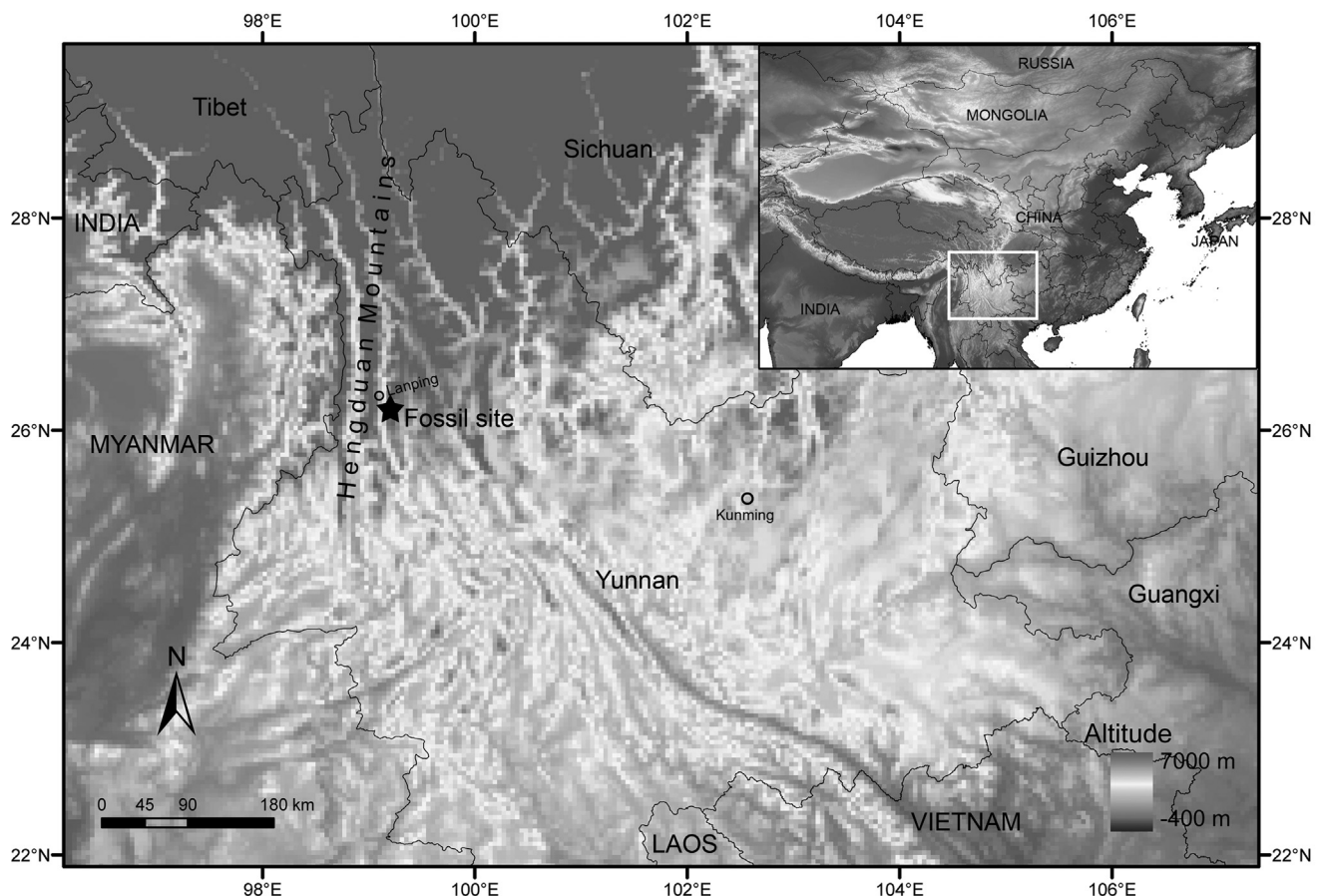


Fig. 1. Map showing the locality of the late Pliocene Fudong flora from which the present fossil pyrenes of *Rubus* were collected.

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