Orchid diversity in the deciduous forest of Bahía de Caráquez and evergreen seasonal forest El Cerro, Parish Ricaurte, Manabí, Ecuador

Diversidad de orquídeas en el bosque deciduo de Bahía de Caráquez y el siempreverde estacional El Cerro, Parroquia Ricaurte, Manabí, Ecuador

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Abstract

This study evaluates orchid diversity in two forests of the Ecuadorian coast, a lowland evergreen seasonal forest El Cerro and a deciduous lowland forest at Bahía de Caráquez, both in Manabí Province. Five transects of 50 x 20 mwere established in each forest where all seen orchids were handpicked. Dominance was estimated by Simpson index (λ), diversity by Shannon-Wiener (H') index, expected species by Chao 2 index, and similarity byJaccard coefficients (J). In forestEl Cerro, 423 orchids were collected, representing 21 species and 17 genera. Dominance was low (0.14) and general H' was 2.34. Chao 2 estimator predicted a total richness of 39 species. The J estimator showed that similarity among transects was low (less than 40%). Transects were characterized by unique species. In spite of the dry environment, 16 orchids were found in the forest at Bahia de Caráquez,belonging to 4 species and 4 genera. Dominance was 0.3 and H' was 1.3. Chao 2 predicted a total richness of 5 species.Threespecies were recorded for the first time for the Manabi Province: *Aspasia psittacina*, *E. rhizomaniacum*and*Peristeria elata*; Eightorchid species had some degree of threat and require special management plans for their conservation.

Keywords: Threatened orchids, Orchidaceae, Biodiversity, *Brassia, Peristeria*.

Resumen

Se evalúa la diversidad de orquídeas en dos bosques de la costa ecuatoriana, un bosque siempreverde estacional de tierras bajas El Cerro y un bosque deciduo de tierras bajas en Bahía de Caráquez, en la provincia de Manabí. En cada bosque se establecieron cinco transectos de 50 x 20 m, recogiendo a mano todas las orquídeas fèrtiles. La dominanciase estimó por el índice de Simpson (λ), la diversidadpor el de Shannon-Wiener (H'), el número de especies esperadas por el de Chao 2 y la similaridadpor el coeficiente de Jaccard (J). En el bosque El Cerro, se recolectaron 423 orquídeas, representando 21 especies y 17 géneros. La dominancia fue baja (0.14) y la diversidad general H' fue 2.34.El estimador Chao 2 predijo una riqueza total de 39 species. El estimador J mostró que la similaridad entre los transeptos fue baja (menor a 40%). Los transeptos se caracterizaron por tener especies exclusivas. A pesar del ambiente seco, se recolectaron 16 orquídeas en el bosque de Bahía de Caráquez, pertenecientes a 4 especies y 4 géneros. La dominancia fue 0.3 y H' fue 1.3. El índice Chao 2 predijo una riqueza total de 5 especies.Tres especies fueron reportadas por primera vez para la Provincia de Manabí: *Aspasia psittacina*, *E. rhizomaniacum* y*Peristeria elata*; Ocho especies de orqídeas tuvieron algún grado de amenaza y requieren planes especiales de manejo para su conservación.

Palabras clave: orquídeas amenazadas, Orchidaceae, biodiversidad, *Brassia*, *Peristeria*.

Introduction

The family Orchidaceaeis one of the largest families among Angiosperms, with approximately 25,000-30,000 species worldwide (Mulder and Mulder 1990). Most orchid speciesare distributed in the Neotropics (Dressler 1982). Member of this wide spread group of plants can be herbs, epiphytes or terrestrial plants and they can occupy different habitats (Hodgson and Anderson 1991). Orchid species can adapt to different environments and can be easily grown in green houses.

In spite of its small size (283,561 km^2), Ecuador has a large diversity of habitats and microclimates. The height of the Andean ridge, the influence of warm and cold sea currents,and variable precipitation, lead tothe proliferation of orchids (Dodson and Escobar 1994, Dodson 2001, 2002). Jacquemyn *et al.* (2005) indicate that in tropical systems, one of the major gradients that may exert large differences on plant species composition and diversity is altitude. In this regards, Krömer *et al.* (2007) found a mid-elevation peak (500 – 1200 meters above sea level, m.a.s.l.) for vascular epiphyte diversity in Bolivian mountain forestswithin the range 350 -2200 m.a.s.l. Kuper *et al.* (2004) suggest that the floristic turnover between Neotropical montane epiphyte floras is higher than between lowland epiphyte floras. Montane study sites located only a few kilometers apart from each other often show considerable differences in their epiphyte species inventories.

Endara (2011) indicates that there is currently a record of 4187 orchid species in Ecuador, with a high level of endemism, since 1707 species have only been reported for this country. A total of 3035 orchid species have been collected and preserved in herbariums. Orchids are distributed from 0 to 4500 m.a.s.l., and there is a high diversity at heights between 1000 and 3000 m.a.s.l., with the highest diversity between 1500 and 2500 m.a.s.l. (Dodson 2003). At present, it can be verified that endemic orchid species in the coastal low lands have a restricted distribution, concentrated in the altitude levels 84 to 351 m.a.s.l., where the present study was made. Most endemic species are epiphytes (82%), but 8% of them are terrestrial species and 5% are facultative terrestrial species or epiphytes. However, in the coastal deciduous forests all reported endemic species are epiphytes (Endara 2011).

The forest of El Cerro is considereda lowland evergreen seasonal one while the forest at Bahía de Caráquez is a deciduous low lands forest (Ministerio del Ambiente 2013). Both communitiesare at this time affected by the growth of agriculture and livestock activities, which replace the natural vegetation by plants with commercial interest and pastures. There is need to perform studies on the vegetation of the area, before the forests disappear and no record could be made of the richness of species in these fragile ecosystems.

A considerable number of orchids present in the dry forests of the Ecuadorian coast between 84 and 351 m.a.s.l.,are threatened to disappear due to indiscriminate cutting of the remains of the primary forest and the growth of agricultural frontier.

The present study was made to identify the most abundant species and the threat categories of orchid species in two wild areas. Threats were evaluated according to the parameters of conservation of IUCN (2012) and appendices I to IV of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2015). This will allow for the establishment of priorities for the conservation of endemic species and their geo-referencing in wild forests.

Material and methods

The study was performed on primary forests. Plantswere collected in theforest El Cerro, Parish Ricaurte of Chone Municipality, at a height of 351 m.a.s.l. (UTM 17 M 0523319N 9835351E); and in the forest of Bahía de Caráquez, of Sucre Municipality(UTM 17 M 0607652N 9930402E), at 84 m.a.s.l.,both in the Province of Manabi, Ecuador.

Ministerio del Ambiente (2013) describes the characteristics of the lowland evergreen seasonal forest El Cerro as stratified with an average canopy between 20 and 25 m, with emerging individuals up to 40 m in height. Although leaves are maintained during the entire year, some of them fall during the dry season (May to December). Annual precipitation is close to 880 mm and average temperature is around 24 °C. This forest develops on hilly terrains below 400 m.a.s.l. Some characteristic tree families of this forest are Moraceae, Lecythidaceae, Fabaceae, Malvaceae and Polygonaceae. The deciduous low land forest has expanded canopies between 10 and 25 m, with close to semi-open undercanopy and scarce herbal stratum. The tree leaves regularly fall during the dry season (also May to December). Annual precipitation is around 700 mm and average temperature is close to 26 °C. This forest develops on old alluvial flat lands, soft hilly terrains or mountain bases from 0 - 400 m.a.s.l. Some characteristic tree families of this forest are Malvaceae, Achatocarpaceae, Fabaceae, Sterculiaceae, Cactacea and Euphorbiaceae.

Samples were collected by a teamof five observers during the rainy season on March 2015.In both forests, five 50 x 20 m transects (0.1 ha each with a total 0.5 ha) were established according to methods used by Gentry and Dodson (1987) to determine the diversity of epiphytic plants. Transects were established with consideration of the microhabitat variation in each forest, in order to make a quantitative comparison between habitats. To reduce the "botanist effect", described by Kindlmann and Vergara Cassas (2011) pertaining to the sampling effort, the same number of transects were established in both study sites and sampled with the same intensity.

In the forest El Cerro, transects were separated by a distance of 200 m from each other. Transect R1 was located at the base of a hill; R2 was located on the slope of the hill; R3 was on the top of the hill with some dead standing trees; R4 was located on the slope of a hill and had a portion of flat land with clearings in the forest and many dead trunks, either standing or fallen, due to storms; R5 was on a slope. Transects R1, R2 and R3 had mostly young trees with smaller amount of mosses on the branches. This contrasted with transects R4 and R5 which had older and taller trees, with abundant mosses and Bromeliaceae on the branches. Transect R4 had numerous clearings associated to fallen or dead trees.

In Bahía de Caráquez, forest density was similar in all transects; transect B1was located on top of a hill and 2 km apart from the other transects; B2 and B3 were at the base of a hill while B5 y B5 were on top of a hill.In order to verify the absence of orchids in transects B3, B4 and B5, a resampling was performed in September 2015, with similar result.

Orchidswere identified using binoculars while walking along the transects, and were collected with a 6 m long pruner. Plants without flowers were cultivated in a green house near El Cerro forest, at a height of 300 m.a.s.l.and average temperatureof 32°C, until flowers emerged toallowfor taxonomic identification.

The flowers were collected and preserved in ethyl alcohol with 10% glycerin. Identification of species was made by comparison to samples fromHerbario Nacional del Ecuador (Quito Ciencias Naturales Ecuador - QCNE), the Tropicos data base of the Missouri Botanical Garden and by consulting Dodson (1999), Dodson and Escobar (1994) and Endara (2011). Botanists of the University of Florida in the USA specializing in orchids verified species identification.Collected samples were deposited into the Herbarium QCA of the Pontifical Catholic University of Ecuador. Information of each identified species will be part of the "Catalogue of Orchids from the forest El Cerro, Ricaurte Parish, Manabi, Ecuador" (Author, in preparation).

The categories of threat of the orchid species were:not evaluated (NE), not applicable (i.e. not threatened; NA), data deficient (DD), least concern (LC), near threatened (NT), vulnerable (VU), endangered (EN), critically endangered (CE), regionally extinct (RW), extinct in the wild (EW) and extinct (E) (Endara 2011; IUCN 2012).

Data analysis

Alfa diversity in each location was calculated using Simpson diversity index (λ, Simpson 1949), since the primary interest of the study was to measure the relative dominance of some species in thestudy sites (Ludwig, 1988).

$\lambda = \Sigma p_i^2$ (1)

where p_i (= n_i / **N**) is the relative abundance of species *I*; niis the number of individuals of species *i*and **N** is the total number of species in the sample.

The Shannon-Wiener diversity index (H') (Shannon y Weaver, 1948) was estimated in both study sites:

$$H' = -\sum_{i=1}^{N} pi ln(pi) \quad (2)$$

where N is the number of species in each sample and p_i is the relative abundance of species *i* in the sample, as in (1).

The values of λ and H' among the different transects were compared estimating their variance, degrees of freedom and the Student t-tests using the procedure described in Simpson (1949) and Moreno (2001). A significance level (α) of 0.05 was maintained using the Bonferroni correction (Bonferroni 1936), to counteract the reduction in *α* due to multiple comparisons. In the case where *m* comparisons were to be made, the new α level (α') was α / *m.*

To complement the Shannon-Wiener index, Pielou (1975) evenness (J') was estimated as:

$J' = H' / H_{max}$ (3)

where H_{max}= ln(N) is the maximum possible diversity in a community of N species. J' varies between 0 and 1, with the latter corresponding to a community in which all species are equally represented.

The non-parametric index Chao 2 (Chao 1987) was used to estimate the number of expected species in a community using occurrence data from multiple samples in aggregate to estimate the species diversity of the whole study site:

$Chao\ 2 = S + L^2 / 2M$ (4)

where S as in (2), L is the number of species present in a single sample and M is the number of species present in two samples.
Beta diversity was used to compare the richness among communities and was estimated through Jaccard similarity coefficient (Jaccard 1901) and calculated as follows:

$Ij = C / (A + B – C)$ (5)

where A and B are the number of species in each community and C is the number of shared species between them; Ij varies between 0 and 1.

Results

Diversity at forest El Cerro

A total of 423 orchids were collected in this location, suggesting that average (± SD) orchid density was 846 ± 492 plants/ha. They were grouped into 21 species representing 17 genera (Table 1). The most frequent and abundant species in this sample were *Epidendrum rhizomaniacum* Rchb. f. (29.8%)*,Oncidium* sp 5 (10.1%), *Cyrtochiloides riopalenquianum* Dodson (9.9%), *Epidendrum anceps* Jacq. 1763 (9.9%)*, Pescatoria wallisii* Linden & Rchb. f. (9.9%) and *Brassia jipijapensis* Dodson & Williams (8.3%).

Table 1. Abundance of orchid species recorded in 50 x 20 m transects in the forest El Cerro, Manabí, Ecuador.

Genus or species	Transect R1	R2	R3	R4	R5	Frequency in general plot	Relative frequency
Epidendrum rhizomaniacum	0	9	66	0	51	126	0.298
Oncidium sp 5.	0	0	0	0	43	43	0.102
Cyrtochiloides riopalenqueanum	0	0	0	41	1	42	0.099
Epidendrum anceps	42	0	0	0	0	42	0.099
Pescatoria wallisii	0	0	0	0	42	42	0.099
Brassia jipijapensis	14	10	10	0	1	35	0.083
Gongora grossa	11	0	7	0	0	18	0.043
Polystachya concreta	0	5	12	0	1	18	0.043
Psygmorchis pusilla	5	2	3	0	0	10	0.024
Dimerandra rinbachii	0	0	0	0	9	9	0.021
Stanhopea aff. anulata	0	4	0	0	4	8	0.019
Psygmorchis sp.	6	0	0	0	0	6	0.014
Oncidium sp. 1	5	0	0	0	0	5	0.012
Maxillaria sp 1.	0	0	4	0	0	4	0.010
Peristeria elata	0	0	0	2	2	4	0.010
Xylobium sp.	0	4	0	0	0	4	0.010
Epidendrum macroöphorum	1	0	0	0	2	3	0.007
Catassetum expansum	0	1	0	0	0	1	0.002
Notylia sp.	0	0	1	0	0	1	0.002
Stelis sp.	0	0	0	0	1	1	0.002
Trigonidium riopalenquense	0	0	0	1	0	1	0.002
TOTAL ABUNDANCE	84	35	103	44	157	423	1

There was little variation in the number of orchid species in each transect atthis location (range 7 – 11) (Table 2). However, a high proportion of species (29 to 46%) was unique to each transect. Density of orchids does not seem to be associated to the geographical position of the transect, since the lowest and largest density were found in the transects on slopes.

Table 2. Number of unique and shared orchid species found in each transect in the forest of El Cerro, Ricaurte Parish, Manabí, Ecuador

	Transects				
Species	R1	R2	R3	R4	R5
Unique	3	2	2	1	4
Shared	4	5	5	2	7
New	7	5	2	3	4
Total	7	7	7	3	11
Cumulative new species	7	12	14	17	21

Simpson dominance index was lowest (0.198)in transect R2 with 7 species identified while the largest dominance (0.871) was observed in transect R4 with the smallest richness (3 species) (Table 3).The dominance in transects R1, R2, R3 and R5 was significantly different than that of R4 ($p<0.05$), but the Student t-test could not separate clearly the dominance among the former transects. The dominance of the entire plot was 0.141.

Table 3. Diversity indices and number if expected species of orchids in the forest El Cerro, Ricaurte Parish, Manabí, Ecuador. Values with similar letter are non-significant ($p<0.05$).

Index	**Total site**	**Transect**				
		R1	**R2**	**R3**	**R4**	**R5**
Richness	21	7	7	7	3	11
Simpson dominance (λ)	0.141	0.307^{a}	0.198^{ab}	0.441^{ac}	0.871^{d}	0.256^{a}
Shannon-Wiener_(H’)	2.339	1.489^{a}	1.746^{a}	1.219^{a}	0.292^{b}	1.57^{a}
Evenness (J’)	0.768	0.765	0.897	0.626	0.266	0.655
Chao-2 (Number expected species)	39					

The Shannon-Weaner H' index increased with the number of species, from 0.29 in R4 (with 3 species) to 1.75 in transect R2(with 7 species) (Table 3). Diversity in transects R1, R2, R3 and R5 was not significantly different among each other, but differ significantly from that of R4 ($p<0.05$). Diversity of the entire plot was 2.339, significantly higher than that of any transect. The evenness of species presence was high among transects, from 0.63 to 0.90, except in transect R4 which was 0.27. In all transects there were one to three species more abundant that the other, which varied among the transects, being *E. anceps* the most abundant species in R1, *B. jipijapensis* and *E. rhizomaniacum* in R2; *E. rhizomaniacum* in R3; *C. riopalenqueanum* in R4 and *E. rhizomaniacum, O*. sp 5 and *P. wallissi* in R5 (Table 1).

The estimation of the number of expected species in the total plot using Chao 2 estimator predicted a total richness of 39 species for the entire plot, which indicated that the recount of 21 species in the field samples reached 54% of the species expected in the inventory.

According to Jaccard Ij similarity index, the order of similarity among transects was: R2 – R3> R5 > R1 > R4 (Fig. 1).In general, there was a low similarity among transects. The largest similarity value was between transects R2 and R3 (40%) and was due to sharing4 of the 7 orchid species in them, while the remaining transects had similarities from 0 to 29% sharing 3 species or none. Transect R4 was the most dissimilar to the othershowing many clearings due to fallen or dead trees and the least amount of orchid species. Only *Brassia jipijapensis* was shared by four transects, while *Epidendrum rhizomaniacum* and *Polystachia concreta* were shared by three transects.

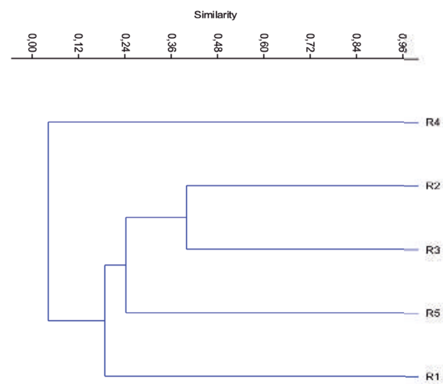


Fig. 1. JaccardIj similarity index, the order of similarity among transects was: R2 – R3> R5 > R1 > R4

Diversity at forest of Bahía de Caráquez

A total of 16 orchid were collected in this location, suggesting that average (±SD) orchid density was 32 ± 49 plants/ha. They were grouped into 4 species representing 4 genera (Table 4). Only transects B1 and B2 showed the presence of orchids. The most frequent species in this site was *Campylocentrum* sp. (37.5%), followed by *Cattleya* sp. and *Catassetum expansum* Rchb.f., both with (25%). All individuals were collected in a general stage of dehydration.

Table 4. Abundance of orchid species recorded in 50 x 20 m transects in the forest of Bahía de Caráquez, Manabi, Ecuador.

	Transect			
Genus or species	**B1**	**B2**	**Frequency in general plot**	**Relative frequency**
Cattleya sp.	2	2	4	0.250
Campylocentrum sp.	3	3	6	0.375
Catassetum expansum	4	0	4	0.250
Lokhartia sp.	2	0	2	0.125
Total	11	5	16	1.0

In this location,Simpson diversity index varied between 0.27 and 0.52 (Table 5). Dominance in transect B1 was approximately similar to that of the entire plot. Likewise, the diversity index H' was higher in B1 and approximately similar to the entire plot (1.34 and 1.32, respectively).

Table 5.Diversity indices and number of expected species of orchids in theforest of Bahia de Caráquez, Manabí, Ecuador. Values with similar letter are non-significant ($p<0.05$).

Index	Total B	B1	B2
Richness	4	4	2
Simpson dominance (λ)	0.281	0.273[a]	0.52[b]
Shannon-Wiener(H')	1.321	1.342[a]	0.673[b]
Evenness (J')	0.95	0.97	0.97
Chao-2 (Number expected species)	5		

The estimator Chao 2 predicted a total richness of 5 species for the entire plot, which indicated that the recount reached 80% of the species expected in the inventory.

Orchids habit

All collected orchids were epiphytes, most of them growing on branches of live trees or fallen trunks, at heights from 0.5 m to 15 m (Table 6); only *Lokhartia* sp. was observed growing on the stem of host trees. The vertical distribution of orchids in El Cerro forest could be divided into three strata, a lower stratum 0.5 - 4 m, an intermediate one 4 – 10 m and an upper stratum 10-15 m. Although species could occupy several strata in the forest, most orchids were found in a single one. An estimate of 14 species (67%) of the orchids in El Cerro forest were found in the lower stratum, 4 species (19%) in the intermediate and 3 species (14%) in the upper stratum. In contrast, the 4 orchid species in the forest of Bahía de Caráquez were found in the intermediate one. Trees in the latter forest did not grow higher than 10 m.

Table 6. Height (m) at which orchids were collected in the forests El Cerro (transects R) and Bahía de Caráquez (transects B), Manabí, Ecuador.

Xylobium sp.		15						15
Epidendrum rhizomaniacum		10	15		0.5 - 3			9
Gongora grossa	04-ago		10-dic					9
Polystachya concreta		10	7		3			7
Stanhopea aff. *anulata*		10			1.5 - 3			6
Catassetum expansum		5				04-ago		6
Cattleya sp.							04-ago	6
Oncidium sp. 1	03-may							4
Lokhartia sp.						03-may		4
Campylocentrum sp.							03-may	4
Oncidium sp 5.					2.5 - 3			3
Cyrtochiloides riopalenqueanum				01-abr	3			3
Psygmorchis pusilla	2	1.5 - 8						3
Peristeria elata				3	2			3
Stelis sp.					3			3
Trigonidium riopalenquense				3				3
Epidendrum anceps	1.5 - 3							2
Brassia jipijapensis	02-mar	02-abr	3		1			2
Dimerandra rinbachii					1.5 - 2			2
Psygmorchis sp.			01-mar					2
Epidendrum macroöphorum	2				02-mar			2
Notylia sp.			2					2
Pescatoria wallisii					0.5 - 2			1
Maxillaria sp 1.			1					1

Heliophilous orchid species, like *Epidendum rhizomaniacum*, *Gongora grossa, Xylobium* sp.Or *Pollystachia concreta,* were collected beyond 9 m at El Cerro forest while *Lokhartia* sp. and *Campylocentrum* sp. were collected at 4 m in the forest of Bahía de Caráquez. Umbrophilous species, like *Dimerandra rimbachii*or*Notylia* sp., were found at the lower strata of the forests (1.5 – 4 m), but also at higher strata, like *Cattleya* sp. in the forest of Bahía de Caráquez, which was found at 8 m. This individual was protected from the sun light by Cactaceae growing in the vicinity of the host tree. Eleven of the 21 species (52%) found in El Cerro forest can be considered umbrophilous, while three of the four orchid species (75%) found in the forest of Bahia de Caráquez were heliophilous.

Forests similitude

Species composition showed important differences between the evaluated forests, since only one species, *Catassetum expansum,*of the total record of 23 species, was shared in both sites. However, the color of the flowers of *C. expansum* in El Cerro forest was dark wine in the callus of the lip and yellow with dark spots surrounding the labellum (Fig. 2), whereas in the Bahía de Caráquez forest the callum and the lip were orange and the remaining of the labellum was yellow and the sepals were green (Fig. 3).Simpson dominance index and Shannon-Weaner diversity index of forest El Cerro were significantly higher than in the dry forest of Bahía de Caráquez ($p<0,01$). The Ij similarity index between the two study sites was low (0.042).

Threat categories

Three of the collected species were first records for Manabí Province: *Pescatoria wallisii* Linden &Rchb.f., *Epidendrum rhizomaniacum* and *Peristeria elata* Hook (Fig. 4-6). Some species are reported in the IUCN category VU, like *Aspasia psittacina* (*Rchb. f.) Rchb. f.*, *Cyrtochiloides riopalenqueanum*, *Gongora grossa* Rchb.f., *Peristeria elata* Hook. and *Trigonidium riopalenquense* (Fig. 7-10). One species considered in the category EN was found, *B. jipijapensis* (Fig. 11). Other species are in category NT, among them: *Dimerandra rinbachii* (Schltr.) Schltr , (Fig. 12- 13) *Psygmorchis pusilla* (L.) Dodson & Dressler and *Pescatoria wallisii* Linden &Rchb.f.




2	*Catassetum expansum*	3	*C a t a s s e t u m expansum*	4	*Pescatoria wallisii*	5	*Epidendrum rhizomaniacum*

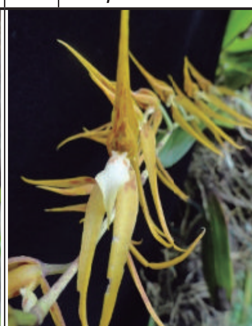
6 *Peristeria elata*

7 *Aspasia psittacina*

8 *Cyrtochiloides palenquianum*

9 *Gongora grossa*

10 Trigonidium riopalenquense



11 *Brassia jipijapensis*

12 *Dimerandra rinbachii*

13 *Psygmorchis pusilla*

Discussion

All the species evaluated in this study were epiphytes. Atwood (1986) and Endara (2011) indicate that the number of epiphytic orchids surpasses that of ground ones. The former are mostly localized on the canopy of host trees, associated to abundant mosses, but also on fallen or standing dead trunks in humid forests. The epiphytic habit is the life form observed in 82% in the population of orchids in Ecuador (Endara 2011).

Environmental factors at El Cerro forest like higherhumidity and precipitation, lower temperature and abundant mosses on the branches of tree hosts were factors favoring the proliferation of epiphytic orchids, in contrast to the drier conditions observed at the forest of Bahía de Caráquez. Both, density and species richness were 26 times and five times higher in El Cerro forest, respectively.The general dominance of El Cerro forest was lower and total diversity was higher than the forest in in Bahía de Caráquez. However, the dominance and diversity within transects in both forest was comparable (λ was in the range 0.2 to 0.9 and H' from 0.3 to 1.8 in El Cerro Forest, while λ values were 0.3 to 0.5 andH' 0.7 to 1.3 in the forest at Bahía de Caráquez). This phenomenon may be associated to the lower and comparable number of orchid species present in transects of both forests.

Eveness is associated to the way species are represented in numbers within a community (Pielou 1975). The few orchid species found in the forest of Bahía de Caráquezwere more uniformly represented (evenness 0.97 in both transects) than the species in El Cerro forest (evenness 0.3 to 0.9). The drier environment in the forest at Bahía de Caráquez may prevent any species to become dominant in comparison with the more lenient environment at El Cerro forest.

Clearing in El Cerro forest due fallen trees, possibly caused by heavy rains and windstorms, showed a smaller amount of orchids than those covered with higher density of trees. Although orchids were still present on branches of the fallen host trees, the greater illumination and drier environment probably affected the survival and reproductive ability of the orchids present.

The distribution of orchid among forest transects in both locations was heterogeneous, both in density and species composition, which was reflected in the low similarity among transects, according to Jaccard's index.Furthermore, all transects in El Cerro forest had exclusive orchid species whose proportion varied from 29 to 46% of the total orchid richness of the forest, in spite of the large size of the area covered in the transects. Each transect was characterized by a set of unique species, suggesting that orchid dispersal has limitations and that each group of individuals of a species within a transect behaves as a meta population, with variable capacity to interact with other individuals within the forest (Winkler *et al.* 2009).

Dispersal limitation of orchids could be associated to several factors, like: different availability of appropriate host tree species to hold orchids (Martínez-Meléndez *et al.* 2008, Orta-Pozos y Lopez-Trabanco 2013, but see Hiets and Hirtz-Seifert 1995 for a non-significant role of host tree species on orchid distribution), scarcity of appropriate species of pollinators that limitsthe fertilization of flowers and seed production (Tupac-Otero and Flanagan 2013; Batygina *et al.* 2003), lack of specific mycorhizal symbiotic fungus that would restrictorchid seed germination (McCormick *et al.* 2013). The limited dispersal of certain orchid species could be associated to the endemism observed in western Ecuador,where 20% endemic species have been reported (Dodson and Gentry 1993).

Density of orchidschanged according to the type of forest and height within it. In El Cerro forest, most orchids were umbrophilous and occupied the lower stratum (0.5-4 m), with a fast reduction of density and species richness towards upper strata. Above 10 m, only 3 heliophilous species were found. In the forest at Bahía de Caráquez, most orchid species were found in the intermediate stratum (4 – 10 m), suggesting that the lower stratum in this site are less appropriate for orchid survival.

After verifying the species in the National Herbarium, that of the Pontificia Universidad Católica del Ecuador and the Tropicos data base of the Missouri Botanical Garden, it was verified that three orchid species registered in this study were first records for the Province of Manabi:*Pescatoria wallisii*, *Epidendrum rhizomaniacum* and *Peristeria elata.*The latterhas a restricted distribution in Ecuador, and was reported for three provinces: Pichincha, Los Rios and Manabi, in the ecoregion of coastal forests (Mites 2015). *Pescatoria walissii* has a wide distribution in seven provinces of Ecuador, occupying coastal and southern mountain forestsfrom the Andes ridge towards the south. *Epidendrum rhizomaniacum* is found in five provinces, mainly in coastal and mountain forests of central and southern Ecuador.

Eightof the recorded orchid species in this study have different threat categories, five are vulnerable, one is endangered and two are near threatened (IUCN 2012; Mites 2015).Some threat factors that determine such condition could be the natural habitat destruction, the growth of agricultural frontier and the excessive extraction of orchids from the wild (Endara 2011).

Conclusions

Orchid diversity was highin the evergreen seasonal forest, where 21 orchid species were found with low dominance, where individual species form isolated patches within the forest. In spite of the drier conditions of the deciduous forest at Bahia de Caráquez, 4 species of orchids were foundwith higher dominance than was observed in the evergreen forest.

Epiphytic orchids live on host tree branches and trunk up to 15 m, but also on fallen and standing dead trunks. Umbrophilous orchid species occupied mainly the lower layer (0.5-4 m) of the forest El Cerro. Heliophilous species were found in both El Cerro and Bahía de Caráquez forests occupying middle (4-10 m) to upper (10-15 m) strata.

Finally, conservation efforts and actions in the forests evaluated have high priority, in order to maintain the orchid diversity and endemism, as well as that of the vascular plants in general. It is necessary to reduce the threat imposed on the wild forests from the growth of the agricultural frontier.Management plans are necessary for the conservation of species categorized as threatened, which incorporate the identification of natural populations, studies on their population dynamics and *in situ* and *ex situ* conservation programs, with the help of botanical gardens, research institutions and universities of the country.

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Figures' leyends

Figure 1. Similarity based on Jaccard coefficient among transects at forest El Cerro, Ricaurte Parish, Manabí, Ecuador.

Figure 2. *Catassetum expansum* at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 1003.

Figure 3. *Catassetum expansum* at forest Bahía de Caráquez, Manabi. Specimen deposited into QCA with code MMC 997.

Figure4.*Pescatoria wallisii*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 992.

Figure5.*Epidendrum rhizomaniacum*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 988.

Figure6. *Peristeria elata*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 991.

Figure 7. *Aspasia psittacina* at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code: MMC 983.

Figure 8.*Cyrtochiloides riopalenqueanum*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 986.

Figure9.*Gongora grossa*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 990.

Figure10.*Brassia jipijapensis*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 984.

Figure11.*Dimerandra rinbachii*at forest El Cerro, Ricaurte Municipality, Manabi. Specimen deposited into QCA with code MMC 987.