



Understanding the plant diversity on the roof of the world—A brief review of flora of Pan-Himalaya

Qiang Wang^{1,2,*} and Deyuan Hong^{1,*}

¹State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China

²College of Life Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

*Correspondence: wangqiang@ibcas.ac.cn (Q.W.); hongdy@ibcas.ac.cn (D.H.)

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Pan-Himalaya covers the northeastern Hindu-Kush, Karakoram, Himalaya, and Hengduan mountains. These majestic mountain ranges form the highest region in the world, which is called “the roof of the world.” Of the 35 recognized biodiversity hotspots in the world,¹ three are wholly or partially included in Pan-Himalaya, i.e., Himalaya, Mountains of Southwest China, and Indo-Burma. However, although this region is an important and indispensable source of biodiversity, the plant diversity of Pan-Himalaya is poorly known. There is even no complete record of the flora for this most unique region. Currently, climate change and loss of global biodiversity are huge risks facing human society. Understanding the components and changes of plant diversity on the roof of the world will definitely provide new insight into these ecological crises.

To investigate the plant diversity of this unique geographical region, the Institute of Botany, Chinese Academy of Sciences (IBCAS) launched the Flora of Pan-Himalaya (FPH) project in 2010. Led by IBCAS, this international project has brought together 116 plant taxonomists from 15 countries (China, Czech Republic, Germany, India, Ireland, Japan, Myanmar, Nepal, Pakistan, Poland, Russia, Sweden, Switzerland, the United Kingdom, and the United States). The aim of the FPH project is to understand the plant diversity of Pan-Himalaya, and present the first complete record of the flora of Pan-Himalaya (an anticipated 50-volume series, consisting of 80 books).

THE ALPINE FLORA OF AN UNPARALLELED GEOGRAPHICAL REGION

The Indian plate broke off from the gigantic supercontinent Gondwana,² and finally plowed into the underbelly of Asia around 60 Ma. This great geographical movement thrust up the entire Pan-Himalaya region, and subsequently formed some of the most beautiful, extensive, and revered mountain ranges on earth. Although the Qinghai-Tibet Plateau is usually called “the roof of the world” in China, the Pan-Himalaya is the real “roof.” The main ridge of Pan-Himalaya has an average elevation of more than 6,000 m, and contains nine of the 10 highest peaks on earth. It is also home to more than half of the 7,000-m peaks of the world. The tropical, subtropical, and temperate climate, monsoons from the Indian and Pacific Oceans, and strong orogeny³ in Pan-Himalaya have provided a great opportunity for the evolution of endemic plants, which has ultimately led to incredible biological richness. This region has some of the most spectacular alpine flora in the world and highly diverse biomes, such as mountain tropical rain forest, seasonal rain forest, mountain evergreen broad-leaved forest, coniferous and broad-leaved mixed forest, cold and warm coniferous forest, subalpine shrub meadow, alpine meadow, and subnival meadow. According to a preliminary report from the project, there are 282 families, 2,535 genera, and 19,485 species of vascular plants in Pan-Himalaya. It is remarkable that the Pan-Himalaya region is only one-sixth the size of Europe and one-eleventh the size of North America, but has twice the number of plant species of the former and about



Figure 1. A conceptual view of Mt. Everest, the highest point of Pan-Himalaya and its representative alpine plants

1.5 times that of the latter. Although the exact number of species in Pan-Himalaya will be amended after taxonomic revision, these preliminary findings still show the extreme richness of Pan-Himalaya in terms of plant diversity (Figure 1).

PROGRESS AND INITIAL ACHIEVEMENTS OF THE FPH PROJECT

The goals of the international FPH project are to see the unseen plant diversity of Pan-Himalaya and to provide a theoretical basis for conservation of plant resources in this region. For the past 10 years, the FPH project has organized 15 comprehensive expeditions (>10 taxonomists) and more than 400 teams (each consisting of 3–5 taxonomists), and has investigated nearly all areas of Pan-Himalaya (except those areas in Northeast Afghanistan). Members of these expeditions have collected more than 150,000 specimens, and have taken more than 200,000 pictures of vascular plants in Pan-Himalaya. Observation data, living seeds, and silica gel-dried leaves have been collected as well. New or updated illustrations have been drawn for more than 1,000 representative species. The FPH project has financially supported the visits of about 100 taxonomists to herbaria in Asia, Europe, and America, and the collection of more than 1 million specimens from Pan-Himalaya; most of which are preserved in 50 herbaria (including K, BM, E, P, PE, and KUN) and have been carefully examined. Based on extensive field work and integrative phylogenetic analysis, one new family, 10 new genera, and more than 100 new species from Pan-Himalaya have been described. Nine books were published by Science Press and Cambridge University Press, and drafts of 20 additional books have been completed.

THE PRESSING NECESSITY AND SIGNIFICANCE OF COMPLETING THE FPH PROJECT AND SUGGESTIONS FOR ACCELERATING THE PROJECT

As the roof of the world, Pan-Himalaya plays a vital role in the global climate. The possible destruction of its glaciers and disruption to the monsoons will be fatal to the global ecosystem. However, the present situation in Pan-Himalaya is not encouraging. Expansion of vegetation has been observed in the subnival belt of Pan-Himalaya,⁴ which might be a strong signal of global warming. The most severe threats the ecosystems as well as the plant diversity of Pan-Himalaya are facing come from human consumption activities, irrational exploitation, growing settlements, grazing, and excessive harvesting of plants. A sound knowledge of the plant diversity of Pan-Himalaya is the only way to achieve sustainability, and it is also essential for ecological civilization development, which is now an important national policy of China.⁵ The FPH project is the first and key step in improving our knowledge of the plant diversity in Pan-Himalaya.

It is very difficult to complete a large, concise, scientifically sound study of flora, especially for such a unique region extremely rich in plant diversity. It has taken 10 years to complete the nine published books and the drafts of 20 additional books, which describe only a third of the flora of Pan-Himalaya. It is necessary to accel-

erate the FPH project, because we cannot afford to wait another 20 years to record the remaining two-thirds of the flora. We must understand the spectacular plant diversity of Pan-Himalaya as soon as possible, before losing any species. Thus, here we present the following suggestions to accelerate the project: (1) send more expeditions to Pan-Himalaya and use more advanced technology (such as unmanned aerial vehicles, remote sensing, and artificial intelligence) to collect habitat and phenotype data, as well as specimens; (2) accelerate the digitalization of the abundant specimens collected by the project, and improve the efficiency of specimen transfer between the FPH authors and the main herbaria distributed in countries including China, France, the United Kingdom, and the United States, since the COVID-19 pandemic is still not over; (3) hold more frequent and regular workshops or meetings for FPH authors, online or offline, and strengthen discussion among authors; and (4) strengthen support given to the authors by the editorial office in terms of preparing plant illustrations and taxa distribution maps, verifying specimen origin, collecting literature, and polishing drafts. The ideal schedule is to have 40 new books (including 20 online versions) published within 5 years and to complete the remaining volumes in the second 5 years.

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DECLARATION OF INTERESTS

The authors declare no competing interests.