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Diversity of corticolous lichens in cloud forest remnants in La Cortadura, Coatepec, Veracruz, México in relation to phorophytes and habitat fragmentation

Rosa Emilia PÉREZ-PÉREZ[a], Gonzalo CASTILLO-CAMPOS[b] & Marcela Eugenia da Silva CÁCERES[c]*

[a]Escuela de Biología, Benemérita Universidad Autónoma de Puebla CP 72570, Puebla, México

[b]Instituto de Ecología, A.C. Carretera Antigua a Coatepec, No. 351, El Haya, CP 91070 Xalapa, Veracruz, México

[c]Departamento de Biociências, Universidade Federal de Sergipe, CEP: 49500-000, Itabaiana, Sergipe, Brazil

Abstract – In order to make an inventory and learn more about the corticolous lichens diversity on the tree layers of the different environments of the cloud forest (Bosque Mesófilo de Montaña, BMM) in La Cortadura, Veracruz, a transect along the best preserved hill of the forest was delimited, in which 100 m^2 squared plots were delineated every 25 m and with different orientations on the slope. Lichen coverage was estimated among trees that had a DBH higher than 20 cm, on the orientation with the greatest lichen coverage. A non-quantitative and opportunistic sampling was done as well, among the same phorophytes. The data were analyzed using the principal component analysis. For each orientation on the hill, a Shannon diversity index was obtained. The species indicator analysis was applied, as well as the circular distribution method. The results indicate that within every 100 m^2 square plot, there were 62 individuals on average of the different phorophyte taxa, which host 108 lichen species: 52 (49.5%) correspond to foliose lichens, 47 (44.8%) to crustose lichens, 4 (3.8%) to fruticose lichens and 2 (1.9%) to dimorphic lichen thalli. In the BMM, in spite of being heterogeneous, the genus *Quercus* predominates, which benefits the lichen community, even though it is subject to changes in the forest structure, the available substratum, and to its capability to disperse.

Cloud forest / Lichen community / Diversity / México

INTRODUCTION

In México, the number of lichen species could well reach 5,000 species (Lücking *et al.*, 2009), with Veracruz being one of the states with the greatest number of known species so far (700), out of which 230 have been reported in rainforests (Herrera-Campos *et al.*, 2014). Among these, the cloud forest (BMM) is one of the most diverse ecosystems in México; it concentrates a high portion of the country's flora (ca. 10%), and it also has a high rate of endemism, due to the

* Corresponding author: emilia.perez@correo.buap.mx

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rugged terrain of its mountains. This forest shows a discontinuous distribution, in fragments of different sizes, and high species turnover rates between relatively close sites (Rzedowski, 1996). Nevertheless, it is also one of the most endangered ecosystems in México, mainly due to deforestation and changes in land use, which have caused a reduction of more than 50% of its original area (Williams-Linera, 2002; Challenger, 1998). In recent years, floristic inventories of this type of vegetation have intensified on the Pacific slope, as well as on that of the Gulf of México (Puig *et al.*, 1983; Luna *et al.*, 1988; Meave *et al.*, 1992; Santiago & Jardel, 1993).

In the state of Veracruz, the could forest, which used to cover large areas, is about to disappear, when 90% of the vegetation has been modified and the remaining 10% is in serious danger being surrounded by pastures, disturbed forests and secondary vegetation; all of which reduces its area even more due to the edge effect (Williams-Linera *et al.*, 2002; Williams-Linera, 2007). The few non-disturbed forests, and forest fragments in good state of preservation are found in places with very steep hills, which makes it difficult to access, thus also difficult to transform/perturb them. It is here that floristic inventories and ecological studies have been carried out (Álvarez-Aquino *et al.*, 2005; Williams-Linera *et al.*, 2005), thanks to which it is known that in spite of many disturbances, there are still relatively well preserved forest fragments left. It has been estimated that these patches host 43 species (= 21%) of the endemic flora of the state (Castillo-Campos *et al.*, 2005); and new taxa are still being described (Castillo-Campos *et al.*, 2009a, 2009b, Castillo-Campos *et al.*, 2013a, 2013b).

In the center of the state of Veracruz, only 10% of the original forest coverage is left (Williams-Linera, 2007), and that it hosts the greatest number of endangered species, among which and without a doubt are lichens. We know very little, almost nothing about the lichen diversity present within this type of vegetation (Miramontes-Rojas *et al.*, 2009; Córdova-Chávez *et al.*, 2014); thus, it is paramount to record and learn more about the diversity of corticolous lichens of the tree layers of the different environments of the cloud forest (BMM) in La Cortadura, Veracruz.

MATERIALS AND METHODS

Study site – The study was carried out at the locality of La Cortadura, located in the central highlands of the state of Veracruz, México (Fig. 1). The region of La Cortadura is covered by BMM, and is located on the slopes of Cofre de Perote, between 1,800 and 2,000 m, where the soil type Andosol humic of volcanic origin predominates. The site consists of a municipal reserve (Municipality of Coatepec) and a private property (García-Franco *et al.*, 2008). This part of the state of Veracruz is relatively well preserved, since 80% of the whole area corresponds to BMM, and 20% to other land uses (Fig. 1). The weather in this region is temperate-humid with an average temperature of 18°C (minimum 10-14°C and maximum 20-23°C) and an annual rainfall of 1,500 mm distributed throughout the year, with abundant rainfall from June to September (Williams-Linera, 2007; García-Franco *et al.*, 2008). The terrain in the area is highly irregular, with very steep slopes, and at the bottom of the gorges there are perennial water runoffs, which conform the springs of the highlands of The

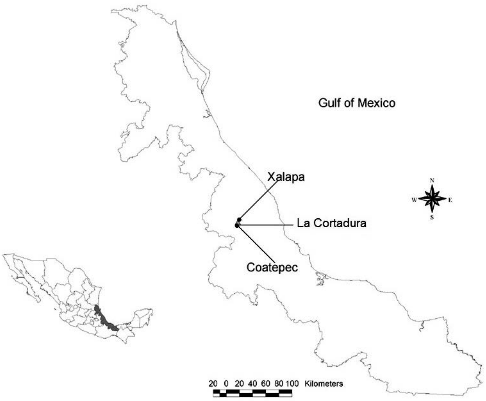

Fig. 1. Geographic situation of La Cortadura region, between Xalapa and Coatepec, State of Veracruz, Mexico.

Antigua river basin; this river basin in the state of Veracruz (2,326 km^2, 0-3,000 m) is considered by CONABIO (2000a, 2000b) as a region of high biodiversity (AAB), as a Terrestrial Priority Area (Pico de Orizaba-Cofre de Perote) and as a hydrological Priority Area (Gulf de México: Río La Antigua) (Muñoz-Villers & López-Blanco, 2008; García-Franco *et. al.*, 2008).

Lichen sampling and taxonomic identification – In order to include in the sampling all possible variation of lichen populations on the vegetation, 1,700 m^2 were sampled on a transect along the best preserved hill of the cloud forest. Within the transect, 17 sampling (10 × 10 m^2) squared plots were delineated every 25 m: 9 on the crest (C), 4 on the slope with north-east orientation (NE), 3 to the south-west (SW) and 1 to the east (E) (Table 1). Within each squared plot, a general environmental evaluation was done, taking into account woody coverage, bare soil, stoniness (all taken as related percentages to the sampling squared plot), as well as height and diameter at breast height (DBH) of all rooted trees. However, lichen coverage was estimated only on the tress that had DBH > than 20 cm, on the orientation in which a greater lichen coverage was observed (Cáceres *et al.*, 2007); for every squared plot, a piece of transparent plastic, 20 × 50 cm was used sub-divided in squares of 2 × 2 cm, which make a total of 250 squares and 1,000 cm^2, which conform the totality (100%) of the coverage per micro-quadrant (Kuusinen, 1994a; 1994b; Pérez-Pérez *et al.*, 2011); at the same time, a non-quantitative and opportunistic sampling was carried out (Cáceres *et al.*, 2008), which allowed us to record and make an inventory of lichen diversity of the BBM of La Cortadura, Veracruz. A list of all identified lichen and phorophyte species was made, following the Cronquist classification (1988) for phorophytes. Whereas for lichens, specialized corresponding keys were followed. The back-up phorophyte and lichen specimens were stored in the herbarium (XAL) of the Instituto de Ecología, A.C.

Data analysis – The data were analyzed using ordination and classification methods. The squares were sorted out with the main components analysis (PCA), taking into account presence-absence of the lichen species and the orientation of the recorded samplings in order to spot any spatial gradient among the phorophytes. For each orientation on the slope, the Shannon diversity index was obtained. The programs MVSP- V 3.13 y PCOrd 5.0 (McCune & Grace 2002) were used. The species indicator analysis (ISA) was applied, in order to identify those species that were significant indicators of a site ($p < 0.05$), for which

1,000 repetitions of the Montecarlo test were done. The (ISA) has an indicating value, based on the frequency and abundance of lichens (McCune & Grace, 2002; Cáceres *et al.*, 2007; Pérez-Pérez *et al.*, 2011). For each orientation on the slope, the Shannon diversity index was also applied, taking into account lichen coverage per orientation on the phorophyte; at the same time, the circular distribution method was used, using the Raleight and the V ($p < 0.05$) tests for corroboration (Zar 1999). Statistical analyses were made with the programs PCOrd 5, Statistica 6 and Excel.

RESULTS

Forest Inventory

On average, each 100 m^2 squared plot had 62 individuals from the different phorophyte taxa (Fig. 2), apart from herbs, vines and shrubs of species typical of the BMM, such as *Parathesis melanosticta* (Schldl.) Hemsley, *Hedyosmum mexicanum* Cordemoy, *Alchornea latifolia* Sw., *Liquidambar styraciflua* L.*,* *Miconia glaberrima* (Schldl.) Naudin*,* *Quercus laurina* Bonpl., *Turpinia occidentalis* (Sw.) G. Don.*,* *Vaccinium leucanthum* Schltdl. y *Clethra mexicana* DC.

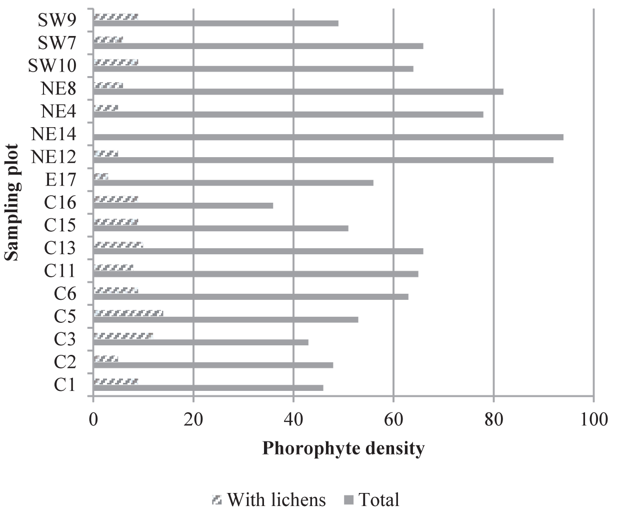

Fig. 2. Total number of phorophyte individuals of the different taxa registered per 100 m^2 squared plot (solid lines) and number of phorophytes that had a DAP > than 20 cm and had presence of lichens.

Ordination

Given the characteristics of the different environments of the BMM, it is observed that the squared plots of the south-west and the crest tended to cluster, as shown in Fig. 3, where there is a tendency of phorophyte richness per 100 m^2 that goes from lower richness to higher, and from left to right where axis 1 splits

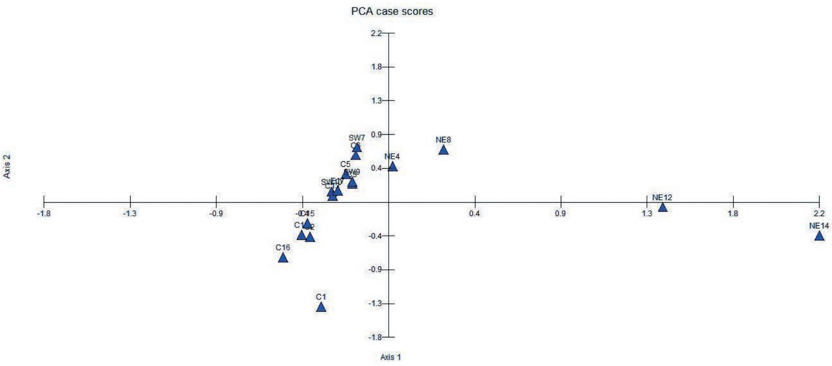

Fig. 3. Phorophyte spatial gradient, taking into account presence-absence of lichens and the orientation of the samplings

into two groups of squares. At the point where squares 4, 8, 12 y 14 split, due to their north-east orientation, and greater phorophyte richness, ranging from 12 to 14 phorophytes with DBH > than 20 cm per 100 m^2; and there is the group to the left including squares 1, 2, 3, 5, 6, 7, 9, 10, 11, 13, 15, 16 and 17, which have variable phorophyte richness of 5 to 11 species of trees.

On the two orientations of the slope (SW y C), the greatest number of phorophyte individuals with lichens was obtained, as well as the highest values regarding lichens richness and diversity (Table 1).

A total of 127 tree individuals, belonging to 13 different tree species were sampled (Table 2); on eight out of those, it was possible to find more than 50% of lichen coverage. It is important to mention that *Quercus laurina* Bonpl., the only species found in all squared plots, was also the one showing the greatest lichen richness, followed by *Prunus samydoides* Schltdl. (15 squares), *Phyllonoma laticuspis* (Turcz) Engl. (14), *Zanthoxylum melanostictum* Schltdl. & Cham. (13) and *Vaccinium leucanthum* Schltdl. (12 squares).

A total of 108 lichen species were collected (Table 3), out of which, 69 were collected on the selected phorophytes of the samples squares, and the rest during the opportunistic sampling. Some of the stems were too small, or lacked reproductive structures; thus, were not useful for species identification.

Of the collected species, 52 (49.5%) correspond to foliose lichens, 47 (44.8%) to crustose lichens, 4 (3.8%) to fruticose lichens and 2 (1.9%) to compound lichens. Considering only the species collected on the selected phorophytes, we learned that out of the 56 species collected on the crest, only 12 species showed the greatest coverage, whereas foliose lichens predominated

Table 1. Lichen diversity on the different orientations of the slope

Aspect	*Tree density*	*Phorophyte with lichens*	*Richness lichens*	*Total cover (cm^2)*	*Mean*	*Stand. Dev.*	*Stand. Error*	*Diversity index (H)*
Crest	471	84	56	17600	255.07	389.122	46.84	3.303
East	56	3	5	160	2.32	9.085	1.09	1.524
Northeast	346	16	17	2544	36.87	114.579	13.79	2.199
Southeast	179	24	24	2320	33.62	72.881	8.77	2.761

Table 2. Phorophyte species and number of sampled individuals on the different orientations of the 17 squared plots

Aspect	*Phorophyte*			*Richness lichens*
	Specie	*Family*	*Frequency*	
Crest	*Alnus acuminata* Kunth	Betulaceae	5	11
	Clethra mexicana DC.	Clethraceae	1	1
	Ilex discolor var. *tolucana* (Hemsl.) Edwin ex T.R. Dudley	Aquifoliaceae	2	5
	Liquidambar styraciflua L.	Altingiaceae	4	6
	Phyllonoma laticuspis (Turcz.) Engl.	Phyllonomaceae	1	1
	Podocarpus matudae Lundell	Podocarpaceae	1	3
	Prunus samydoides Schltdl.	Rosaceae	9	13
	Quercus laurina Bonpl.	Fagaceae	42	35
	Ternstroemia sylvatica Schltdl. & Cham.	Pentaphylacaceae	4	6
	Vaccinium leucanthum Schltdl.	Ericaceae	12	14
	Zanthoxylum melanostictum Schltdl. & Cham.	Rutaceae	3	6
East	*Quercus laurina* Bonpl.	Fagaceae	3	5
Northeast	*Alchornea latifolia* Sw.	Euphorbiaceae	3	7
	Phyllonoma laticuspis (Turcz.) Engl.	Phyllonomaceae	1	1
	Quercus laurina Bonpl.	Fagaceae	9	7
	Ternstroemia sylvatica Schltdl. & Cham.	Pentaphylacaceae	1	1
	Zanthoxylum melanostictum Schltdl. & Cham.	Rutaceae	2	7
Southeast	*Clethra mexicana* DC.	Clethraceae	2	3
	Liquidambar styraciflua L.	Altingiaceae	1	3
	Pinus patula Schltdl. & Cham.	Pinaceae	1	2
	Prunus samydoides Schltdl.	Rosaceae	5	6
	Quercus laurina Bonpl.	Fagaceae	12	13
	Ternstroemia sylvatica Schltdl. & Cham.	Pentaphylacaceae	1	1
	Vaccinium leucanthum Schltdl.	Ericaceae	1	1
	Zanthoxylum melanostictum Schltdl. & Cham.	Rutaceae	2	3

over crustose lichens. On the eastern slope, five species were found (four foliose and 1 crustose), on the northeastern slope 17 species were found, out of which, four showed the greatest coverage (three crustose and one foliose); whereas on the southeastern slope, out of the 24 collected species, seven showed the greatest coverage (five foliose, one compound and one crustose) (Tables 1 & 4). On the other hand, the species indicator analysis (ISA) indicates that *Tylophoron moderatum* Nyl. and *Parmotrema* cf. *mellissii* showed some degree of preference for the eastern slope.

Taking into account presence-absence of lichen species in the different forest environments, it's been found that the crest and the SW are the ones sharing the greatest number of species (18), followed by the crest and the NE with 11 species; being these species common to the three orientations: *Cladonia* sp., *Herpothallon rubrocinctum*, *Megalospora sulphurata*, *Parmotrema cristiferum*, and *Parmotrema mellissii*; whereas *Hypotrachyna* sp. was common to the four orientations. The obtained results seem to indicate that at the crest, as well as on the slope with south-west orientation, there is no evidence of preference for any particular orientation on the phorophyte, whereas on the east and northeast, they tend to be oriented to the northeast and southeast of the phorophyte (Table 5).

Table 3. Lichen species found on the sampled squared plots of the BMM at La Cortadura, Veracruz (highlighted names indicate the species from the opportunistic sampling)

Species	*Species*
Ampliotrema sp.	*Leptogium azureum* (Sw. ex Ach.) Mont.
Ancistrosporella australiensis (G. Thor) G. Thor	*Leptogium burnetiae* C.W. Dodge
Bacidia heterochroa (Müll. Arg.) Zahlbr.	*Malcomiella hypomelaena* (Nyl.) Cáceres & Lücking
Bacidiopsora sp.	*Malmidea piperis* (Spreng.) Kalb, Rivas Plata & Lumbsch
Brigantiaea leucoxantha (Spreng.) R. Sant. & Hafellner	*Malmidea vinosa* (Eschw.) Kalb, Rivas Plata & Lumbsch
Carbacanthographis sp.	*Megalospora* sp.
Chapsa sp.	*Megalospora sulphurata* Meyen
Cladonia macilenta Hoffm.	*Myriotrema* sp.
Cladonia sp.	*Ocellularia* sp. A
Coenogonium sp.	*Ocellularia* sp. B
Crocynia pyxinoides Nyl.	*Pannaria* sp.
Unknown sp. A	*Parmelia* sp.
Unknown sp. B	*Parmelinopsis* cf. *minarum*
Unknown sp. C	*Parmelinopsis horrescens* (Taylor) Elix & Hale
Dibaeis absoluta (Tuck.) Kalb & Gierl	*Parmotrema cetratum* (Ach.) Hale
Diorygma sp.	*Parmotrema* cf. *mellisii*
Eugeniella leucocheila (Tuck.) Lücking, Sérus. & Kalb	*Parmotrema cristiferum* (Taylor) Hale
Everniastrum cf. *arsenei*	*Parmotrema lobuliferum* (C.H. Ribeiro & Marcelli) O. Blanco, A. Crespo, Divakar, Elix & Lumbsch
Everniastrum vexans (Zahlbr. ex W.L. Culb. & C.F. Culb.) Hale ex Sipman	*Parmotrema mellissii* (C.W. Dodge) Hale
Fissurina sp.	*Parmotrema peralbidum* (Hale) Hale
Flavoparmelia rutidota (Hook. f. & Taylor) Hale	*Parmotrema rampoddense* (Nyl.) Hale
Flavoparmelia sp.	*Parmotrema robustum* (Degel.) Hale
Graphidaceae sp. A (sterile)	*Parmotrema* sp.
Graphidaceae sp. B (sterile)	*Parmotrema subisidiosum* (Müll. Arg.) Hale
Graphis leptoclada Müll. Arg.	*Parmotrema subrugatum* (Kremp.) Hale
Graphis librata C. Knight	*Parmotrema subsumptum* (Nyl.) Hale
Graphis mexicana (Hale) Kalb, Lücking & Lumbsch	*Parmotrema subtinctorum* (Zahlbr.) Hale
Graphis rhizicola (Fée) Lücking & Chaves	*Parmotrema ultralucens* (Krog) Hale
Graphis sitiana Vain.	*Peltigera polydactylon* (Neck.) Hoffm.
Graphis striatula (Ach.) Spreng.	*Pertusaria* sp.
Graphis subassimilis Müll. Arg.	*Pertusaria tropica* Vain.
Graphis tenella Ach.	*Phaeographis* cf. *dentritica* group
Hemithecium sp.	*Phyllopsora buettneri* (Müll. Arg.) Zahlbr.
Herpothallon rubrocinctum (Ehrenb.) Aptroot, Lücking & G. Thor	*Phylopsora ochroxantha* (Nyl.) Zahlbr.
Heterodermia appalachensis (Kurok.) W.L. Culb.	*Polymeridium suffusum* (Knight) Aptroot
Heterodermia boryi (Fée) Kr.P. Singh & S.R. Singh	*Porina* sp.
Heterodermia crocea R.C. Harris	*Protoparmelia multifera* (Nyl.) Kantvilas, Papong & Lumbsch
Heterodermia japonica (M. Satô) Swinscow & Krog	*Pseudocyphellaria aurata* (Ach.) Vain.
Heterodermia lamelligera (Taylor) Trass	*Punctelia bolliana* (Müll. Arg.) Krog
Heterodermia microphylla (Kurok.) Skorepa	*Punctelia hypoleucites* (Nyl.) Krog
Heterodermia obscurata (Nyl.) Trevis.	*Punctelia* sp.
Heterodermia sp.	*Punctelia* sp. A
Hypotrachyna costaricensis (Nyl.) Hale	*Pyrenula* cf. *duplicans* group
Hypotrachyna imbricatula (Zahlbr.) Hale	*Ramalina leptocarpha* Tuck.
Hypotrachyna isidiocera (Nyl.) Hale	*Sticta beauvoisii* Delise
Hypotrachyna punoensis Kurok. & K.H. Moon	*Sticta sylvatica* (Huds.) Ach.
Hypotrachyna sp. A	*Syncesia psaroleuca* (Nyl.) Tehler
Hypotrachyna sp. B	*Teloschistes flavicans* (Sw.) Norman
Hypotrachyna sp.	*Telothrema* sp.
Hypotrachyna subpustulifera Elix	*Trypethelium ochroleucum* (Eschw.) Nyl.
Lecanactis sp.	*Tylophoron moderatum* Nyl.
Lecanora sp.	*Usnea filipendula* Stirt.
Leptogium austroamericanum (Malme) C.W. Dodge	*Usnea rubicunda* Stirt.

Table 4. Lichens with the greatest coverage (total and relative), and their presence-frequency on the sampled phorophytes, taking their orientation on the slope into account

Aspect	*Specie*	*Frequency*	*Total Cover ± Error Stand.*	*Relative Cover (%)*	*ISA p*
Crest	*Herpothallon rubrocinctum*	11	1732 ± 12.23	9.31	
	Parmotrema mellissii	30	1536 ± 3.93	8.26	
	Parmotrema robustum	9	1424 ± 7.30	7.66	
	Unknown sp. C	6	1100 ± 8.65	5.91	
	Graphis subassimilis	1	1000 ± 11.90	5.38	
	Phyllopsora buettneri	1	1000 ± 11.90	5.38	
	Ocellularia sp.	10	948 ± 5.62	5.10	
	Crocyia pyxinoides	1	900 ± 10.71	4.84	
	Parmotrema subsumptum	1	900 ± 10.71	4.84	
	Parmotrema rampoddense	1	600 ± 7.14	3.23	
	Everniastrum vexans	8	584 ± 3.93	3.14	
	Peltigera polydactylon	1	500 ± 5.95	2.69	
East	*Parmotrema* cf. *mellisii*	1	52 ± 17.33	32.5	0.025
	Flavoparmelia sp.	1	40 ± 13.33	25	
	Tylophoron moderatum	1	32 ± 10.67	20	0.025
	Hypotrachyna sp.	1	20 ± 6.67	12.5	
	Everniastrum vexans	1	16 ± 5.33	10	
Northeast	*Megalospora sulphurata*	1	600 ± 35.29	23.58	
	Herpothallon rubrocinctum	4	596 ± 24.02	23.43	
	Graphidaceae (sterile)	3	372 ± 16.57	14.62	
	Parmotrema mellissii	3	248 ± 9.80	9.75	
Southeast	*Parmotrema mellissii*	4	416 ± 9.30	17.93	
	Parmotrema cristiferum	1	220 ± 8.80	9.48	
	Cladonia sp.	2	216 ± 7.28	9.31	
	Parmotrema lobuliferum	2	192 ± 6.47	8.28	
	Herpothallon rubrocinctum	3	180 ± 5.02	7.76	
	Sticta beauvoisii	2	172 ± 5.45	7.41	
	Flavoparmelia sp.	3	144 ± 4.11	6.21	

To confirm the above, the circular distribution method was applied, using the Raleight and V ($p < 0.05$) tests for checkup (Zar, 1999), resulting in the first, that the values are non-significant, which indicates that the lichen communities in the site distribute at random. Nevertheless, the V test proved significant for the NE orientation, where most of the lichens were present on the northeast of the phorophytes. Lichens distribution is without a doubt influenced by the physical characteristics of the site, such as exposure of the slope, tree density, presence of stumps, the disturbance factor, etc. It has been observed that at the crest and southeast orientations, lichens can spread in every direction, whereas on the east and northeast slopes, preference toward the northeast and south-east is noticeable (Fig. 4).

Table 5. Index of diversity by orientation on the slope and on the sampled phorophytes (Phorophyte frequency by aspect: Crest = 84, East = 3, Northeast = 17 and Southeast = 25); H = diversity index

Aspect		*Richness*	*Total Cover (cm^2)*	*Stand.Dev.*	*Stand. Error*	*H*
Plot	*Phorophyte*					
Crest	E	6	1280	123.81	16.55	0.906
	N	14	994	70.65	9.44	1.846
	NE	21	4266	175.81	23.5	2.488
	NW	9	820	42.28	5.65	1.963
	S	9	316	17.72	2.37	1.879
	SE	15	4872	251.54	33.61	2.011
	SW	30	5568	216.71	29	2.603
	W	4	484	41.47	5.54	0.984
East	NE	2	56	17.53	7.84	0.598
	SE	3	104	22.16	9.91	1.026
Northeast	N	2	136	24.66	6	0.606
	NE	15	2372	200.37	49	2.033
	SE	2	36	6.34	1.54	0.637
Southeast	N	5	404	39.91	8.15	1.462
	NE	7	272	23.19	4.73	1.717
	NW	4	308	40.29	8.23	0.955
	S	4	304	45.20	9.23	0.887
	SE	9	596	54.76	11.18	1.665
	SW	6	436	47.09	9.61	1.358

DISCUSSION AND CONCLUSION

The results of the structure and tree composition analysis of the sampled site match those reported by García-Franco *et al*. (2008), who stated that in spite of the fact that the forest at La Cortadura is surrounded by an anthropised area, it is still in good state of conservation. The forest still hosts a dense tree coverage and emergent trees of up to 40 m in height, as well as a canopy with an average height of 27 m; being these remnant trees the ones that have allowed the conservation of lichen communities (Jüriado *et al*., 2011, Király *et al*., 2013).

Most foliose lichens are found at the crest where there is greater tree density; these results match those by Woda *et al*., 2006, who suggest that complex interaction between light conditions, relative air humidity and the capability of the forest to collect fog affect the abundance of epiphytes; whereas crustose lichens are more light-resistant and are found on the NE slope where there is less tree density.

Nascimbene *et al*., (2014) suggest that lichen diversity is closely related to forest heterogeneity. Lichens preference for either a slope orientation (*Tylophoron moderatum* and *Parmotrema* cf. *mellisii*, which showed preference for the eastern slope), or for a phorophyte (different studies indicate that lichens prefer north orientation (Kivistö & Kuusinen, 2000; Pérez-Pérez *et al.*, 2011) would depend on light conditions, temperature and DAP (Estrabou *et al.*, 2014; Soto-Medina *et al.*, 2012), matching observations made by authors such as Löbel *et al*. (2006), Jüriado *et al.* (2009), and Nascimbene *et al*. (2009). Kivinen *et al.* (2012) point out that lichen distribution is subject to the microclimatic conditions

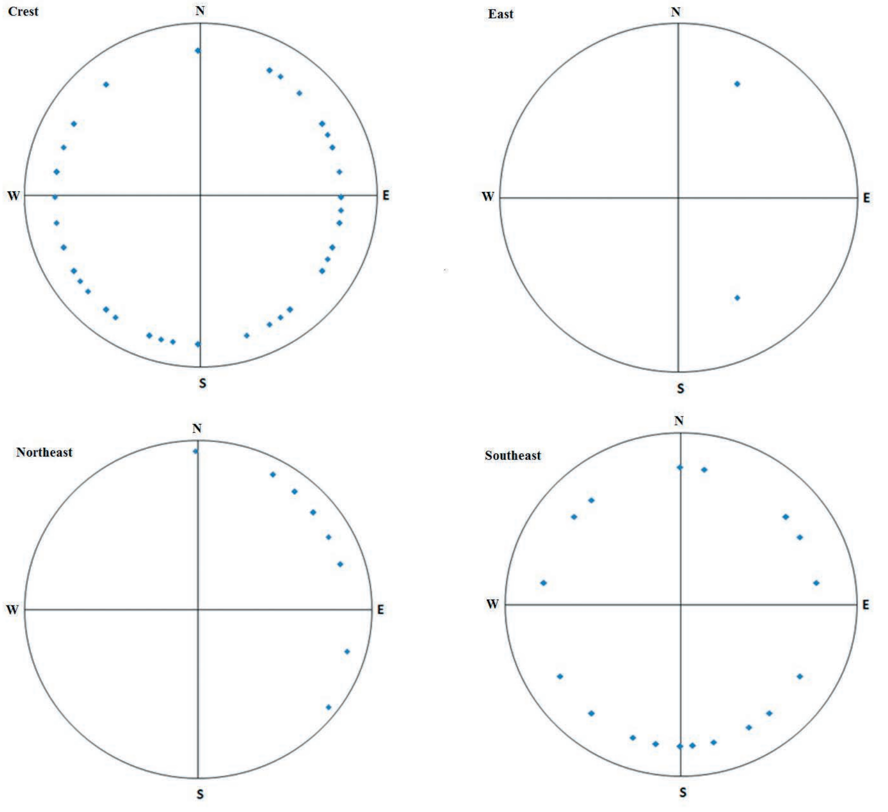

Fig. 4. Distribution of lichen communities on the different orientations of the sampled phorophytes

resulting from forest structure, as well as to the available substrate, which either allows colonization, or not; together with the species capability to spread locally (Öckinger *et al.*, 2005). However, another important factor that must be taken into account is that the phorophyte that showed the greatest frequency was *Quercus laurina*, and one characteristic of this genus is that, due to its rough bark, it retains more humidity for a longer period of time; thus it is considered a favorable host for lichens (Vicol, 2010, Király *et al.*, 2013).

It is true that the greatest threats for the forests are forest management, air pollution and changes in landscape structure (Thor, 1998), The presence of species, typical of tropical forests, such as *Herpothallon rubrocinctum* (Aptroot *et al.*, 2009), which was one of the most abundant, as well as the new species for Mexico (Córdova-Chávez *et al.,* 2014), show us how diverse the cloud forest is in terms of lichens, even in spite of being one of the most seriously affected ecosystems by local and global change (Zotz & Bader 2009). In fact, cloud forest conservation at La Cortadura is closely related to its difficult Access, which allows it to still have heterogeneity in its landscape; while the lichen community, even if it is subject to changes in the forest structure; due to the available substrate and to its capability to spread, it's being favored by the presence of remnant phorophytes of the genre *Quercus,* which allow maintenance.

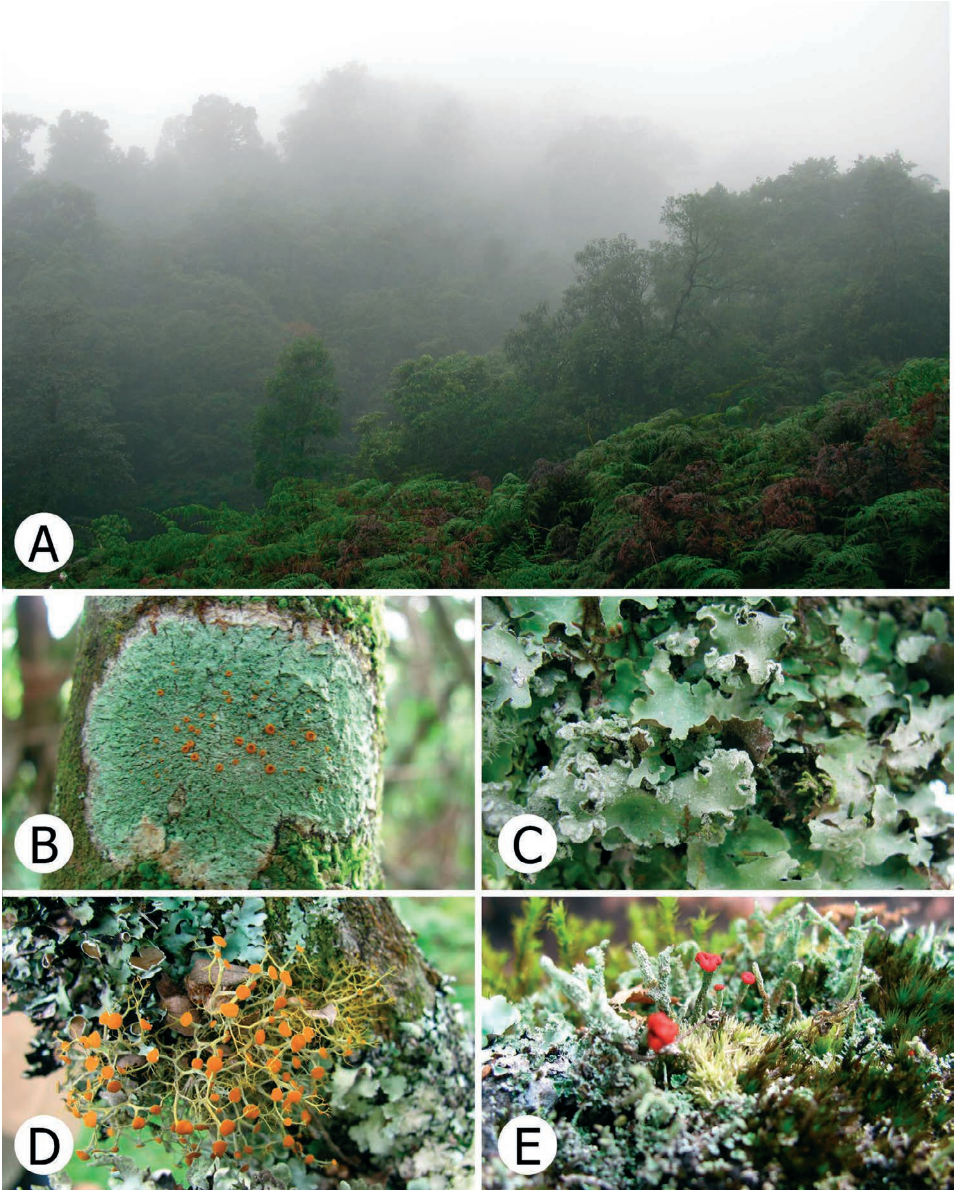

Fig. 5. **A.** Cloud forest from La Cortadura, Veracruz, **B.** *Brigantiacea leucoxantha*; **C.** *Flavopunctelia soredica;* **D.** *Teloschistes flavicans;* **E.** *Cladonia macilenta* (Pictures by R.E. Pérez-Pérez)

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