

## SPATIAL STRUCTURE OF *PLEUROTHALLIS*, *MASDEVALLIA*, *LEPANTHES* AND *EPIDENDRUM* EPIPHYTIC ORCHIDS IN A FRAGMENT OF MONTANE CLOUD FOREST IN SOUTH ECUADOR

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KEY WORDS: altitudinal range, colonization, phorophyte specificity, phorophyte trunk diameter, seed dispersal, spatial patterns

Orchids are the most diverse family of vascular plants in Ecuador with 228 genera and nearly 4000 species. More than 60% of these species are epiphytes, being *Pleurothallis* R.Br., *Epidendrum* L., *Lepanthes* Sw. and *Masdevallia* Ruiz & Pav., with 472, 358, 314 and 226 species respectively, some of the genera with greater number of epiphytic orchids (Dodson 1994-2003).

Although Ecuador is among those countries with the highest orchid biodiversity in the world, it also has one of the highest rates of deforestation: 1.2% of the country's forests are lost each year (FAO 2005). Extensive deforestation practices currently taking place pose a major threat for the survival of these orchids as they are greatly dependent on the environmental conditions of the forests that sustain them, and the host trees (phorophytes) on which they grow. Thus, understanding of orchid-phorophyte interactions, as well as the patterns of spatial distribution and colonization in secondary succession forests regenerated after deforestation, is essential for the *in situ* conservation. Nevertheless, few studies have been conducted in this field, and scientific basis supporting population reinforcement or reintroduction actions is scarce.

The purpose of this study is to assess the spatial distribution of epiphytic orchids of the above-mentioned genera in an Ecuadorian fragment of secondary montane cloud forest to infer patterns of seed dispersal and colonization. In addition, the effects of phorophyte identity and size on orchid establishment are analyzed. Specifically the questions posed are: Do the distributions of *Pleurothallis*, *Epidendrum*, *Lepanthes*, and *Masdevallia* plants vary in the altitudinal range of the fragment studied? Are there specific patterns in their spatial distribution resulting from seed dispersal characteristics? Do plants of these orchids exhibit any preference over the trees where they grow? Does phorophyte trunk diameter affect the establishment of these orchids? The results presented, although preliminary, provide useful information for orchid management plans.

The study was carried out in a fragment of regenerated forest located on the Loja-Zamora Chinchipe road, on the border of Podocarpus National Park (southern Ecuador). The age of the forest is about 30 years old, and it is characterized by a steep slope (51%), with trees 5-8 m high and lianas that are over 10 m long. Mean annual precipitation is 2700 mm, and annual mean temperature is 15.5 °C (14.4 - 17.5 °C).

A total of nine 10 x 10 m plots were established at 2200, 2230 and 2250 m a.s.l. (three plots in each altitude). All trees (including fern trees), shrubs and lianas of diameter at breast height (DBH) over 1 cm were determined at the genus level, measured and mapped. The census included 1025 vascular plants belonging to more than 70 different genera. *Miconia* Ruiz & Pav. (148 trees), *Nectandra* Rol. ex Rottb. (65 trees), *Clusia* L. (59 trees), *Elaeagia* Wedd. (59 trees) and *Psammisia* Klotzsch (56) were the most frequent genera.

Presence and abundance of all orchids occurring in the first 3 m height were also recorded. In this zone, which corresponds to zone 1 of Johansson's scheme, the microclimatic conditions are relatively constant (Johansson 1974). In total 2798 orchids belonging to 12 genera were identified. Although it is difficult to make comparisons between different researches

TABLE 1. Distribution of *Epidendrum*, *Pleurothallis*, *Lepanthes* or *Masdevallia* orchids on their respective host trees in a secondary montane cloud forest in South Ecuador. For each orchid genus, frequency of host trees (first column) and frequency of orchid individuals on the different host tree genera (second column) are shown.

Host genus	<i>Epidendrum</i>		<i>Pleurothallis</i>		<i>Lepanthes</i>		<i>Masdevallia</i>	
	n° of trees	n° of orchids	n° of trees	n° of orchids	n° of trees	n° of orchids	n° of trees	n° of orchids
<i>Abuta</i> Aubl.	1	3	-	-	-	-	-	-
<i>Alchornea</i> Sw.	-	-	1	18	-	-	-	-
<i>Alzatea</i> Ruiz & Pav.	-	-	1	1	-	-	-	-
<i>Aniba</i> Aubl.	-	-	1	2	-	-	-	-
<i>Anthurium</i> Schott	1	7	-	-	-	-	-	-
<i>Ardisia</i> Gaertn.	2	10	1	5	-	-	-	-
<i>Axinaea</i> Ruiz & Pav.	-	-	2	2	-	-	1	2
<i>Calyptanthes</i> Sw.	1	1	3	16	-	-	-	-
<i>Cinchona</i> L.	1	7	-	-	-	-	-	-
<i>Clethra</i> L.	-	-	1	1	-	-	-	-
<i>Clusia</i> L.	8	28	2	2	3	4	1	2
<i>Cyathea</i> Sm.	2	2	1	21	-	-	-	-
<i>Endlichera</i> C. Presl	1	18	-	-	-	-	-	-
<i>Elaeagia</i> Wedd.	4	12	5	10	5	6	3	8
<i>Eugenia</i> L.	-	-	-	-	3	5	1	1
<i>Faramea</i> Aubl.	1	3	-	-	-	-	-	-
<i>Ficus</i> L.	-	-	-	-	2	2	-	-
<i>Graffenrieda</i> DC.	2	2	2	2	2	8	-	-
<i>Guarea</i> F. Allam. ex L.	-	-	1	1	-	-	-	-
<i>Hedyosmum</i> Sw.	1	36	-	-	-	-	-	-
<i>Helicostylis</i> Trécul	2	14	6	28	3	8	2	3
<i>Hydrangea</i> L.	1	3	-	-	-	-	-	-
<i>Hyeronima</i> Allem.	2	6	1	1	1	1	-	-
<i>Mabea</i> Aubl.	1	5	-	-	-	-	-	-
<i>Markea</i> Rich.	-	-	1	2	-	-	-	-
<i>Maytenus</i> Molina	-	-	1	1	-	-	1	2
<i>Miconia</i> Ruiz & Pav.	3	8	7	7	12	25	3	4
<i>Mikania</i> Willd.	1	2	-	-	1	5	-	-
<i>Myrsine</i> L.	2	16	1	6	3	8	2	3
<i>Nectandra</i> Rol. ex Rottb.	1	5	3	7	3	8	3	4
<i>Ocotea</i> Aubl.	-	-	1	1	-	-	1	1
<i>Palicourea</i> Aubl.	2	19	2	2	-	-	2	8
<i>Persea</i> Mill.	-	-	1	1	-	-	-	-
<i>Piper</i> L.	1	2	-	-	1	3	-	-
<i>Psammisia</i> Klotzsch	2	4	5	22	3	4	6	7
<i>Psychotria</i> L.	2	3	-	-	3	4	-	-
<i>Ruagea</i> H. Karst.	-	-	1	1	-	-	-	-
<i>Turpinia</i> Vent.	-	-	1	1	-	-	-	-
Fallen tree	3	6	3	13	4	8	1	4
Unidentified liana	1	4	2	5	2	5	-	-
Unidentified tree	1	13	-	-	-	-	2	3
<b>Total</b>	<b>50</b>	<b>239</b>	<b>57</b>	<b>179</b>	<b>51</b>	<b>104</b>	<b>29</b>	<b>52</b>

(mainly because the degree of forest disturbance varies), the high number of orchids that we found on the base of the tree trunks contrasts with other studies, which have reported no orchids or low abundance on this zone (Mehlreter *et al.* 2005). One explanation for our results could be that the lower canopy density of young trees, especially in early succession stages, allows a greater passage of light to the lower areas, providing better conditions for the establishment of orchids. According to this hypothesis, light intensity may affect tree colonization by orchids. In any case, the lower section of the tree trunks seems to have a great relevance for orchids in this regenerating forest.

The most abundant orchid genus was *Stelis* Sw. (73.8%), followed by *Epidendrum* (8.5%), *Pleurothallis* (6.4%), *Lepanthes* (3.7%), *Hexisea* Lindl. (2.5%) and *Masdevallia* (1.9%). Orchids were not uniformly distributed in the altitudinal range studied. *Epidendrum* and *Lepanthes* were more frequent and abundant in lower zone of the fragment. Near 60% of the *Epidendrum* and *Lepanthes* plants were observed at 2200 m. On the other hand, the presence of *Pleurothallis* and *Masdevallia* was similar in all the altitudinal range, although their abundance was greater in the higher zone. Thus, the 66.5% of *Pleurothallis* plants and the 48.1% of *Masdevallia* plants were found at 2250 m. Altitude-related microclimatic factors may be partially responsible for this occurrence pattern, although other environmental factors independent of altitude may also play a role.

Epiphytic orchids were found on 325 of the 1025 recorded trees, shrubs and lianas. The most frequent trees in the fragment were also the ones that had the greatest richness and number of orchids. Of the four genera studied, *Pleurothallis* occupied the greatest number of trees (57), while *Masdevallia* was present in only 29 (see Table 1). The average number of individuals per phorophyte was small in all of them (ranging from 4.8 in *Epidendrum* to 1.8 in *Masdevallia*), but the variance was large especially in *Epidendrum* ( $\pm 34.8$ ) and *Pleurothallis* ( $\pm 16.3$ ) (Table 2). In order to know how the individuals are distributed among phorophytes, Morisita's index ( $I_M$ ) (Hurlbert 1990) was calculated considering the phorophyte as sampling unit. According to this aggregation index (Table 2), two different patterns were

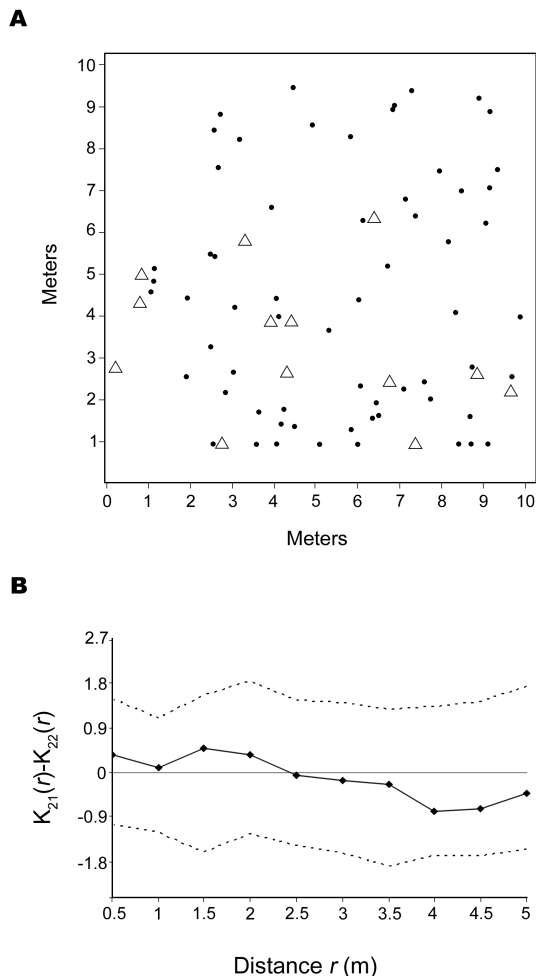


FIGURE 1. **A.** Spatial distribution of trees in plot 1 located at 2250 m. Triangles indicate trees with *Pleurothallis* orchids. **B.** Bivariate point pattern analysis plotting the  $L_{12}$  function across distance. Dotted lines represent the confidence interval of random labelling null hypothesis.

detected: *Epidendrum* and *Pleurothallis* plants tended to be clumped ( $I_M$  values were significantly different from 1), while *Lepanthes* and *Masdevallia* plants were randomly distributed. Differences in seed dispersal process may explain this result. Thus, the aggregated pattern observed in *Epidendrum* and *Pleurothallis* may be due to limited dispersal ability of their seeds. If this were the case, there would be a higher probability of finding a plant of its same genus in a near-by tree than in a more distant tree. To test this hypothesis, a bivariate point pattern analysis was performed in those plots where the number of phoro-

TABLE 2. Average number of individuals per host tree (mean  $\pm$  variance) and Morisita's index ( $I_M$ ) for *Epidendrum*, *Pleurothallis*, *Lepanthes* or *Masdevallia* orchids in a secondary montane cloud forest in South Ecuador. Values in parentheses are minimum and maximum. \*\*\*:  $P < 0.001$ .

Orchid genus	Individuals per host tree	$I_M$
<i>Epidendrum</i>	4.8 $\pm$ 34.8 (1-36)	2.32***
<i>Pleurothallis</i>	3.1 $\pm$ 16.3 (1-21)	2.34***
<i>Lepanthes</i>	2.0 $\pm$ 2.4 (1-7)	1.10
<i>Masdevallia</i>	1.8 $\pm$ 1.3 (1-5)	1.09

phytes was greater than eight (Diggle 1983, Wiegand & Moloney 2004). For *Pleurothallis*, the values of  $K_{21}(r)$ - $K_{22}(r)$  were inside the confidence interval of the null hypothesis of random labelling for the range of distances 0-5 m (Figure 1), which means that presence of these orchids is at random. Similar results were obtained for *Epidendrum*. Thus, since there is no contagious distribution between one phorophyte and nearby trees, seed dispersal in *Epidendrum* and *Pleurothallis* is not limited to short distances. This conclusion is also supported by mean distance between phorophytes (4.0  $\pm$  5.6 m for *Epidendrum* and 4.5  $\pm$  6.8 m for *Pleurothallis*), which is not significantly different than the mean distance between all trees in the plots (4.7  $\pm$  2.5 m), and maximum distance to the nearest neighbour (13.2 m for *Epidendrum* and 6.9 m for *Pleurothallis*). Other reasons, such as differences in life cycle or reproductive biology could explain the presence of these two distribution patterns.

No phorophyte specificity was observed for any of the epiphytic orchids included in the study. *Epidendrum* and *Pleurothallis* grew on more than 20 different genera, and *Lepanthes* and *Masdevallia* on more than 10 (see Table 1). Nevertheless, *Epidendrum* was more frequent on *Clusia*, *Pleurothallis* and *Lepanthes* on *Miconia*, and *Masdevallia* on *Psammisia*. Preference patterns in orchids have also been reported by other authors (Migenis & Ackerman 1993, Díaz-Santos 2000, and Trapnell & Hamrick 2006), although the reasons why

orchids occur on particular species remain unclear.

The possible effect of phorophyte size on orchid establishment was explored calculating the Spearman's correlation coefficient ( $r_S$ ) between DBH and orchid abundance for each of these four genera. No relationship was found in any of them ( $r_S = -0.12$   $P = 0.42$  for *Epidendrum*,  $r_S = 0.15$ ,  $P = 0.27$  for *Pleurothallis*,  $r_S = 0.09$   $P = 0.52$  for *Lepanthes*, and  $r_S = 0.17$   $P = 0.37$  for *Masdevallia*), which means phorophyte trunk diameter does not seem to be a crucial factor for orchid colonization. At present, other phorophyte physical characteristics such as bark stability and roughness, and substrate moisture conditions are being investigated.

In conclusion, this study shows the existence of different patterns of presence and abundance depending on each orchid genus. Anyhow, colonization of new trees does not seem to be constrained by limited seed dispersal. Light conditions may be a more important factor for epiphytic orchid establishment than phorophyte identity and size. The abundance of orchids in the lower section of the tree trunks in this regenerating forest is in clear contrast with previous reports made on primary or non-disturbed forests. This outlines the importance of taking into account the different succession states of the forest in which the orchids occur. Finally, although pattern analysis can be helpful in identifying the causes of present spatial structure, additional experimental studies are needed to determine the underlying processes originating these distributions.

ACKNOWLEDGEMENTS. We thank to Fani Tinitana Imaicela for her help in species identification, and the students Diana Cecilia Guamán and Elizabeth Alexandra Pauta for their field assistance. This work was partially funded by the Universidad Técnica Particular de Loja.

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