Diversity, Distribution and Ornamental Potential of Rwanda's Volcanoes National Park Orchids

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Abstract: Rwanda harbors a great diversity of wild orchids. This work provides an update to the diversity, distribution and ornamental potential of the Volcanoes National Park orchids. A total of 50 orchids species grouped in 23 genera have been identified. In the park, orchids appeared to occur mostly in the area extending from Mount Bisoke to Gahinga. The park proved to be home to a number of orchid species of floriculture merit with their brilliant and delicate blooms such as *Satyrium crassicaule, Cynorkis kassneriana, Satyrium sacculatum* and *Habenaria praestans*. Unfortunately, the orchid diversity of the park has been subject to a number of human-originated threats. Through this study, the issue of an integrated effort of preservation which in part can be done by domestication and ex-situ conservation through ornamental horticulture was discussed.
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1. Introduction

Orchids have fascinated mankind for thousands of years and they are famous not only for the beauty and the odd forms of their flowers but also for the kind of "behavior" they show that is not known for any other plant family (Njopilai & Mapunda, 2007). There are many beliefs relating to power of orchids in Africa, where they are used in love, death and fertility charms. For example, in Eastern and Southern Africa, orchids species like *Cyrtorchis arcuata* and *Eulophia cucullata*, were employed to promote friendship. In general, orchids are rare in African and Rwandan gardens and few of them are cultivated as cut flowers (Kurzweil, 2006). No orchid-associated belief has so far been reported in Rwanda. However, the country harbors a great diversity of wild orchids. This work provides an update to the diversity and distribution of orchids of the Volcanoes National Park (VNP) and discusses their ornamental potential as well as their ex situ conservation. To our best knowledge this is the first attempt to address the issue of VNP orchid domestication as a step forward to ornamental plant resource diversification and as a means of conservation.

2. Methods

Study Area: The survey was conducted in the Volcanoes National Park, located in the Northern Province of Rwanda, between 1021' and 1035' South latitude and 29022' and 29044' East longitude, on the joint border with Uganda and DR Congo.

The climate is cool and wet and the rainfall can reaches the average of 2000mm at 3300m of altitude. The temperature varies according to land topography with an annual average temperature of 19^0C in the capital city Kigali. The park contains five Pleistocene volcanic peaks whose altitude ranges from 3500 to 4500 m and which form part of the watershed between the Nile and Congo River systems.

The vegetation varies considerably with altitude; at lower elevations (2,400-2,500 m) there is a montane forest with *Neoboutonia macrocalyx* as the dominant tree species, above which there is a zone of bamboo (*Yushania alpina*) between 2,500 and 3,200 m, replaced on more humid slopes in the west and south by the *Hagenia-Hypericum* forest. Subalpine vegetation with lobelias, evergreen bushland and thicket occurs between 3,500-4,000 m, while above 4,000 m there is an Afro-alpine vegetation of heath and thicket grassland.

According to Delepierre et al. (2006), and in line with Owiunji et al. (2004, the park is home to more than 30 orchid species, both epiphytic and terrestrial. However, the situation keeps changing due to the discovery of new species and the number of orchid species found in the area is far from being totally known. For example: *Epipogium roseum* and *Satyrium sceptrum* were found in 2007 at the foothills of Gahinga and Muhabura volcanoes, respectively (Luksenberg et al., 2007). A year later, *Polystachya pamelae* was described after it was

discovered on the hillsides of Mount Sabyinyo (Fischer & Killmann, 2008).

Data Acquisition: The analyzed data were collected between October 2006 and August 2008. The sampling was conducted by applying the semi-stratified method during which records were taken inside 5m-radius plots established at every 250m of interval and along trails of 5 m band width, whose choice was also guided by the accessibility of the field. For each species met, phenology was marked; season of observation noted and the GPS coordinates taken (Berghen, 1982; Zonneveld, 1989; Thompson et al., 2003). Given the fact that the field data collection was to some extent limited in scope and time, general conclusions based on the quantitative sampling were made with caution and needed to be backed by additional information borrowed from previously published works. We then delved into the available literature, mainly Toupin (1985), but also, Delepierre & Lebel (2001), Owiunji et al. (2004) and Ntabugi (2008), to enlarge our dataset.

Data Processing and Analysis: The altitude and plant height figures were obtained by computing the average value between the lower and upper limits of the species altitude and plant height range, respectively. As a measure of α-diversity, the Shannon-Wiener index of evenness (E) was calculated by $E = H'/H'_{max}$. $H' = -\Sigma (p_i \log p_i)$, where pi is the proportion of occurrence of the i^{th} species (n_i) of i^{th} genus (N_i), expressed as a proportion of total species occurrence (N) (Kent & Cocker, 1992 in Wezel, 2003). $H'_{max} = \log S$, with S standing for the number of genera, which can also be referred to as the "generic richness". The β-diversity was assessed in terms of species replacement along the altitudinal gradient. Seven elevation classes, at a regular class interval of 500 m, were defined between 500 to 3500 m of altitude; with no overlap in species identity between classes (Magurran, 2004). For the sake of simplicity of information, only the dominant color of petals was considered for each species. For a given species, the reciprocal value of the total number of corolla color alleles was assigned to each allele. For a given color, the total count value was then deduced by summing up counts for that allele in all species.

3. Results

Species Richness: A total of 50 orchids species grouped in 23 genera have been identified, among which only 25 species and 13 genera were encountered during field explorations: *Angraecum infundibulare, Cynorkis anacamptoides, Cynorkis kassneriana, Disa stairsii, Disperis dicerochila, Disperis reichenbachiana, Epipactis africa, Habenaria coeloglossoides, Habenaria peristyloides, Habenaria petitiana, Habenaria praestans, Habenaria tenuispica var. eggelingli, Habenaria welwitschii, Liparis bowkeri, Polystachya cultriformis, Polystachya kermesina, Polystachya leonardiana, Polystachya macropoda* and *Satyrium crassicaule*. The list also includes 5 newly referenced species: *Epipogium roseum, Polystachya pamelae, Satyrium sacculatum, Satyrium sceptrum* and *Stolzia williamsonii*. One of the recorded species, *Eulophia streptopetala*, appears on the list of plant species protected by law (Primature, 2008).

A set of 10 other species comprises elements expectable in the park but which were not recorded during the study period. They include: *Disa eminii, Disperis anthoceros, Disperis kilimandjarica, Eulophia angolensis, Polystachya albescens, Polystachya dewanckeliana, Polystachya lawalreana, Polystachya woosnamii, Satyrium ecalcaratum and Stolzia cupuligera*. However, there still seems to be a great chance for them to be found in the area. Since they are referred to in the "Flora of Rwanda" as being part of the Northern and VNP flora, their occurrence in the park is likely to be confirmed through further explorations.

The park is also believed to accommodate a number of other species which were unfortunately neither encountered during the survey nor did give us such enough evidence as to their probable occurrence in the park. Four of them (*Calanthes sylvatica, Chamaengis sarcophyhlla, Cyrtorchis arcuata, Eulophia horsfallii*), are described in the "Flora of Rwanda" as part of the South West flora region while the occurrence of 11 others (*Cheirostylis lepida, Habenaria macrandra, Jumellea filicornoides, Malaxis prorepens, Manniella gustavi, Nervilia adolphi, Nervilia subintegra, Oeceoclades lubbersianna, Oeceoclades maculata, Platylepis glandulosa* and *Zeuxine elongata*) has been so far confirmed only in neighboring countries. However, given the fact that their presence in the VNP has been suggested by a number of authors, including Minitere, (2003) and Owiunji et al. (2004), further investigation is also recommendable.

Geographic Distribution: The majority of species were found in the area that extends from Mount Bisoke to Gahinga through Sabyinyo area. Recorded species include types common to the Intertropical East African Region and belonging to genera characteristic of African orchid flora such as *Habenaria, Satyrium* and *Eulophia*. Interestingly, no epiphytic species has been recorded on Muhabura volcano. All recorded *Polystachyas* are epiphytic and most of them are confined to the Albertine Rift,

including at least two species endemic to Rwanda: *Polystachya pamelae* and *Polystachya leonardiana*. In the park, the genus mainly occurs in the western part, more watered, while *Disa stairsii* and *Cynorkis anacamptoides* are among species with a larger habitat range. The richness first increases gradually with altitude up to 2500 m then decreases sharply, with around 68 % of the total number of species lying between 2250 and 3250 m, an altitudinal range that comprises the *Hagenia-Hypercum* vegetation zone, making it, along with the montane grassland and scrub, the richest band. One representative of the majestic and Africa-confined Angraecum genus, that is, *Angraecum infundibulare*, was recorded. Two species of the Old World: *Eulophia anglolensis* and *Eulophia streptopetala* were identified while three genera common to both the Old and New World were observed: *Habenaria*, *Epipactis* and *Liparis*.

Plant Average Height: Average plant height ranges between 3 and 350 cm. The distribution of size frequency for species was characteristic. There were fewer species as plant average height increased. For that reason, the curve appears in a 'J' shape rotated by 180^0 Left-Right and out of plane.

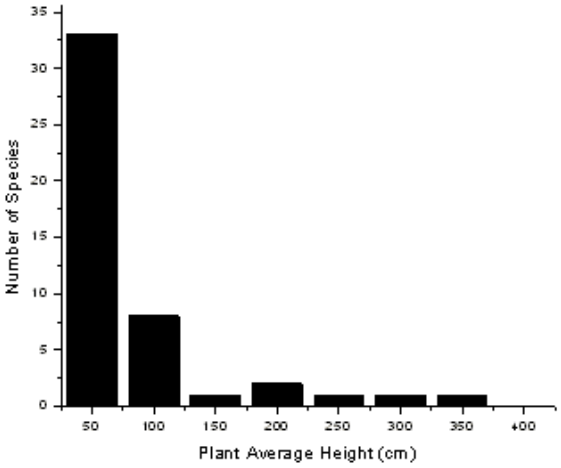

Figure 1. Plant Height Range Frequency (*species are distributed into classes according to discrete plant height values of a 50cm range each*).

Around 87% of the 47 species, for which data was available, grow to less than 100 cm high. It led us to suggesting that r-selection might have prevailed in the orchid speciation process that followed the volcanic activity that resulted in the formation of the virunga massive. Furthermore, according to the general diversity–stability theory, an ecosystem's ability to buffer perturbations depends on the ability of the species in the community to respond differentially to perturbations. Thus, increasing diversity of forms might have been a response of the VNP orchid population to ensure that such variability exists, despite the fact that the number of species is relatively low. The greater the variance of species' responses in a community, the lower the species richness required to buffer an ecosystem (McCann, 2000). Interestingly, no correlation was found between plant height and altitude ($r=0.0198$, $p>0.05$).

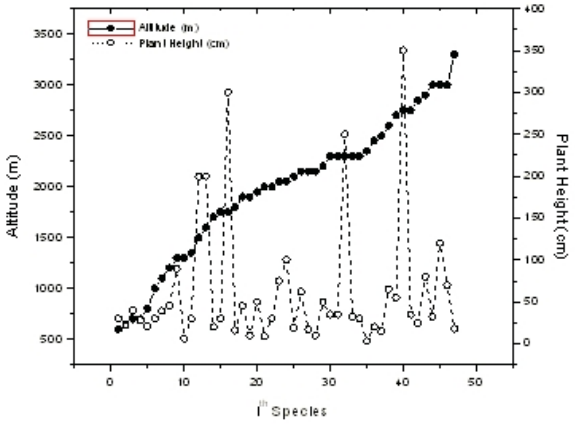

Figure 2. Altitude-Plant Height (*a single chart was used to visualize an eventual correlation between distributions of values altitude and plant height. On the horizontal axis are aligned i^{th} species in an increasing order of their respective values for altitude*).

In the absence of this kind of relationship, the idea of a possible dwarfism due to geographical determinism among VNP orchid species along the altitudinal gradient was unlikely. One of the possible reasons to that is the diversity of habitats within the park which tends to absorb the effect of altitude on distribution patterns of body size.

α and β Diversity: The floristic composition showed the prevalence of two genera: the epiphytic *Polystachyas*, distributed mainly in the western and most watered part of the park and *Habenarias*, which are terrestrial and have the highest occurrence in the eastern part of the VNP. They are followed by *Satyriums*, one of the Africa characteristic orchid genera and whose range extends from the Zambezi Floral Region to the Indian Peninsula, through the Horn of Africa. The calculated Shannon-Weaver index of evenness equals to 0.86, close enough to 1, which illustrates that VNP orchid species tend to be regularly distributed in the respective genera ; no single genus significantly dominates the trend. In line with Magurran (2004) on changes of β-diversity with elevation in Siskiyou mountains of Oregon and

California, findings of this work suggest that the number of VNP orchid species at a given elevation range increases gradually with altitude up to 2500 m before decreasing a bit sharply.

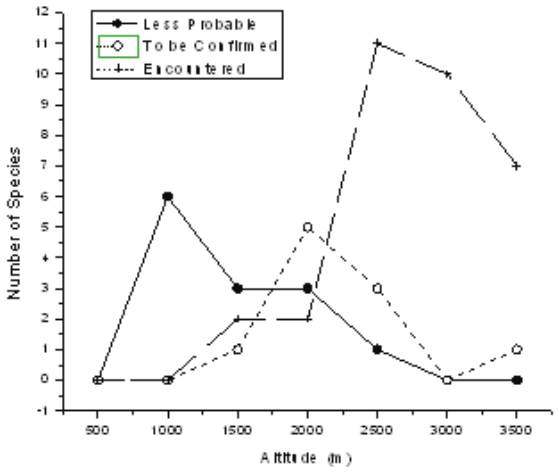

Figure 3. Altitude Range Frequency (*species are distributed into classes of altitude of a 500m range each*).

Furthermore, a statistical analysis showed that the distribution curve of encountered species along this altitudinal gradient significantly draws from a Gaussian distribution (N=0.85, p>0.05).

Flower Dominant Color: There are more species with single flower color allele (52%) than those with different possibilities of flower pigmentation (48%) among recorded species. Despite the human high preference of short-wavelength colors, the most liked being the saturated Blue (Schloss, 2010), it appears that, for flower pigmentation among VNP orchids, longer wavelengths, 495-750 nm, were privileged during the speciation process. Nearly 65 % of VNP orchid colors are within the band extending from Red to Green through Orange and Yellow. The remaining species get their corolla pigmentation in the Violet portion of the visible light, 380–450 nm, with two major colors: Pink and Purple. No blue flower was encountered. The least frequent color is Orange while Yellow was the most observed pigment (28.8% of the total point counts), contrary to the suggested idea that African orchids are mostly white (www.theflowerexpert.com, 10.08.2010). Orange occurs only as an alternative to Yellow or Red color for *Polystachya macropoda* and *Polystachya kermesina*, respectively. In accord with Kurzweil (2006), like elsewhere in Africa, the VNP orchids are not popular in cultivation. However, a number of them have beautiful flowers with their brilliant and delicate blooms and deserve special attention from horticulturists: *Satyrium crassicaule* (Pink), *Cynorkis kassneriana* (Pink), *Satyrium sacculatum* (Red) and *Habenaria praestans* (White).

Ex Situ Conservation: The literature mentions a greater number of species than what was recorded in this study. In particular, it includes around 15 low altitude orchid species, with a frequency peak at around 1000 m; which, to our best knowledge, despite their confirmed presence in neighboring countries, are likely to have disappeared due to forest cutting and clearing that took place decades ago and are thus less probable to be found in the park nowadays. Even in the years to come, despite tremendous effort of in-situ conservation, part of the VNP orchid diversity may succumb to human disturbance. Therefore, there is a need of an integrated effort of preservation which in part can be done by domestication and ex situ conservation through ornamental horticulture. In that regard, there has to be developed a plant germplasm suited to the growth conditions of the concerned species and ornamental horticulture should assume a new dimension in Rwanda, that of a tool of biodiversity conservation. The genotypes could then be maintained as living plants, either in the field, in pots within a nursery or by the establishment of seed seedbanks to maintain representative samples of wild species of floriculture merit. We note that, as we write this paper, only few of the orchid species recorded in this study can be said to have already been successfully introduced into cultivation, the oldest case of a successful domestication being that of *Eulophia streptopetala*. Efforts aimed at introducing *Disa stairsii* into cultivation failed, at least until late 1980s, as plants faded just after the first bloom (Troupin, 1985).

4. Conclusion

The aim of this work was, among others, to discuss the ornamental potential of the VNP orchids. 25 species, grouped in 13 genera, were encountered during field explorations. Only 35 % of the VNP orchid flower colors are within the Violet portion of the visible light, 380–450 nm, with two major colors: Pink and Purple. No blue or cyan flower was encountered. The least frequent color was Orange while Yellow was the most observed pigment. The park proved to be home to a number of orchid species of floriculture merit, which deserve special attention from horticulturists: *Satyrium crassicaule* (Pink), *Cynorkis kassneriana* (Pink), *Satyrium sacculatum* (Red) and *Habenaria praestans* (White).

Unfortunately, the orchid diversity of the park has been subject to various threats and, despite a significant effort of in-situ conservation, the pace is not likely to reverse in the near future. Through this study, the issue of an integrated effort of preservation which in part can be done by domestication and ex situ conservation through ornamental horticulture was echoed.

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References

1. Berghen CV. Initiation à l'étude de la végétation. Jardin National Botanique de Belgique. 3ème édition, Meise, Belgique, 1982 :263.
2. Delepierre G., Lebel JP. La Liste des Orchidees du Rwanda. Taxonomania 2001 :5 10 :5-9.
3. Delepierre G., Lebel, JP. Les orchidées du Rwanda. 2006.
4. Fischer E., Killmann D. *Polystachya pamelae*, a new species from the Volcanoes National Park, Rwanda. Die Orchidee 2008:59 (1):53-57.
5. Kent M., Cocker P. Vegetation description and analysis: a practical approach. Belhaven Press, London, 1992:363.
6. Kurzweil H. Orchids of Southern and Central Africa. Singapore Gardenwise, Botanical gardens Newsletter 2006:27: 6-9.
7. Luksenberg B., Nsanzurwimo A. 4 nouvelles espèces référencées pour le Rwanda découvertes au sein du Parc National des Volcans. Taxonomania 2007 : 21 :19.
8. Magurran AE. Measuring Biological Diversity. Blackwell Science Ltd, Malden, USA, 2004:256-11.
9. Mccann KS. The Diversity-Stability Debate. Nature 2000:405: 228-233.
10. Minitere. National Strategy and Action Plan for the Conservation of Biodiversity in Rwanda. Ministry of Lands Resettlement and Environment. Administrative Report. Kigali, Rwanda, 2003:80.
11. Njopilai L., Mapunda D. Edible Orchids in Makete district, the Southern Highlands of Tanzania: distribution, population and status. CBM Master Theses. Sweddish Biodiversity Center, Uppsala Universitet, 2007:39:68.
12. Ntabugi, A. (2008). Contribution à l' Etude Phyotogéographique des Orchidées du Parc National des Volcans. Mémoire, Butare, 2008 :30-10.
13. Owiunji I., Nkuutu D., Kujirakwinja D., Plumptre A., Nsanzurwimo A., Fawcett K., Gray M., Mcneilage A. (2004). The biodiversity of the virunga volcanoes. WCS, DFGFI, ICCN, ORTPN, UWA, IGCP. Kigali, Rwanda. 2004: 97.
14. Primature. List of protected animal and plant species in Rwanda. Official Gazette of the Republic of Rwanda, 2008: 22 :91-95.
15. Schloss K.B. An Ecological Valence Theory of Human Color Preferences. Department of Psychology, University of California, Berkeley, USA. 2010.
16. Thompson K., Austin KC. Smith RM., Warren PH., Angold PG., Gaston KJ. Urban domestic gardens (I): Putting small-scale plant diversity in context. Journal of Vegetation Science 2003:14: 71-78.
17. Troupin G. Flore du Rwanda, Spermatophytes, Volume IV. Musée Royal de l'Afrique Centrale. Tervuren, Belgique, 1985 :651.
18. Wezel A. Plant species diversity of homegardens in humid and semiarid Cuba and its importance for self-sufficiency of households. Conference on International Agricultural Research for Development, 2003:12.
19. Zonneveld IS. The land unit - A fundamental concept in landscape ecology, and its Applications. Landscape Ecology 1989:3(2): 67-86.

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