

Biodiversity hotspots of magnolia species in China

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ABSTRACT

Magnolia is one of the most primitive angiosperm families. Here, we delineated the biodiversity hotspots of magnolia species in China based on secondary published plant atlas. We found that magnolia species were concentrated in southern China. Biodiversity hotspots identification algorithm revealed that roughly 1.6% of the landmass in China supported 90% of magnolia species. Our results not only guide the biodiversity conservation of magnolia species in China, but also improve the understanding of the hidden ecological processes. These will be helpful for the further exploration of environmental determinants explaining the spatial pattern of magnolia species richness.

Keywords-Biodiversity hotspots, Conservation, Ecological processes, Identification algorithm, Magnolia species

I. INTRODUCTION

Magnoliaceae, the magnolia family, is one of the most primitive extant lineages of angiosperms (93.5-110 mya), and therefore has important contributions towards our understanding of the origin and diversification of flowering plants [1]. Conservation assessments published by the International Union for the Conservation of Nature (IUCN) show that at least 48% of magnolia species are threatened with extinction in the wild, mainly as a consequence of the extensive logging and habitat loss due to agriculture and livestock farming [2]. Accordingly, there is an urgent need to identify the biodiversity hotspots and thus to pinpoint the conservation priority for this family [1, 2]. Magnolia family comprises over 300 species which are mainly distributed throughout southeastern Asia and tropical America [2]. Asia is the home to approximately two-thirds of the species and China is considered as the country with the richest magnolia species all over the world. Consequently, magnolia species in China provides an excellent circumstance for understanding the spatial structure in species richness and exploring the underlying mechanisms. In this paper, we aim to identify the biodiversity hotspots of magnolia species in China. This work may delineate the biodiversity distribution and provide the management guidance for the biodiversity conservation of magnolia species in China.

II. MATERIALS AND METHODS

2.1. Species Richness Data

Based on the recently published book *Atlas of Woody Plants in China* [5], we obtained distribution maps for 111 magnolia species using ArcGIS 10.3 [6]. This book provides one of the most comprehensive databases for species distribution in China. It compiled the country level occurrence for all 13,570 native woody species in China using extensive literature (such as floras, references on nature reserves, monographs of field investigations, scientific articles and specimen records). 26 experts on botany, ecology and taxonomy from different regions of China have checked each species distribution to improve the precision of this database [5]. Magnolia species are mainly distributed in the southern China: virtually all regions of Taiwan, Hainan, Yunnan, Guangxi, Guangdong, Sichuan, Guizhou, Chongqing, Hubei, Jiangxi, Fujian, Zhejiang and Shanghai, part of Tibet, Gansu, Shaanxi, Henan, Anhui and Jiangsu (Fig. 1). Only one species *Oyama sieboldii* is distributed in the northeastern China. *Oyama sieboldii* is widely distributed both in the northeastern and southern China. The 111 magnolia species comprise of 82 species characterized by the evergreen life-form, and 29 species with the deciduous life-form [5]. In order to reduce the effect of area on species richness, we divided the study area into equal-area quadrats of 100 km × 100 km with Albers cubic equal area projection. We excluded the quadrats which cover landmass < 50% of a full-sized quadrat to control area effect, as done in previous studies [7]. 111 magnolia species distribution maps were overlaid with the quadrats, and the number of species present at each quadrat was counted as species richness.

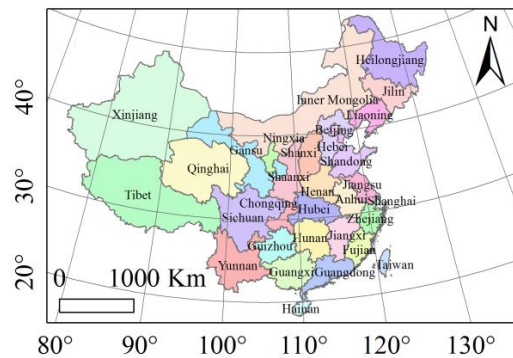


Figure 1. Distribution of provinces in China.

2.2. Hotspots Identification

Biodiversity hotspots recognize the significant clustering distribution of species, which not only guide conservation efforts and ecological management [3], but also somewhat indicate the spatial pattern in species richness. We applied the complementary algorithm [8], whose principle is determining the smallest number of quadrats that contain all the species, to identify biodiversity hotspots for magnolia species in China. Initially, the quadrat with the maximum number of species was chosen. All species found in the first chosen quadrat were then excluded from the further consideration.

III. RESULTS AND DISCUSSION

Three quadrats located in Guizhou and Yunnan comprised more than 40 species. Species richness was lowest in the northeast and central regions of China, and Taiwan, where quadrats harbored only one species. Typically, Jilin and Liaoning contained only one species *Oyama sieboldii* (small deciduous tree); Shandong merely supported *Liriodendron chinense* (deciduous tree) and *Oyama sieboldii*; Hebei simply harbored *Yulania liliiflora* (deciduous shrub) and *Oyama sieboldii*; Taiwan also merely consisted of two species *Michelia compressa* (evergreen tree) and *Parakmeria kachirachirai* (evergreen tree). The complementary algorithm manifested that 26 quadrats, which covered 2.7% of China's land, included all magnolia species (111 species). 15 quadrats occupied 1.6% of the landmass in China and included 90% of the magnolia species (100 species). Consequently, these 15 quadrats were recognized as the biodiversity hotspots, which were mostly situated in the southern Yunnan (Fig. 2).

Both morphological and molecular evidences have revealed that Magnoliaceae can be considered as one of the most primitive angiosperm family [1]. Thus, magnolia species are exceptionally important in researches on biogeography and plant evolution [11]. Additionally, magnolia species are of

Secondly, the quadrat with the maximum number of species that were not already chosen was selected. If two quadrats have the same species richness, we selected the quadrat with higher weighted species richness. Weighted species richness was calculated by summing up weights of the species present within this quadrat, and weight of each species was defined as the number of all quadrats where each species was found. This process was conducted iteratively until all 111 species were contained in the chosen quadrats. Quadrats consisting of 90% species were identified as hotspots [9, 10].

remarkable value owing to their timber, medicinal and food products and ornamental values, which make magnolia species act as the attractive flagship for plant conservation [2]. Here, we delineated the magnolia species distribution in China and discovered that the highest species richness appeared in the southern China and especially clustered in Guizhou, Yunnan and Guangxi (Fig. 2). While, the quadrats supporting the lowest species richness occurred in the Tibetan Plateau, Sichuan, Gansu, Shaanxi, Henan, Anhui, Shandong, Hebei, Liaoning, Jilin and Taiwan.

Many magnolia species are assessed as threatened with extinction, and therefore it is urgently needed to recognize the biodiversity hotspots for planning conservation actions [2]. To achieve this goal, we employed the complementary algorithm to select 15 quadrats (each quadrat covered the area of 104 km²) which encompassed 90% of 111 magnolia species in China as the hotspots [8, 9, 10]. Most of the quadrats denoted as hotspots were distributed in the high altitudes due to the heterogeneous habitats for plant species in the mountainous regions, which was consistent with previous reports [4, 10, 12, 13]. Typically, the first-order selected quadrat was located at the southeastern Yunnan, which consisted of 44.

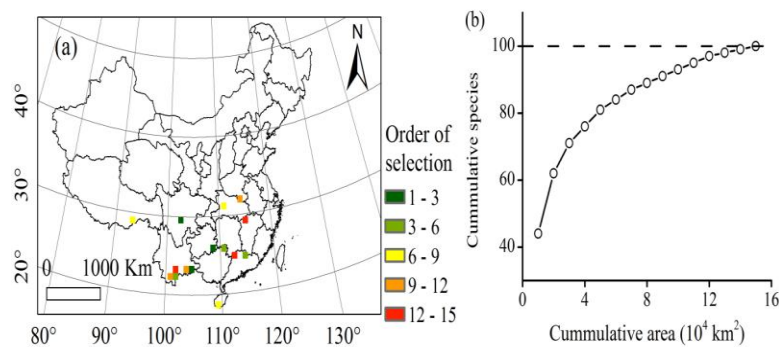


Figure 2. Biodiversity hotspots for magnolia species in China. (a) Geographical distribution of hotspots: the value of each quadrat represented the selection order through the complementary algorithm; (b) Relationship between the number of cumulative species and the number of cumulative area.

Magnolia species and thus covered many endangered species (Fig. 2). For instance, the critically endangered and narrowly distributed species *Michelia coriacea* (evergreen tree) retains high levels of genetic diversity, mostly at the within-

IV. CONCLUSION

In this study, we identified the biodiversity hotspots of magnolia species (one of the most primitive angiosperm families) in China by the published plant species atlas and identification algorithm. The results showed that southern China supported the most magnolia species and 90% of

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