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Translated from the original in spanish **Original article**

Vascular epiphytes in a permanent plot in Andean forest in the "Francisco Vivar Castro" University Park, Loja, Ecuador

Epífitas vasculares en una parcela permanente en bosque andino en el Parque Universitario "Francisco Vivar Castro", Loja, Ecuador

Vascular epiphytes in a permanent partnership in the Andes forest in the "Francisco Vivar Castro" University Park, Loja, Equador

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ABSTRACT

Most trees in Andean forests are covered by epiphytes. The objective of the study was to evaluate the floristic composition, structure and preference of vascular epiphytes in certain phorophytes. Three phorophytes were selected in each 20 x 20 m subplot of a one hectare permanent plot and recorded: $D_{1.30}$ > 20 cm, crown foliage, visibility and branching. The inventory of the epiphytes was carried out by climbing the phorophytes following their vertical distribution. Structural parameters such as density, abundance, frequency, importance value index and Shannon diversity were calculated. The habitat preference of epiphytes was calculated by the number of individuals per host and per section. 7,610 individuals of 12 species, 8 genera and 4 families were recorded. The most ecologically important species in all sections of the phorophytes are: *Anthurium oxybelium*, *Peperomia galioides*, *Tillandsia tovarensis, Cyrtochilum aureum, Pleurothallis maxima*, *Tillandsia biflora*. The vascular epiphytes recorded prefer to live in section 3, *Tillandsia tovarensis, Pleurothallis maxima* and *Tillandsia biflora* are the most abundant. *Alnus acuminata* and *Cedrela montana* are the most preferred phorophytes for vascular epiphytes.

Keywords: Andean forest, diversity of vascular epiphytes, phorophyte, vertical distribution and habitat preference.

RESUMEN

La mayoría de los árboles de los bosques andinos están cubiertos por epífitas. El objetivo del estudio fue evaluar la composición florística, estructura y la preferencia de las epífitas vasculares en determinados forófitos. Se seleccionaron tres forófitos en cada subparcela de 20 x 20 m de una parcela permanente de una hectárea y se registró: $D_{1,30}$ > 20 cm, frondosidad de copa, visibilidad y ramificación. El inventario de las epífitas se efectuó mediante escalada a los forófitos siguiendo su distribución vertical. Se calcularon parámetros estructurales como densidad, abundancia, frecuencia, índice valor de importancia y diversidad Shannon. La preferencia de hábitat de las epífitas, se calculó mediante el número de individuos por hospedero y por sección. Se registraron 7 610 individuos de 12 especies, 8 géneros y 4 familias. Las especies ecológicamente más importantes en todas las secciones de los forófitos son: *Anthurium oxybelium*, *Peperomia galioides*, *Tillandsia tovarensis, Cyrtochilum aureum, Pleurothallis maxima*, *Tillandsia biflora*. Las epífitas vasculares registradas prefieren vivir en la sección 3, *Tillandsia tovarensis, Pleurothallis maxima* y *Tillandsia biflora* son las de mayor abundancia. *Alnus acuminata* y *Cedrela montana* son los forófitos de mayor preferencia para las epífitas vasculares.

Palabras clave: bosque andino, diversidad de epífitas vasculares, forófito, distribución vertical y preferencia de hábitat.

RESUMO

A maioria das árvores das florestas andinas estão cobertas por epífitas. O objetivo do estudo foi avaliar a composição florística, estrutura e a preferência das epífitas vasculares em determinados forófitos. Selecionaram se três forófitos em cada subparcela de 20 x 20 m de uma parceria permanente numa hectare e se registrou: $D_{1,30}$ > 20 cm, frondosidade de copa, visibilidade y ramificação. O inventário das epífitas efetuou se mediante escalada aos forófitos seguindo sua distribuição vertical. Se calcularam parâmetros estruturais como densidade, abundância, frequência, índice valor de importância e diversidade Shannon. A preferência de hábitat das epífitas, se calculou mediante o número de indivíduos por hospedeiro e por seção. Se registraram 7 610 indivíduos de 12 espécies, 8 géneros y 4 famílias. As espécies ecológicamente mais importantes em todas as seções dos forófitos são: *Anthurium oxybelium*, *Peperomia galioides*, *Tillandsia tovarensis, Cyrtochilum aureum, Pleurothallis maxima*, *Tillandsia biflora*. As epífitas vasculares registradas preferem viver na seção 3, *Tillandsia tovarensis, Pleurothallis maxima* y *Tillandsia biflora* são as de maior abundância. *Alnus acuminata* y *Cedrela montana* são os forófitos de maior preferência para as epífitas vasculares.

Palavras chave: Floresta andina, diversidade de epífitas vasculares, forófito, distribuição vertical e preferência de hábitat.

INTRODUCTION

Ecuador is one of the 17 megadiverse countries on the planet, due to its location in the center of the world, the presence of the Andes Mountains, the Coastal Region, the Amazon jungles and the Galapagos Islands (Aguirre 2018), it has great wealth floristics given by 18,568 species of vascular plants of which 25 % are endemic. A large part of this diversity and endemism of plants develop in the Andean forest, which is why it represents one of the most threatened biodiversity *hot spots* in the Northern Andes (Tejedor-Garavito *et al.,* 2012).

In the case of Hoya de Loja, the Andean Forest is in danger of disappearing, about 3,459 hectares have been deforested during the period 2014 2016, due to conversion of use for agricultural expansion, forest fires and expansion of the urban area (MAE 2018). The disappearance of these not only causes the decline of forest species, but also affects one of the important ecological groups such as vascular epiphytes (MAE 2016 and Paredes-Ulloa et al., 2021).

Studying vascular epiphytes is important not only because they are a component of the diversity in tropical and Andean forests, but also because of the function they play in their recovery dynamics, since by stratifying vertically, they constitute habitat for fauna and offer a wide variety of niches and resources (Einzmann and Zotz 2016) for other groups. Therefore, the Andean Forest of the "Francisco Vivar Castro" University Park at an altitude of 2,250 m a.s.l., with an area of 12.93 ha (Aguirre *et al.,* 2016) constitutes a site of interest for the study of this ecological group.

Under these considerations, the study aims to evaluate the composition, structure and habitat preference of vascular epiphytes in a permanent plot of one hectare of the Andean Forest.

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MATERIALS AND METHODS

Study area

The study was carried out in the "Francisco Vivar Castro" University Park (PUFVC), property of the National University of Loja, in the province of Loja, located at the UTM coordinates: 700 5929 554 223 N, 700 9709 553 139 S, 701 3099 553 171 E, 699 9619 554 049 W, between 2 130 to 2 520 m asl and occupies an area of 99.13 ha (Figure 1). This area is part of the Project: Ecological processes of vegetation in the university park "Francisco Vivar Castro", National University of Loja. Phase III. 2022-2023.

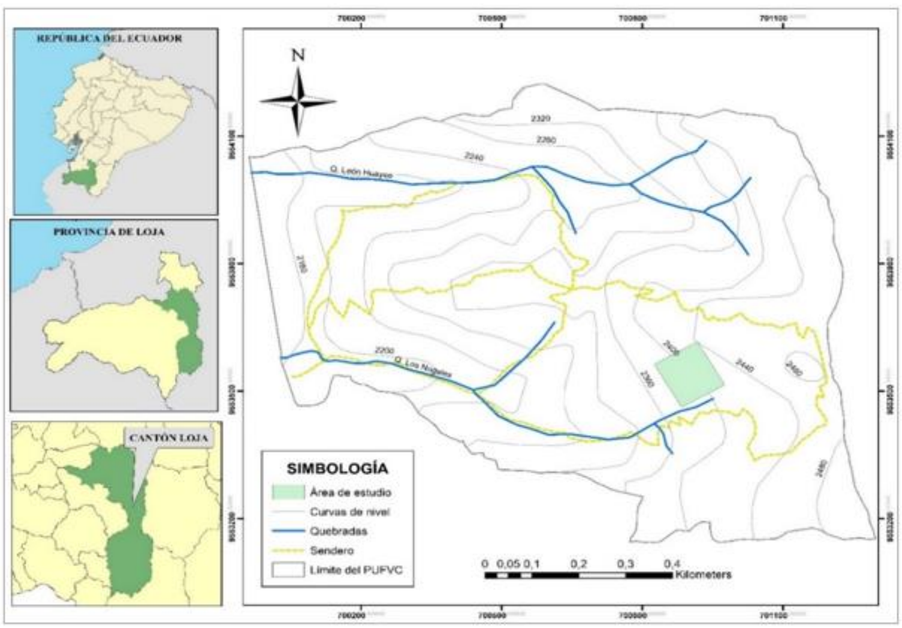

Figure 1. - Location of the study area plot within the "Francisco Vivar Castro" University Park, Loja, Ecuador

Selection of forums

For this research, information from the tree census of a permanent plot of one hectare in the Andean Forest of the PUFVC was taken as a basis. In each of the 25 subplots of 20 x 20 m (400 m ^{2}), three trees (phorophytes) were selected, considering four aspects: D $_{1.30 \text{ m}}$ greater than 20 cm, crown width and visibility (height of crown and crown diameter) and branching (Figure 2).

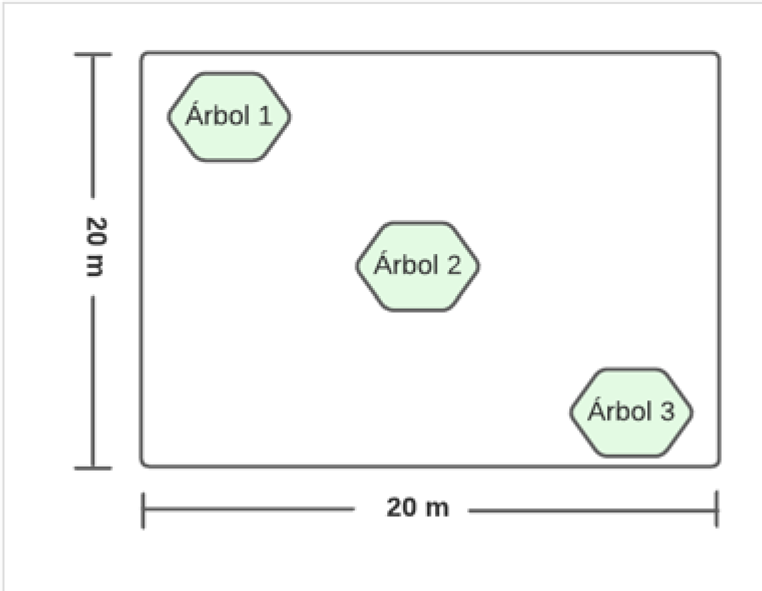

Figure 2. - Selection of phorophytes in the sampling subplots

Evaluation of vascular epiphyte assemblages in each phorophyte

The evaluation of epiphyte assemblages present in each phorophyte was carried out by direct observation with binoculars and climbing each tree under study. The individuals of vascular epiphytes (bromeliads, orchids, aroids and piperaces) present in each phorophyte were recorded. These were collected for later identification in the "Reinaldo Espinosa" Herbarium of the National University of Loja.

Data logging for structural parameters

Given that the distribution of epiphytes on the phorophyte varies vertically and horizontally, each tree selected in the subplots was subdivided into three sections (Figure 3): section 1 (Sa1) from the base to 3 m; section 2 (Sa2) is the middle part, above section 1 and below the first branch; and section 3 (Sa3) from the first branch to the crown of the tree, this is a modification to the method of Johansson (1974).

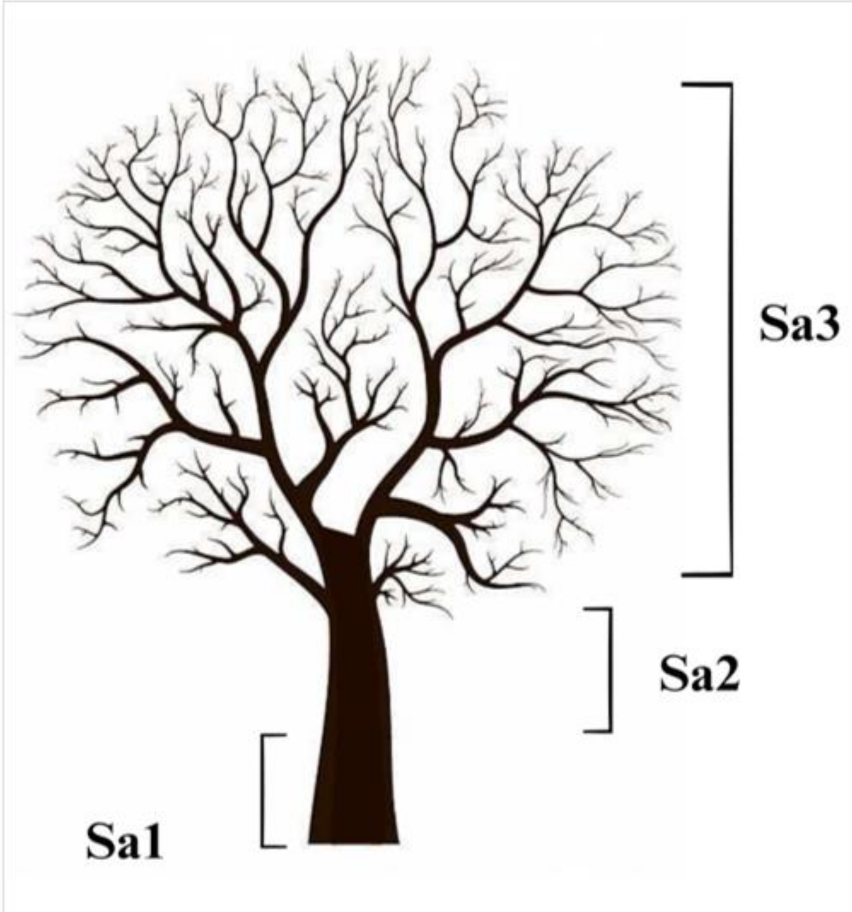

Figure 3. - Phorophyte sections used for quantification of vascular epiphytes

Data analysis for composition and structure

With the data collected from the vascular epiphytes in each of the trees in the subplots, the structural parameters were calculated: relative density (RD), relative frequency (FR) and IVI. The species accumulation curve was made using the chao 2 index to check the representativeness of the sampling. To compare the density between vertical section of the phorophytes, the richness by botanical families and the density by species of epiphytes, a non-parametric Kruskal-Wallis test was carried out with a confidence level of 5 %. Statistical analyzes were used with the EstimateSWin910 statistical package.

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The vascular epiphytes that have the greatest preference towards a host(s) were defined and the percentage of preference was calculated through a direct rule of three, because the magnitudes are directly proportional. In addition, the phorophytes with the greatest presence of epiphytic individuals in each section, the species with the greatest abundance of individuals and the sections that prefer these species were identified.

A cluster analysis was carried out to recognize the existence of groups among phorophytes according to the species of epiphytes that inhabit them; and another between the three sections. For this, the *complete* linkage method was used and 50 % similarity and 80 % respectively were considered as the cut-off point or reference line for defining the clusters.

RESULTS

Floristic composition and structure of vascular epiphytes

Figure 4 shows the species accumulation curve, which shows the sampling effort. This curve was adjusted with the Chao 2 estimator. The observed richness is 12 species, the non-parametric Chao 2 estimator estimates 18 species for the sample of 75 hosts. The sampling did not allow us to cover all the diversity of epiphytes, registering 67 % of the expected species.

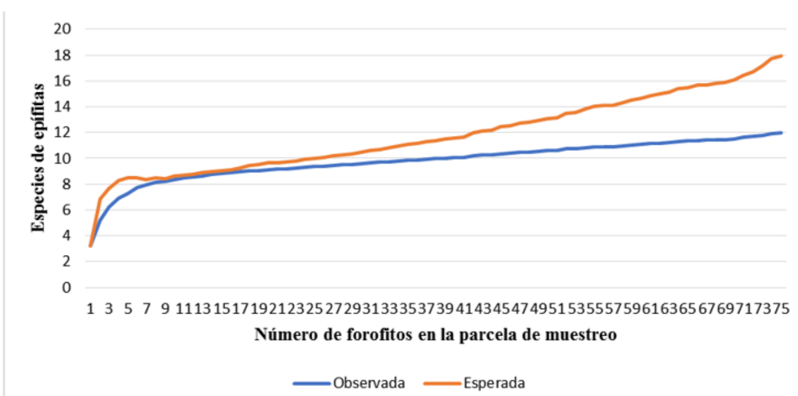

Figure 4. - Accumulation curve of vascular epiphyte species in the Andean forest

12 species of epiphytes were recorded within eight genera and four families. The number of epiphytes recorded was 7,610 individuals in 75 phorophytes inventoried. Table 4 identifies the 21 host species of vascular epiphytes, with the sampling density and estimated density per hectare (Table 1).

Table 1. - Number of epiphyte individuals in the sampling and the estimated density for one hectare in the Andean Forest of the PUFVC

host species	No.E/H	No em	No.H/ha	No.E/ha
***Alnus acuminata* Kunth**	22	3 830	51	8 879
***Axinaea macrophylla* (Naudin) Triana**	1	17	8	136
***Cedrela montana* Moritz ex Turcz.**	4	1 313	eleven	3 611
***Clethra revoluta* (Ruiz and Pav.) Spreng.**	7	476	80	5 440
***Critoniopsis pycnantha* (Benth.) H. Rob.**	1	55	6	330
***Guettarda hirsuta* (Ruiz and Pav.) Pers.**	4	56	8	112
***Hedyosmum scabrum* (Ruiz y Pav.) Solms**	2	8	64	256
***Miconia obscura* (Bonpl.) Naudin**	2	54	fifteen	405
***Morus insignis* Bureau**	1	twenty	39	780
***Morella interrupta* (Berth.) Lægaard**	1	4	1	4
***Andean Myrsine* (Mez) Pipoly**	2	65	23	748
***Nectandra laurel* Klotzsch ex Nees**	4	497	73	9 070
***Oreopanax andreanus* Marchal**	1	70	7	490
***Oreopanax rosei* Harms**	2	173	30	2,595
***Prunus opaca* (Benth.) Walp.**	5	128	44	1 126
***Roupala loxensis* IM Johnst.**	2	263	19	2 499
***Saurauia bullosa* Wawra**	2	62	14	434
***Sciodaphyllum pedersenii* in ed.**	4	213	36	1 917
***Siparuna muricata* (Ruiz y Pav.) A. DC**	1	42	66	2 772
***Vismia baccifera* (L.) Triana and Planch.**	6	211	22	774
***Zinowiewia madsenii* C. Ulloa and P. Jørg.**	1	53	2	106

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Legend: No.E/H: Number of epiphytic individuals per host, No.E/m: Number of epiphytic individuals in the sample, No.H/ha: Estimated number of hosts per hectare; No.E/ha: Number of epiphytic individuals estimated for 1 ha.

Vertical structure of vascular epiphytes by sections

Table 2 shows the most abundant epiphytes by section; generally, in section 3 there was a greater number of epiphyte individuals and the unique presence of the orchid *Cyrtidiorchis rhomboglossa*. In section 1 the most abundant species were from the Piperaceae family: *Peperomia alata* and *Peperomia galioides,* followed by *Anthurium oxybelium;* while the least abundant ones corresponded to the Bromeliaceae and Orchidaceae families. In section 2 as in 3, the vascular epiphytes with the largest number of individuals corresponded to *Tillandsia tovarensis* (Bromeliacea), *Cyrtochilum aureum* and *Pleurothallis maxima*. The species with the fewest individuals were

Tillandsia cylindrica, Stelis emarginata and *Epidendrum* sp.

Tallandsia tovarensis is the only species that shows a drastic increase in the number of individuals, particularly between section 3 and the rest of the sections, presenting a marked presence in all the phorophytes of the plot. The species best represented in the number of individuals correspond to *Pleurothallis maxima* and *Cyrtochilum aureum,* which tend to increase towards the top of the trees (Table 2).

Table 2. - Structural parameters of the vascular epiphytes of section I in the permanent plot of the PUFVC

	Section 1				
Family	**Scientific name**	**d**	**Dr %**	**Fr %**	**IVI**
Piperaceae	*Peperomia alata* Ruiz and Pav.	292	54.07	36.78	45.43
Araceae	*Anthurium oxybelium* Schott.	84	15.56	22.99	19.27
Piperaceae	*Peperomia galioides* Kunth	44	8.15	14.94	11.55
Orchidacea	*Pleurothallis maxima* Luer	43	7.96	3.45	5.71
Orchidacea	*Cyrtochilum aureum* (Lindl.) Senghas	3. 4	6.3	5.75	6.02
Bromeliaceae	*Tillandsia tovarensis* Mez.	28	5.19	9.2	7.19

Bromeliaceae	*Tillandsia biflora* Ruiz and Pav.	9	1.67	23	1.98
Bromeliaceae	*Tillandsia cylindrica* S. Watson	3	0.56	1.15	0.85
Araceae	*Anthurium* sp.	2	0.37	23	1.33
Orchidacea	*Epidendrum* sp	1	0.19	1.15	0.67
	Total	540			
	Section 2				
Bromeliaceae	*Tillandsia tovarensis* Mez.	350	41.03	36.27	38.65
Orchidacea	*Cyrtochilum aureum* (Lindl.) Senghas	174	20.4	17.65	19.02
Orchidacea	*Pleurothallis maxima* Luer	158	18.52	10.78	14.65
Piperaceae	*Peperomia galioides* Kunth	53	6.21	6.86	6.54
Piperaceae	*Peperomia alata* Ruiz and Pav.	51	5.98	7.84	6.91
Bromeliaceae	*Tillandsia biflora* Ruiz and Pav.	31	3.63	10.78	7.21
Araceae	*Anthurium oxybelium* Schott.	24	2.81	5.88	4.35
Bromeliaceae	*Tillandsia cylindrica* S. Watson	6	0.7	1.96	1.33
Orchidacea	*Stelis emarginata* (Lindl.) Soto Arenas y Solano	5	0.59	0.98	0.78
Orchidacea	*Epidendrum* sp	1	0.12	0.98	0.55
	Total	853			
Bromeliaceae	*Tillandsia tovarensis* Mez.	4 846	78	39.47	58.73
Orchidacea	*Pleurothallis maxima* Luer	547	8.8	16.45	12.63
Orchidacea	*Cyrtochilum aureum* (Lindl.) Senghas	333	5.36	11.84	8.6
Bromeliaceae	*Tillandsia biflora* Ruiz and Pav.	279	4.49	15.79	10.14
Bromeliaceae	*Tillandsia cylindrica* S. Watson	187	3.01	13,16	8.08
Piperaceae	*Peperomia galioide* s Kunth	12	0.19	0.66	0.43
Piperaceae	*Peperomia alata Ruiz* and Pav.	8	0.13	1.32	0.72
Araceae	*Anthurium oxybelium* Schott.	3	0.05	0.66	0.35
Orchidacea	*Cyrtidiorchis rhomboglossa* (Lehm. and Krzl.) S. Rauschert.	2	0.03	0.66	0.35
	Total	6 217			

Note: *D: Density; Dr:Relative Density; Fr:Relative frequency; IVI:Importance value index.*

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Comparison of species by family in each section of the phorophytes

The Kruskal-Wallis test showed that there are no significant differences in the number of epiphyte species with respect to the phorophyte section. In the case of species richness per family, the test did show significant differences (Figure 5, P = 0.0189). The different letters indicate that there is a difference between the numbers of species per family.

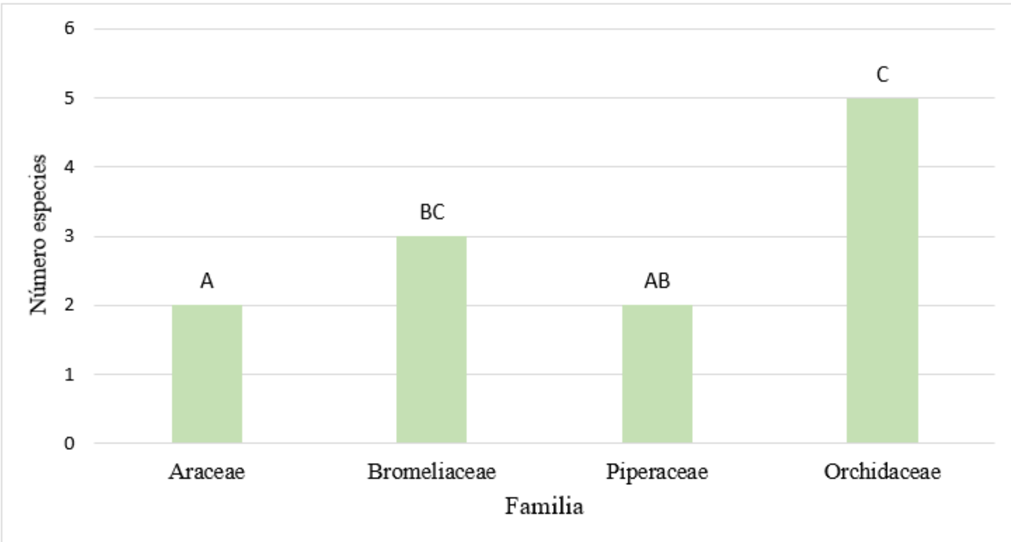

Figure 5. - Number of epiphytic species per family in the permanent plot

Preference of vascular epiphytes towards hosts

It was detected that only four tree species are more preferred as hosts (Table 3), among these *Alnus acuminata* represents one of the most preferred hosts for epiphytes of any family, particularly for species of the Orchidaceae family.

Table 3. - Percentage of preference of the epiphytic species to the host in the permanent plot of the PUFVC

Epiphytes	**Host**	**% Pr**	**No.E**
Anthurium oxybelium Schott.	*Alnus acuminata* Kunth	22.52	25
Anthurium sp.	*Clethra revoluta* (Ruiz and Pav.) Spreng.	fifty	1
Anthurium sp.	*Saurauia bullosa* Wawra	fifty	1
Cyrtochilum aureum (Lindl.) Senghas	*Alnus acuminata* Kunth	38.82	210
Cyrtidiorchis rhomboglossa (Lehm. and Krzl.) S. Rauschert.	*Alnus acuminata* Kunth	100	2
***Peperomia alata* Ruiz and Pav.**	*Alnus acuminata* Kunth	43.87	154
Peperomia galioides Kunth	*Alnus acuminata* Kunth	26.61	29
Pleurothallis maxima Luer	*Alnus acuminata* Kunth	73.40	549
***Stelis emarginata* (Lindl.) Soto Arenas y Solano**	*Prunus opaca* (Benth.) Walp.	100	5
***Tillandsia biflora* Ruiz y Pav .**	*Alnus acuminata* Kunth	43.57	139
Tillandsia cylindrica S. Watson	*Alnus acuminata* Kunth	21.32	68
Tillandsia tovarensis Mez.	*Alnus acuminata* Kunth	50.80	2 654

***Note**: % Pr: percentage of preference, No.E: Number of epiphyte individuals*

Similarity between sections and between hosts by epiphytic load

According to the position of the cut line in the dendrogram of the cluster analysis, two groups are distinguished (Figure 6), one that groups section 1 (Sa1) and section 2 (Sa2) and another for section 3 (Sa3).

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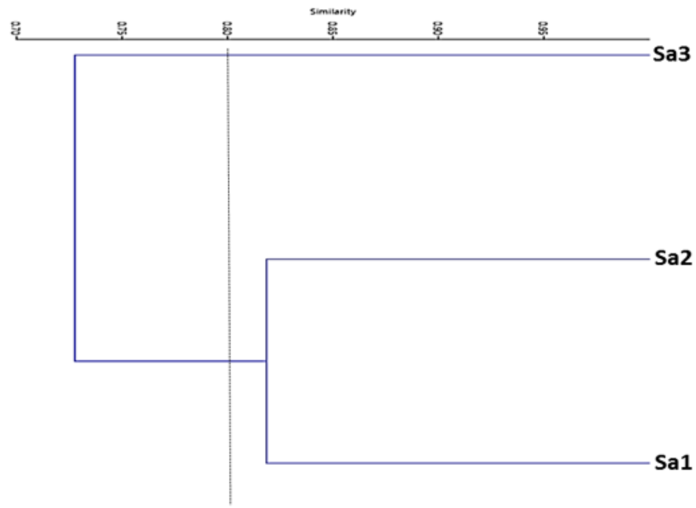

Figure 6. - Similarity between sections by epiphytic load sections in the permanent plot

The cluster analysis of the epiphytic species in relation to the host (Figure 7 and Table 4) shows that with 50% similarity, 8 groups are identified. With the same association of epiphytes, the phorophytes *Oreopanax rosei, Axinaea macrophylla* and *Morella interrupta* and the group formed by *Vismia baccifera, Alnus acuminata* and *Nectandra laurel* are recognized. The phorophyte *Siparuna muricata* that differs the most in terms of epiphytic species in relation to the rest.

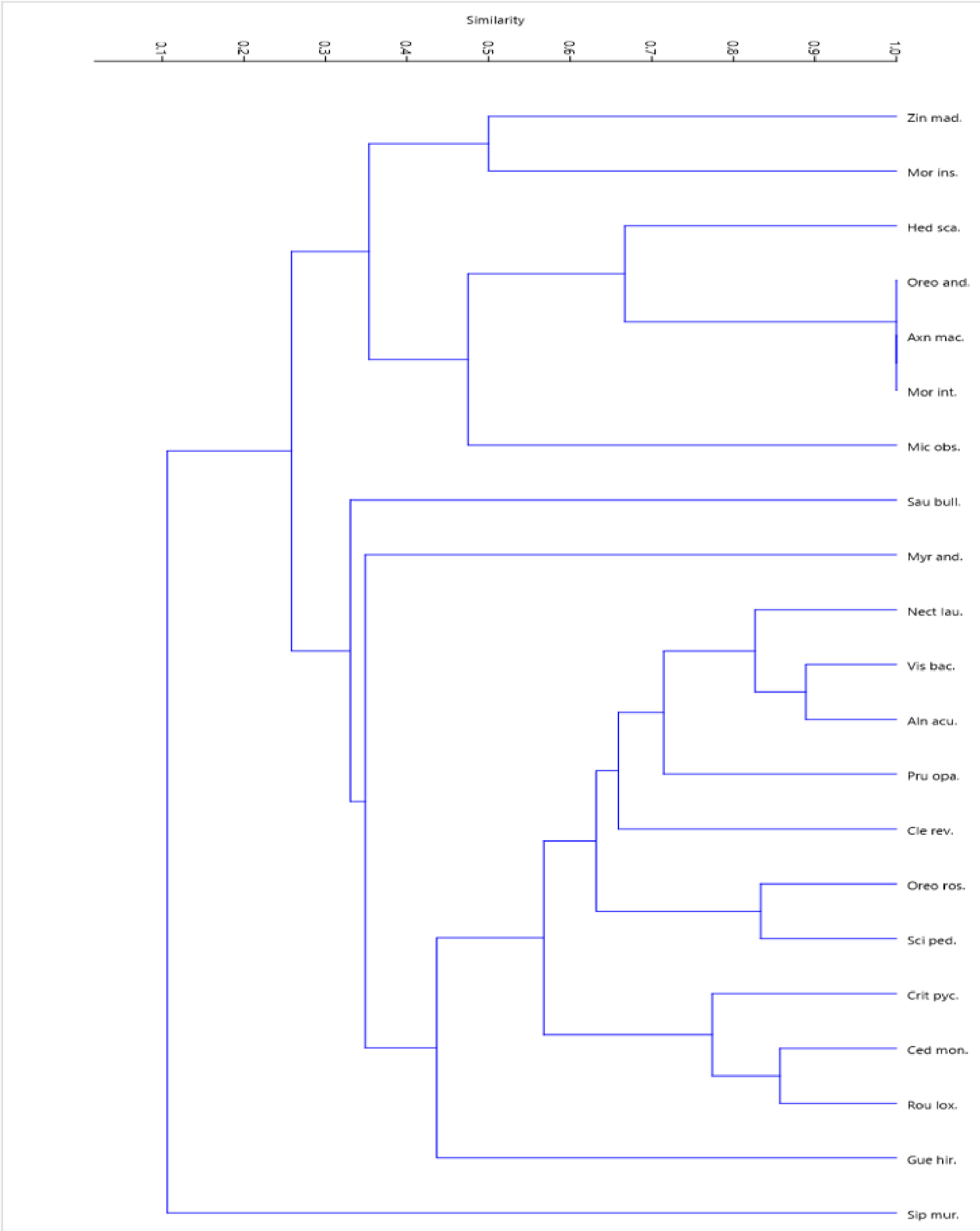

Figure 7. - Similarity between hosts due to the presence of epiphytes in the permanent plot

Legend: Sip mur.: *Siparuna muricata* (Ruiz y Pav.) A. DC, Gue hir.: *Guettarda hirsuta* (Ruiz y Pav.) Pers., Rou lox.: *Roupala loxensis* IM Johnst., Ced mon.: *Cedrela montana* Moritz ex Turcz, Cri pyc.: *Critoniopsis pycnantha* (Benth.) H. Rob., Sci ped.: *Sciodaphyllum pedersenii*, Pink Oreo: *Oreopanax rosei* Harms, Cle rev.: *Clethra revoluta* (Ruiz and Pav.) Spreng, Pru opa.: *Prunus opaca* (Benth.) Walp., Aln acu.: *Alnus acuminata* Kunth, Vis baca.: *Vismia baccifera* (L.) Triana and Planch., Nec lau.: *Nectandra laurel* Klotzsch ex Nees, Myr and.: *Myrsine andina* (Mez) Pipoly, Sau bull.: *Saurauia bullosa* Wawra, Mic obs.: *Miconia obscura* (Bonpl.) Naudin, Mor int.: *Morella interrupta* (Benth.) Lægaard, Axn mac.: *Axinaea macrophylla* (Naudin) Triana, Ore and.: *Oreopanax andreanus* Marchal, Hed scan.: *Hedyosmum scabrum* (Ruiz y Pav.) Solms, Mor ins.: *Morus insignis* Bureau, Zin mad.: *Zinowiewia madsenii* C. Ulloa and P. Jørg.

75 % of the epiphytes prefer *Alnus acuminata as hosts, Cedrela montana* 33%, and *Cletra revoluta* 25%, the rest of the tree species are used as hosts interchangeably (Table 4).

Table 4. *- Percentage of preference of epiphytic species towards hosts in the permanent plot of the Andean forest of the PUFVC*

Epiphytic species	**Host**	**% Preference**
Anthurium oxybelium Schott.	*Alnus acuminata* Kunth	22.52
	Roupala loxensis IM Johnst.	21.62
	Sciodaphyllum pedersenii in ed.	11.71
Anthurium sp	*Clethra revoluta* (Ruiz & Pav.) Spreng.	fifty
	Saurauia bullosa Wawra	fifty
	Morus insignis Bureau	9.91
Cyrtochilum aureum (Lindl.) Senghas	*Alnus acuminata* Kunth	38.82
	Cedrela montana Moritz ex Turcz.	21.26
	Nectandra laurel Klotzsch ex Nees	13.68
Cyrtidiorchis rhomboglossa **(Lehm. & Krzl.) S.**	*Alnus acuminata* Kunth	100
Epidendrum sp.	*Clethra revolut* a (Ruiz & Pav.) Spreng.	100
Pleurothallis maxima Luer	*Alnus acuminata* Kunth	73.40
	Cedrela montana Moritz ex Turcz.	10.16
Stelis emarginata **(Lindl.) Soto Arenas & Solano**	*Prunus opaca* (Benth.) Walp.	100
Peperomia alata Ruiz & Pav.	*Alnus acuminata* Kunth	43.87
	Roupala loxensis IM Johnst.	12.82
	Siparuna muricata (Ruiz & Pav.) A. DC	11.97
	Critoniopsis pycnantha (Benth.) H. Rob.	1.14
	Siparuna muricata (Ruiz & Pav.) A. DC	11.97
Peperomia galioides Kunth	*Alnus acuminata* Kunth	26.61
	Clethra revoluta (Ruiz & Pav.) Spreng.	10.09
	Prunus opaca (Benth.) Walp.	11.93
	Saurauia bullos at Wawra	22.94
	Critoniopsis pycnantha (Benth.) H. Rob.	9.17

Tillandsia biflora Ruiz & Pav.	*Alnus acuminata* Kunth	43.57
	Nectandra laurel Klotzsch ex Nees	12.23
	Oreopanax andreanus Marchal	16.30
	Oreopanax rosei Harms	10.03
	Axinaea macrophylla (Naudin) Triana	3.14
	Morella interrupta (Benth.) Lægaard	0.31
	Oreopanax andreanus Marchal	16.30
Tillandsia cylindrica S. Watson	*Alnus acuminata* Kunth	21.32
	Cedrela montana Moritz ex Turcz.	22.57
Tillandsia tovarensis Mez.	*Alnus acuminata* Kunth	50.80
	Cedrela montana Moritz ex Turcz.	19.47
	Morella interrupta (Benth.) Lægaard	0.06
	Morus insignis Bureau	0.17
	Oreopanax andreanus Marchal	16.30
	Zinowiewia madsenii C. Ulloa & P. Jørg.	1.01
	Guettarda hirsuta (Ruiz & Pav.) Pers.	0.92

DISCUSSION

Floristic composition and structure of vascular epiphytes

In this study, individuals of epiphyte species were found that show preferences for certain phorophytes and sections within the phorophytes, with greater abundance in the tree crowns. The presence of 12 species from 8 genera and 4 families was determined, recorded in 75 sampled trees. Studies on epiphytes in Ecuadorian Andean forests are not so abundant, particularly due to the difficulty of field work (Paredes-Ulloa *et al.,* 2021). In this regard, Henao-Díaz *et al.* (2012) reported a similar diversity and density of vascular epiphytes in Colombian sub-Andean and lowland forests and argued that this was in direct relation to host height and altitude above sea level. However, the present study shows a lower species richness, which could be due to the degree of forest intervention and its recovering condition (Aguirre *et al.*, 2016). These alterations to natural forests, which produce changes in the elements of their structure, affect all the communities dependent on these ecosystems, mainly the epiphytes (Bartels 2012).

The families with the greatest number of species and individuals are Bromeliaceae and Orchidaceae, this is similar to what was reported by Paredes-Ulloa *et al.* (2021), which seems to be a regularity of the Andean forests of Ecuador. This representativeness is influenced by the morphological, ecological and physiological adaptations that these epiphytic species present in order to respond to various environmental restrictions such as light exposure, low nutrient availability, temperature changes and especially precipitation (Ding *et al.*, 2016).

The high abundance of *Tillandsia tovarensis* in the forest can be explained by the tendency of the species to form conglomerates which sometimes almost completely cover the crowns of the phorophytes, not allowing the growth of other species around them. The *Tillandsia genus,* due to the characteristic of forming tanks or reservoirs with its leaves, is the key to reproduction and development through the retention of water and nutrients (Ding *et al.*, 2016).

Regarding the richness by sections in the sampled phorophytes, there is great similarity in the number of species in the three sections of the trees, which determines that the variation in richness per vertical section is not significant. This result is different from Paredes-Ulloa *et al.* (2021) in a piedmont evergreen forest where epiphytes (orchids) are clearly concentrated in the upper canopy. However, in relation to the density of epiphytes there were significant differences between sections (Figure 6), so the existence of a selectivity of epiphytic individuals in the highest sites is recognized. This behavior of greater concentration of individuals in the upper canopy was consistent with the studies of Krömer *et al.* (2007) and Paredes-Ulloa *et al.* (2021), which should be related to the best availability of light for vegetative and photosynthetic activities.

So, in the vertical distribution, the preference of the species to a particular section is observed. An example of this is the bromeliads, which are present in all sections but in greater frequency and density in the upper one. Furthermore, in high sections the wind speed and solar radiation increase while the relative humidity decreases, which provides the formation of microclimates in the forest sections, a situation that affects the presence of some groups of vascular epiphytes.

In the case of orchids, there is no generality for some species, the density increases as one ascends through the sections of the host, such as in *Cyrtochilum aureum* and *Pleurothallis maxima*. However, this did not occur with *Cyrtidiorchis rhomboglossa, Epidendrum sp.* and *Stelis emarginata*, all these orchids. In this regard, Rasmussen and Rasmussen (2018) and Paredes-Ulloa *et al.* (2021) report that this family tends to have greater species richness but with low density of individuals. Another possible cause of the limited number of individuals could be related to external morphology since these species have poor anchorage (Rasmussen and Rasmussen 2018). The higher frequency and density of *Peperomia alata* and *Peperomia galioides*, in section 1 of the phorophytes could be related to the higher humidity (Mai *et al.*, 2016 and Martínez-Bautista *et al.*, 2019).

The species diversity in the different sections was medium to low in terms of composition and abundance, respectively compared to the results of Rasmussen and Rasmussen (2018), and may be the response to forest alterations in the last 30 years since the Wealth is positively associated with the age of succession (Paredes-Ulloa *et al.*, 2021).

Habitat preference by vascular epiphytes

Characteristics such as the presence of emerging adult trees with abundant and thick branches, rough bark determine the presence of epiphytes, particularly their richness (Armijos *et al.*, 2017). In this regard, Krömer *et al.* (2007) and Rasmussen and Rasmussen (2018) report that elements that facilitate the colonization of epiphytes are determinants in habitat preference such as the size of the tree, since it regulates the intensity of light captured by epiphytes in the canopy or interior, the structure of the tree, presence of the number of thick branches, a rough bark, the presence of metabolites that favor or inhibit its development and not to mention the retention of water and nutrients. However, Paredes-Ulloa *et al.* (2021) suggest that the most important characteristic is the diameter of the host, which facilitates the presence of a greater number of epiphytes.

The abundance of *Alnus acuminata* as a preferred phorophyte for nine species of vascular epiphytes could be related not only to the abundance of tree species in the area but also to the physiognomy of the specimens, since the vast majority had a large, highly branched appearance, with semi-rough bark and spaces between the branches like a slit that favors the preference of the phorophyte (Martínez-Meléndez *et al.,* 2008 and Salazar-Ramirez *et al.,* 2014). But *Cedrela montana*, with lower abundance in the area, had a high value as a preferred species, which is related to the presence of irregular longitudinal fissures in its trunk that determines the preference for its bark and tree structure.

CONCLUSIONS

In the Andean forest, 7,610 individuals of vascular epiphytes were recorded in four families and 12 species, where *Tillandsia tovarensis, Pleurothallis maxima* and *Cyrtochilum aureum* were the most abundant.

There is a distribution pattern in species and abundance in the studied families, Bromeliaceae and Orchidaceae towards section 3, while Piperaceae and Araceae were concentrated towards sections 1 and 2 of the phorophytes due to the higher humidity.

Two species of phorophytes are preferred: *Alnus acuminata* and *Cedrela montana* for their diameter, branching and bark characteristics.

In the Andean forest of the "Francisco Vivar Castro" University Park, vascular epiphytes have low and medium diversity in the three sections, reflecting its recovery and growth process.

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Zhofre Huberto Aguirre Mendoza: conception of the idea, research coordinator, financing of funds, statistical analysis, general advice, review and final version of the authorship.

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Jorge Luis Bustamante Jumbo: database creation, statistical analysis, preparation of tables and figures, writing of the original (first version).

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