Hai Ren *Editor*

Conservation and Reintroduction of Rare and Endangered Plants in China

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Preface

In the face of unprecedented biodiversity losses and global change, effective approaches for the conservation of rare and endangered plant species are urgently required. The major approaches to integrative plant conservation include in situ conservation, ex situ conservation, and reintroduction. Reintroduction may be especially effective at protecting and rescuing rare and endangered plants.

China has protected about 65% of the vascular plant communities through in situ conservation in natural reserves and national park systems and has preserved about 60% of the plant species through ex situ conservation in botanical gardens and other ex situ conservation facilities. However, we know less about reintroduction in China. Throughout the book, we and our invited authors explore to what extent information about reintroduction of plants is currently available in China.

This book is composed of two parts. Part I introduces the plant diversity and its conservation in China, and Part II displays some cases of reintroduction of rare and endangered plants in China. The majority of the chapters in the book are devoted to the case studies of reintroduction.

Books such as this one become a reality only with the support and involvement of many people. The editors are indebted to the team of enthusiastic authors, all famous experts in the fields in China, who have made available experience. The editors divide their work as follows: Prof. Hai Ren designed the contents and organized the manuscripts. Prof. Hongfang Lu edited Chaps. 1–4, Dr. Hongxiao Liu edited Chaps. 5–20, Director Ju Zhou co-organized the manuscripts and co-conceived the contents, Prof. Yan Zeng edited tables, photos, and figures. Thanks to Prof. Elizabeth Platt Hamblin for editing English. We thank the anonymous reviewers for their constructive comments. We are very grateful to Dr. Xin Zhu and Beracah John Martyn for their careful fine-tuning of the editorial work at press.

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that this small book will be of value in stemming the tide of plant diversity loss and unsustainable development in China and even in the world. This book is dedicated to Convention on Biological Diversity-COP 15, which will be held in 2021 in Kunming, China.

Guangzhou, China Hai Ren
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Prof. Hongfang Lu, Dr. Hongxiao Liu, Director Ju Zhou, and Prof. Yan Zeng are Associate Editor-in-Chief.

Prof. Hongfang Lu edited Chaps. 1–4, Dr. Hongxiao Liu edited Chaps. 5–20, Director Ju Zhou co-organized the manuscripts and co-conceived the contents, Prof. Yan Zeng edited tables, photos, and figures.

Contents

Reintroduction of *Primulina tabacum* Hance, a Critically Endangered Calciphilous Perennial Herb, in Southern China

Hai Ren, Guohua Ma, Qianmei Zhang, and Xiangying Wen

Abstract *Primulina tabacum* Hance (Gesneriaceae) is a calciphilous perennial herb. There are only eight wild populations with less than 10,000 individuals in Southern China. The distribution, conservation status, ecological and biological characteristics, genetic diversity, reproductive biology, tissue culture, and horticulture of *P. tabacum* were studied before reintroduction. Thousand in vitro-propagated *P. tabacum* plantlets were used to reintroduce at three of the plant's historical and extant habitats. About 10% of the transplanted seedlings survived by 2012. More than 200 next-generation individuals were found in 2018. Facilitation between the species and mosses is important for the reintroduction success.

Keywords Calciphilous perennial herb · Tissue culture · Moss · Facilitation · *Primulina tabacum* · Reintroduction

1 Introduction

Primulina tabacum Hance (Gesneriaceae) is a calciphilous perennial herb (Fig. 1). It was listed as one of the prioritized protected key wild plants of China in 1999 and in the list of wild plants with extremely small populations in China in 2012 (Ren et al. 2010a). It only distributes at the entrances of karst cave drainages along the border among northern Guangdong, southern Hunan, and eastern Guangxi, China. There are only eight wild populations at the region. *P. tabacum* relies on alkaline calciferous groundwater and grows in poor soils (Fig. 2). Because of human disturbances and climate change, the population size of *P. tabacum* has drastically decreased during the past century. It was estimated that there were less than 10,000 individuals in the wild.

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Fig. 1 The individual of *Primulina tabacum* Hance

Fig. 2 The habitat of *Primulina tabacum* Hance

2 Description of Reintroduction

2.1 Feasibility

We have studied the distribution, conservation status, ecological and biological characteristics, genetic diversity (Wang et al. 2013), reproductive biology, tissue culture, and horticulture of *P. tabacum* since 2002 (Ren et al. 2010a). We established reintroduction sites at Lianzhou City, Guangdong, Southern China in 2002. We failed to germinate the seeds at the South China Botanical Garden in 2003–2006. However, we got successful in tissue culture and obtained plantlets in 2007. We used in vitro-propagated *P. tabacum* plantlets to reintroduce the species into three of the plant's historical and extant habitats (Ren et al. 2010b).

2.2 Implementation

We obtained about 4000 plantlets in July and acclimatized these plantlets at the South China Botanical Garden until September 2007. During the acclimation period, 7.2% of the plantlets died from desiccation. Of the remaining plantlets, 1000 were then transplanted into the cave entrances at Dixiahe (112°21′ E, 25°1′ N), Lianzhou City, Guangdong, Southern China, on October 26, 2007. At the time of transplanting, the plantlets were 1.5 ± 0.1 cm in height and 3.0 ± 1.0 cm $\times$ 3.5 ± 1.0 cm in crown size. The transplants were kept natural growth except for watering several times after transplanting. The planting plots were not fenced nor fertilized. In addition, we proposed successfully to the local government to establish a small natural reserve to protect the remaining wild individuals in 2007. We also successfully established an ex situ collection in the experimental area of the Tianxin nature reserve, Lianzhou City, in 2010 (Ren et al. 2010b, 2018).

2.3 Post-planting Monitoring

After transplantation, we monitored the survival, height, and crown of all transplants and examined the causes of death (i.e., insect defoliation, fungal decay, nutrient deficiency, lack of water, or strong radiation) from 2007 to 2012. The monitoring was carried out once per month during the first year and once per year thereafter (Fig. 3.). Microhabitats and soils were also monitored every year. About 10% of the transplanted seedlings survived by 2012. We also found more than 200 next-generation individuals in 2018. Our field observations indicate that transplanted *P. tabacum* grew slower than wild *P. tabacum*. The transplanted *P. tabacum* performed especially well under the cover of the nursing moss, *Gymnostomiella*

Fig. 3 Monitoring the growth of *Primulina tabacum* reintroduced individuals

longinervis Broth. Facilitation between the species and mosses is important for the reintroduction success (Ren et al. 2010b, 2018).

3 Problems and Recommendations

- There may be some remaining populations in remote mountain areas; thus more surveys are needed.
- The local farmers and domestic animals unintentionally disturbed or sometimes destroyed the reintroduction sites.
- Successful reintroduction needs the close collaboration among all stakeholders, including farmers, scientists, and the local government officials.
- Moss plays a key nurse plant to facilitate the reintroduction of *P. tabacum*.
- It is easy to succeed in reintroduction of rare and endangered plants by the integration of biotechnology, nurse plant technology, and ecological restoration technology.
- The best method for conservation of rare and endangered plant is in situ preservation, and reintroduction can be used as a helpful tool to conserve biodiversity, but it is difficult and expensive.

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