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PREFACE

Orchid conservation: further links

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• **Background:** Due in great part to their often complex interactions with mycorrhizal fungi, pollinators and host trees, Orchidaceae present particular challenges for conservation. Furthermore, orchids, as potentially the largest family of angiosperms with >26000 species, species complexes and frequent hybrid formation, are complex to catalogue. Following a highlight in 2015, a further seven papers focusing on orchids, their interactions with beneficial organisms, pollinators and mycorrhiza, and other factors relating to their conservation, including threats from human utilization and changing land use, are presented here.

• **Conclusions**: The production of an online flora of all known plants and an assessment of the conservation status of all known plant species as far as possible, to guide conservation action are the first two targets of the *Global Strategy for Plant Conservation*. Without knowing how many species there are and how they should be circumscribed, neither of these targets is achievable. Orchids are a fascinating subject for fundamental research with rapid species evolution, specific organ structure and development, but they also suffer from high levels of threat. Effective orchid conservation must take account of the beneficial interactions with fungi and pollinators and the potentially detrimental effects of over-collection and changes in land use.

Key words: Conservation biology, fungi, mycorrhizas, Orchidaceae, orchids, pollination ecology, taxonomy.

Orchids continue to be a high-profile group of plants from biological and conservation perspectives, and some groups, e.g. slipper orchids, are among the most endangered groups of organisms (Fay and Rankou, 2016; Fig. 1). Following a previous Highlight (Fay, Pailler and Dixon, 2015, and seven associated papers), many new papers have been published on orchids, their conservation and their interactions with other organisms including humans. In some of these interactions, the orchids are clearly dependent on the other organisms, e.g. mycorrhizal fungi and pollinators, but in one recent paper, the role of litter-trapping plants, including some orchids, in providing food and housing for commensal organisms was stressed (Zona and Christenhusz, 2015).

A further seven papers relating to orchids are presented here. Of these, two relate mycorrhizal associations (Jacquemyn *et al*., 2016; Mujica *et al*., 2016), two relate to interactions, direct or indirect, with humans (Blambert *et al*., 2015; Vogt-Schilb *et al*., 2016) and two relate to pollination and reproduction (Hetherington-Rauth and Ramírez, 2016; Krawczyk *et al*., 2016).

The remaining paper (Pedersen, Srimuang and Watthana, 2016) does not deal directly with interactions with other organisms, instead focusing on the importance of establishing a robust system of classification in setting conservation strategy. Targets 1 and 2 of the current version of the *Global Strategy for Plant Conservation* (Convention on Biological Diversity, 2011) relate directly to the importance of such a robust classification in directing conservation activities. Target 1 calls for the production of an online flora of all known plants and Target 2 calls for an assessment of the conservation status of all known plant species as far as possible, to guide conservation action. Without knowing how many species there are and how they should be circumscribed, neither of these targets is achievable. Orchids, as potentially the largest family of angiosperms (Chase *et al*., 2015), present a challenge in this respect, with >26000 species to catalogue, and the existence of species complexes and occurrence of hybridization in some groups of orchids further complicate the process. Here, Pedersen *et al*. (2016) use a combination of multivariate morphometric analysis and genetic fingerprinting to resolve a species complex in *Geodorum*, demonstrating that the apparently conservation-dependent *G. pulchellum* is not distinct from its commoner relative, *G. siamense*, and that it does not warrant conservation attention. In a recent phylogenetic study (Bone, Cribb and Buerki, 2015), *Geodorum* was shown to be embedded in *Eulophia*, and the genus may end up being subsumed as a result; however, the results presented here relate to the species level and are robust, regardless of any future decision to make *Geodorum* a synonym of *Eulophia* or to split *Eulophia* further.

Characteristics of habitats are important in determining distributions of plants in general and of orchids in particular, due to their often complex interactions with other organisms. For example, Damon *et al*. (2016) investigated orchid distributions in tropical mountain cloud forest ecosystems and demonstrated the importance of ravines as orchid-rich habitats. This was despite the instability of the steep slopes and landslips that are characteristic of these habitats, and the authors noted the importance of management of the surrounding areas in minimizing such risks. Here, Vogt-Schilb *et al*. (2016) investigate changes in orchid distributions on Corsica from surveys carried out 27 years apart at 45 sites on Corsica and the effect of land-use change (measured as change in woody plant cover). The study demonstrates stability at the regional (island) level, but high levels of turnover in species composition at the local level. The authors stress the importance of habitat mosaics for maintaining species diversity at large spatial scales. Blambert *et al*. (2016) investigate the effects of harvesting of two *Jumellea*

FIG. 1. A. Damage to the habitat of two *Cypripedium* species caused by road building in Yunnan, China: an example of the threats to orchids caused by changes in land use. B. One of the remaining plants of *C. tibeticum* at this site (Photos: Maarten Christenhusz)

species (used for their aromatic and medicinal properties) on reproductive patterns and genetic diversity, demonstrating that the rarer species is already affected by over-collection and fragmentation. The authors recommend *ex situ* cultivation as a way of meeting the needs of local people at the same time as preventing further impact on the wild populations.

Presence of suitable fungi has been implicated in orchid distributions (e.g. Rasmussen and Rasmussen, 2014; Rasmussen *et al*., 2015; Davis *et al*., 2015; Lee, Yang and Gebauer, 2015). Here, Jacquemyn *et al*. (2016) demonstrate differences in the mycorrhizal communities associated with recently diverged *Epipactis* species and draw attention to the need for further studies aimed at elucidating the role of habitat-specific adaptations and mycorrhizal divergence in the process of speciation in orchids. In the second paper related to this area of research, Mujica *et al*. (2016) characterize mycorrhizal communities associated with two *Bipinnula* species and examine the effect of soil nutrient availability on these communities.

Orchid reproduction and pollination continue to be active fields of research. The previous highlight included one paper on pollination of *Sprecklinia* species by *Drosophila* involving the production of aggregation pheromones by the orchids (Karremans *et al*., 2015) and one on evolution of reproductive isolation in *Dendrobium* species (Pinheiro *et al*., 2015). Other recent papers related to this general area have been published recently on pollination in non-rewarding *Traunsteinera globosa* (Jersáková *et al*., 2016) that mimics fly-pollinated rewarding species, pollinator rarity as a threat to an orchid with a specialized wasp pollination system (Phillips *et al*., 2015), the role of labellar secretions in attracting insect pollinators in *Bulbophyllum* (Stpiczyńska, Davies and Kamińska, 2015) and the long tongued hawkmoth pollinator niche in African plants with long floral tubes, including orchids (Johnson and Raguso, 2016). In this issue, Hetherington-Rauth and Ramírez (2016) investigate the role of floral scent in pollination of *Gongora* species by euglossine bees, demonstrating that floral scent chemotypes are correlated with distinct bee assemblies. Finally, Krawczyk *et al*. (2016) investigate modes of reproduction in the mycoheterotrophic *Epipogium aphyllum*, revealing that, despite the lack of prezygotic barriers, automatic self-pollination does not occur due to the position of the pollinia. In the absence of pollination, however, parthenogenesis can lead to the production of seed, a tactic that provides for continued seed production even when insect pollination fails.

The papers presented here demonstrate that research into orchids and their interactions with other organisms, including humans, is a vibrant field. We have still much to learn about these interactions, but it is clear that effective orchid conservation must take account of the beneficial interactions with fungi and pollinators and the potentially detrimental effects of over-collection and changes in land use.

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