Biological Conservation 181 (2015) 64–72

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Distribution and conservation of orchid species richness in China

Zejin Zhang [a], Yujing Yan [a], Yu Tian [b], Junsheng Li [b], Jin-Sheng He [a], Zhiyao Tang [a,*]

[a] Department of Ecology, College of Urban and Environmental Sciences, and Key Laboratory of Earth Surface Processes of Ministry of Education, Peking University, Beijing 100871, China
[b] Chinese Research Academy of Environmental Sciences, Beijing 100012, China

ARTICLE INFO

Article history:
Received 22 September 2014
Accepted 23 October 2014

Keywords:
Conservation
Environmental factors
Nature reserves
Orchid
Pattern
Species richness

ABSTRACT

Orchidaceae, the orchid family, is one of the species richest families and the most endangered plant groups. Most orchids are narrowly distributed in specific habitats because of their mycorrhizal specificity, pollinator specialization and limited seed germination rate; compared to plants from other families, orchids are extremely susceptible to habitat disturbance. However, little is known about how orchids are distributed and how they are protected at large scales. In this study, we developed a distribution database for all the 1449 orchid species in China. Using this database, we explored patterns of orchid richness in relation to climate, net primary productivity and habitat heterogeneity in China. We then evaluated the *in situ* conservation status of the orchids in China by overlapping the species distribution and the terrestrial national and provincial nature reserves (NNRs and PNRs) in C\hina. We found that 90% of orchid species in China were distributed in 258,800 km^2 (2.7% of China's landmass). Net primary productivity, elevation range, and temperature seasonality together explained 34.4% of variance in orchid richness. On average, NNRs covered 12.1%, NNRs and PNRs together covered 29.1%, of orchid distribution areas. However, there were still 154 (including 83 endemic to China) narrowly distributed orchid species not covered by NNRs; and 48 (including 28 endemic to China) were not covered by either NNRs or PNRs. We proposed that nature reserves specifically designed for orchids need to be established in Southwest China and Hainan Island.

1. Introduction

Orchidaceae, the orchid family, is one of the species richest families of seed plants. It is composed of five subfamilies, 880 genera and more than 25,000 species in the world (Cribb et al., 2003). Many orchid species are important in horticultural for their charismatic flowers, and some species, such as *Gastrodia elata* and *Dendrobium offcinale*, have pretty high medical values especially in traditional Chinese medical science (Luo et al., 2003). Because orchids have mycorrhizal specificity, pollinator specialization and limited germination rates (Gravendeel et al., 2004; Cozzolino and Widmer, 2005; McCormick and Jacquemyn, 2014), most orchids are narrowly distributed in specific habitats (Lozano et al., 1996) and are extremely susceptible to habitat disturbance comparing to other plants (Cozzolino and Widmer, 2005; Jacquemyn et al., 2005, 2007). Currently, the orchid populations have been decreasing due to habitat loss and over-collection for ornament and medicine usage (Huang, 2011). In addition, Orchidaceae has a higher proportion of threatened genera and species than most other families (Pillon and Chase, 2007). The susceptibility and limited distribution may cause large-scale extinction events in orchids under future climate change (Swarts and Dixon, 2009). Considering its great value, endangered situation and its key role in ecosystem, Orchidaceae is frequently used as flagship group in biological conservation (Baillie et al., 2004). These characteristics make it important to explore the distribution and conservation status of orchids.

Orchids are widely distributed in the tropics and subtropics with different life forms (Cribb et al., 2003). Recent studies suggested that distribution of orchids were limited by the joint effect of habitat availability and pollination limitation (McCormick and Jacquemyn, 2014). Specifically, patterns of orchid richness are regulated by habitat size and elevation range at large scales (Jacquemyn et al., 2005; Schödelbauerová et al., 2009; Acharya et al., 2011), while by light availability, soil moisture, canopy height and area (especially for the epiphytic orchids) at fine scales (Gravendeel et al., 2004; Huang et al., 2008; McCormick and Jacquemyn, 2014). However, compared to the large number of orchid species, knowledge on the large-scale patterns and controls of orchid richness is limited (Chapman and Wang, 2002; Chen et al., 2009).

* Corresponding author. Tel./fax: +86 10 6275 4039.
E-mail address: zytang@urban.pku.edu.cn (Z. Tang).

http://dx.doi.org/10.1016/j.biocon.2014.10.026
0006-3207/

Harboring more than 1300 orchids, China is one of the orchid richest countries in the world (Chen et al., 2009). The number is increasing as new species and varieties continued to be found (Liu et al., 2007). In China, orchids are distributed mainly in the southern to southwestern part of China, such as Yunnan, Sichuan and Taiwan Provinces (Chen et al., 2009). Most studies on orchids in China are focused on taxonomy and biogeography (Luo et al., 2003).

Facing the reality that a large number of species are at risk and the time and resources are limited, the primary way China employed for species conservation must be *in situ* conservation, thus setting up nature reserves (Heywood and Dulloo, 2005). Through *in situ* conservation, target species could be preserved along with its original habitat and genetic diversity (Ellstrand and Elam, 1993; Heywood and Dulloo, 2005). Up to 2012, China has set up more than 2600 nature reserves in order to protect its mega-biodiversity, including 363 national (NNRs) and 872 provincial nature reserves (PNRs) (Zhao et al., 2013). Unfortunately, there is no protection regulation for *in situ* conserving orchids (McBeath and McBeath, 2006). Among all these NNRs, only one, the "Yachang Orchid Nature Reserve", together with some PNRs, is specially designed for protecting orchids, albeit that most of the NNRs and PNRs have included different orchids (He et al., 2007). Besides, a recent evaluation based on species checklists of nature reserves illustrated that most of the orchids were not covered by nature reserves (Qin et al., 2012), thus, the protection of orchids in China is still a challenge. Therefore, it is of particular significance to strengthen the protection of the orchids in China.

In this study, we analyzed the distribution patterns of orchid richness and evaluated the *in situ* conservation status of orchids in China. To do this, we first compiled a distribution database of orchids and a spatial database of NNRs and PNRs in China. Based on these databases, together with other spatial databases of environments, we explored the patterns of orchid richness in relation to environments and identified the hotspots of orchid richness in China. We then evaluated the *in situ* protection status of orchids in China. The questions we asked were: (1) How orchid species were distributed and where were the hotspots located in China? (2) What environmental factors affected the distribution of orchid richness in China? (3) How orchids were protected in China?

2. Material and methods

2.1. Data collection

2.1.1. Distribution of orchids in China

We first compiled the county level occurrence for orchid species in China using all available literatures, such as national, provincial, local floras, checklists of nature reserves, monographs of field investigations for plants, and scientific articles, as well as specimen distribution records (www.cvh.ac.cn). The nomenclature of orchid checklist followed the recently published Flora of China (volume 25, Chen et al., 2009. Available at http://foc.eflora.cn/). Non-native species were excluded.

Since the county level occurrence may over-estimate the distribution of each species, we also collected the upper and lower elevation records and habitat type of each species to refine the distribution. We overlapped the county level occurrence with a vegetation map of China (1: 1,000,000) (Editorial Committee of Vegetation Map of China, 2007) and a digital elevation model (DEM) obtained from the United States Geological Survey (at a resolution of 30 m, available at http://reverb.echo.nasa.gov/reverb/redirect/wist). The distribution area is defined as the grid containing the habitat type and elevation between the upper and lower elevation of a species in the county where the species occurring. The orchid distributions were then transferred into grids at a resolution of 10×10 km. In total, the database contained 484,791 records of distribution girds for 1449 species (and varieties). We assigned life-form information for each species as terrestrial (748 species), epiphytic (688 species) and lithophytic (267 species) (some species have more than one life forms). We also assigned all the species as endemic (526 species) and non-endemic (923 species) to China according to their distributions.

We grouped the orchids into four types according to their range size, namely, most narrowly distributed quarter (Q1), narrowly distributed quarter (Q2), widely distributed quarter (Q3) and most widely distributed quarter (Q4).

2.1.2. Environmental factors

We used climate, productivity and habitat heterogeneity as possible determinants of large-scale patterns of orchid richness in China. Climatic data were obtained from the WorldClim database (Hijmans et al., 2005. Available at: http://www.worldclim.org/). We used the following climatic variables to explore the influence of climate on the orchid richness in China: mean annual temperature (MAT, °C), mean temperature of the warmest (MTWM, °C) and coldest month (MTCM, °C), potential evapotranspiration (PET, mm), actual evapotranspiration (AET, mm), mean annual precipitation (MAP, mm), growing season precipitation (GSP, mm; defined as precipitation between May and October), moisture index (IM, unitless), seasonality of temperature (TSN, unitless) and precipitation (PSN, unitless), and annual range of temperature(ART, °C).

We used the satellite based net primary productivity (MODIS-NPP, g C m^2, available at: ftp://e4ftl01.cr.usgs.gov) to represent productivity.

We used elevation range (RELE, m, defined as the difference between the highest and lowest elevation in the grid, calculated based on the USGS-DEM) and number of vegetation types (VGT, defined as number of natural associations based on the vegetation map of China of 1: 1,000,000) in each 10×10 km grid as surrogates of habitat heterogeneity.

We calculated all the aforementioned environments by overlapping the 10×10 km grid system with spatial distribution of these variables using a geographical information system (ArcGIS 10.0, ESRI, 2012).

2.1.3. Spatial database of nature reserves in China

Among the 2600 nature reserves in China, 319 NNRs covering 9.4×10^5 km^2 (~10% of the total landmass), and 835 PNRs covering 3.7×10^5 km^2 (~4% of the total landmass), are terrestrial ones. To evaluate the representativeness of orchids in the nature reserves, we compiled the spatial database on NNRs and PNRs (Zhao et al., 2013) by digitalizing all terrestrial NNRs and PNRs through the geographical information system software ArcGIS 10.0 (ESRI, 2012).

2.2. Data analysis

2.2.1. Hotspots identification

Species richness for each gird was calculated as the total number of species in the grid. Complementary algorithm (Dobson, 1997) was applied to identify hotspots of orchid richness in China. The basic idea of this algorithm is recognizing the minimum number of grids that could cover all the species. Grid with the highest species richness was selected first, and then grid with the highest number of the remaining (unselected) species was selected. The process continued iteratively until all species were included in the selected grids (Dobson, 1997). Grids including 90% species (i.e. 1304 out of 1449 species in this study) were set as hotspots (Kati et al., 2004).