Editorial
The Distribution and Diversity of Orchids

Pavel Kindlmann [1,*] **, Tiiu Kull** [2] **and Melissa McCormick** [3]

1 Institute for Environmental Studies, Faculty of Science, Charles University, Benátská 2,
128 01 Prague, Czech Republic
2 Department of Biodiversity and Nature Tourism, Estonian University of Life Sciences, 51014 Tartu, Estonia;
tiiu.kull@emu.ee
3 Smithsonian Environmental Research Center, 647 Contees Wharf Rd, Edgewater, MD 20137, USA;
mccormickm@si.edu
* Correspondence: pavel.kindlmann@centrum.cz

The presence of Orchids is declining worldwide, mostly due to habitat loss and other factors like climate change, which are likely to increase in severity in the coming decades. Thus, one of the most worrying issues is that we still do not know the optimal abiotic and biotic requirements for the maintenance of many of the approximately 30,000 species of orchids. Additionally, there are still unclear issues in orchid taxonomy, nomenclature, and systematics. This all complicates the development of effective conservation methods for this endangered plant group. This Special Issue aims to fill in some of these gaps in our knowledge.

In a study by Smallwood and Trapnell [1], species distribution models were used to investigate the impact of recent climate change on suitable habitat shifts for six North American species in the highly threatened genus *Cypripedium* (Orchidaceae). The researchers found that while the directionality of habitat shifts varied among species, there was a general trend toward higher elevations, and for western species, northward shifts tended to occur. Their findings highlight the complex and sometimes unpredictable responses of closely related species to changing climatic conditions and emphasize the importance of considering a species' geographic region when predicting habitat shifts.

Sumbembayev et al. [2] performed a critical study of herbarium material representing the orchid genus *Dactylorhiza* in Kazakhstan. *Dactylorhiza fuchsii* subsp. *hebridensis* and *D.* × *kerneri* were identified for the first time in the country. New taxa were noted in list form for individual botanical and geographical areas. All taxa were presented in the list and annotated with studied herbarium materials from the Kazakhstan area. Based on the collected and available locations, distribution modeling was carried out for four taxa (*D. incarnata*, *D. majalis* subsp. *baltica*, *D. salina*, and *D. umbrosa*). Bioclimatic data for the present and future (2041–2060) based on four possible scenarios were used. The occurrence of *Dactylorhiza* representatives in Kazakhstan is threatened by global warming. It is likely that some of them may not occur in the country in the future, with *D. incarnata* and *D. majalis* subsp. *baltica* being estimated to lose up to 99.87% of their modern range, or that their range may be significantly reduced, as evidenced by *D. salina* and *D. umbrosa* being estimated to lose up to 80.83% of their present distribution. In the future, it is worth considering global climate change when planning conservation activities and identifying areas that may play a significant role in the functioning of the national flora.

Volatile Organic Compounds (VOCs) are produced by plants to complete a variety of physiological and ecological tasks (including but not limited to stress resistance and pollinator attraction). Genetics is a key factor in determining plants' VOC content and emission; nevertheless, environment strongly influences VOC profiles in plants. Orchids are a widespread group of plants that colonize diverse environments and rely on complex and refined pollination mechanisms to reproduce. Orchid VOCs are rarely studied and discussed in relation to growing conditions. De Agostini et al. [3] compared the volatile

profiles of inflorescences of *Himantoglossum robertianum* sampled in six ecologically diverse populations in Sardinia (an island in Italy). Multivariate statistics separated *H. robertianum* populations based on their chemical profiles. Differences were positively linked to the distance separating populations and reflected the climatological features of the sampling sites. Interestingly, their results differed from those available in the literature, pointing out the high variability of VOC profiles in this food-deceptive orchid.

Szlachetko et al. [4] revised the orchid genus *Andinia* into multiple genera, based on the outcomes of morphological and molecular studies. Additionally, the similarity of the climatic niches occupied by representatives of the *Andinia*-complex was calculated and visualized. The highest number of *Andinia* representatives was found in the Eastern Cordillera real montane forests, while *Neooreophilus* species are found in two ecoregions: the Eastern Cordillera real montane forests and the Northwestern Andes. According to the level of endemism, a unique orchid flora was noted in the Guajira–Barranquilla xeric scrub ecoregion, as well as in the Isthmian-Pacific and the Ucayali moist forests, where single endemic species occur. In the proposed classification, nine genera are recognized within the *Andinia*-complex, three of which (*Xenosiella*, *Chicalia*, and *Minuscula*) are described by Szlachetko et al. A key for the identification of all genera is also provided by the authors. Additionally, the *Amplectentes* and *Bilamellatae* sections of *Neooreophilus* are re-categorized to the subgeneric rank, and the subgenus *Aenigma* is considered a separate genus. A complete list of representatives of each taxon is provided, and new combinations are proposed accordingly. A new species of *Neooreophilus* from Colombia is also described.

Kropf and Kriechbaum [5] investigated the population and reproductive dynamics of *Dactylorhiza sambucina*, a species of orchid characterized by its flower color polymorphism, to understand how pollinator-mediated negative frequency-dependent selection might maintain this trait. Their study, which spanned 18 years, demonstrated that smaller populations are more prone to changes in flower color dominance, while larger populations tend to exhibit constant morph frequencies. The authors argue for the adoption of local analyses to investigate the environmental factors influencing morph frequencies at the micro-habitat scale, as continental analyses have failed to provide explanations for the distribution of morph frequencies across Europe.

Hybridization is a common feature of orchids that has contributed to the evolution of new species. In their paper, Evans et al. [6] investigate hybridization in the genus *Platanthera*, focusing on the parent species *P. blephariglottis*, *P. ciliaris*, and *P. cristata*. They used biallelic SNPs generated via the use of 3RAD sequencing to reveal site-dependent gene flow between species and document extensive hybridization and cryptic hybrids in sympatric sites. The authors highlight the potential effects of hybridization on the evolution and conservation of these species.

Environmental changes can affect many aspects of environmental quality, and the intersection between these changes and species management could pose a major threat to orchids. Křenová et al. [7] demonstrate that combining current population trends with the assessment of habitat types that were historically occupied by *Cypripedium calceolus* suggests different management recommendations than if only current trends were considered. Specifically, while current populations in spruce forests are generally small, which might suggest that spruce forests are poor habitats, historical data suggest they are good habitats. This suggests that a different strategy for managing bark beetles can lead to favorable habitat development and the conservation of *C. calceolus*.

Seed morphology offers important insights into how plants disperse and colonize new locations. Important aspects of seed morphology include seed size, shape, and enclosed air space, as they impact seed dispersal. Ortúñez and Gamarra [8] demonstrated that seed size, shape, and enclosed air space all differ between terrestrial and epiphytic orchids in the genus *Bromheadia* and suggest that those differences reflect the very different dispersal mechanisms associated with terrestrial and epiphytic habitats, resulting in different degrees of rarity among the species.

Mycorrhizal specificity, along with its persistence through developmental stages, has strong effects on orchid distribution. Zhang et al. [9] found that mycorrhizal specificity increased from seed germination to seedling development in three *Dendrobium* species in vitro. Their results suggest that differences in orchid distribution may be related to mycorrhizal specificity and that the critical specificity is found at the seedling stage. They also suggest that switching mycorrhizal fungi between the germination and seedling–adult stages may be associated with orchid rarity.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Smallwood, P.A.; Trapnell, D.W. Species Distribution Modeling Reveals Recent Shifts in Suitable Habitat for Six North American *Cypripedium* spp. (Orchidaceae). *Diversity* **2022**, *14*, 694. [CrossRef]

2. Sumbembayev, A.A.; Nowak, S.; Burzacka-Hinz, A.; Kosiróg-Ceynowa, A.; Szlachetko, D.L. New and Noteworthy Taxa of the Genus *Dactylorhiza* Necker *ex* Nevski (Orchidaceae Juss.) in Kazakhstan Flora and Its Response to Global Warming. *Diversity* **2023**, *15*, 369. [CrossRef]

3. De Agostini, A.; Robustelli della Cuna, F.S.; Cortis, P.; Cogoni, A.; Sottani, C.; Soddu, F.; Sanna, C. Volatile Organic Compounds (VOCs) Diversity in the Orchid *Himantoglossum robertianum* (Loisel.) P. Delforge from Sardinia (Italy). *Diversity* **2022**, *14*, 1125. [CrossRef]

4. Szlachetko, D.L.; Dudek, M.; Naczk, A.; Kolanowska, M. Taxonomy and Biogeography of *Andinia*-Complex (Orchidaceae). *Diversity* **2022**, *14*, 372. [CrossRef]

5. Kropf, M.; Kriechbaum, M. Monitoring of *Dactylorhiza sambucina* (L.) Soó (Orchidaceae)—Variation in Flowering, Flower Colour Morph Frequencies, and Erratic Population Census Trends. *Diversity* **2023**, *15*, 179. [CrossRef]

6. Evans, S.A.; Whigham, D.F.; Hartvig, I.; McCormick, M.K. Hybridization in the Fringed Orchids: An Analysis of Species Boundaries in the Face of Gene Flow. *Diversity* **2023**, *15*, 384. [CrossRef]

7. Křenová, Z.; Lustyk, P.; Kindlmann, P.; Vosmíková, A. Forest Disturbances Threatening *Cypripedium calceolus* Populations Can Improve Its Habitat Conditions. *Diversity* **2023**, *15*, 319. [CrossRef]

8. Ortúñez, E.; Gamarra, R. Seed Morphology, Life Form and Distribution in Three *Bromheadia* Species (Epidendroideae, Orchidaceae). *Diversity* **2023**, *15*, 195. [CrossRef]

9. Zhang, L.; Rammitsu, K.; Kinoshita, A.; Tokuhara, K.; Yukawa, T.; Ogura-Tsujita, Y. Symbiotic Culture of Three Closely Related *Dendrobium* Species Reveals a Growth Bottleneck and Differences in Mycorrhizal Specificity at Early Developmental Stages. *Diversity* **2022**, *14*, 1119. [CrossRef]