Tree canopy composition in the tropical mountain rainforest of los Tuxtlas, Mexico

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Abstract: We studied the arboreal composition of the tropical mountain rainforest's upper canopy in the San Martín Pajapán volcano, Tatahuicapan, Veracruz, México (18°26' N; 94°17' W). Two forest stands were studied, one in an exposed position and one protected. The Shannon index of diversity and the Jaccard index of affinity were calculated to calculate affinities between plots and between stands of different environmental exposures. The average Shannon value was 3.391 +0.121 for the exposed zone and 3.511 +0.53 for the protected zone. There is a greater species number and tree density in the exposed stand. This difference might be caused be different orientation to dominant winds. The diversity index value is high is similar between the stands, despite the important difference in species composition. Rev. Biol. Trop. 56 (3): 1571-1579. Epub 2008 September 30.

Key words: canopy, neotropic, plant biodiversity, rainforest, Tuxtlas.

The Tropical Mountain Rain Forest (sensu Miranda and Hernández 1963) of Mexico has been studied from various scientific approaches analysing the floristic variations as related to environmental factors (Pérez 1967, Chavelas 1967), methodology aspects (Miranda *et al.* 1967) and types of management (Caballero 1978, Toledo 1978). There is significant knowledge about the diversity of trees in the hot-humid zones of Mexico and over the need for their conservation (Carabias 1979, Wendt 1989, Dirzo and García 1992, Ochoa-Gaona *et al.* 2004, Mendoza *et al.* 2005).

There are various proposed hypotheses for explaining the high biological diversity of the tropical forest and many of these complement each other. Among the hypotheses put forward are found the effect of disturbances (Connell 1978; Whitmore and Burslem 1998; Dickinson *et al.* 2000), the different rate of seed predation (Janzen 1970, Connell 1971) and the great stability, globally, of these environments (McArthur 1972).

The objective of this study is to know the arboreal composition of the tropical mountain rainforest's upper canopy so as to contribute new data for understanding the vegetation diversity of the tropical forest.

MATERIALS AND METHODS

Study site: the study was undertaken in the high evergreen jungle in Mexico, in the San Martín Pajapán volcano, between 550 and 650 masl, which corresponds to the municipality of Tatahuicapan, Veracruz, México (18°26' N; 94°17' W).

The soils are fine, reddish clay or laterite (Ríos Macbeth 1952) and acid in nature (pH 2.9-42). The dominant winds are the trade winds, originating in the North Atlantic and the dominant direction is north-easterly to the west

or south. (García 1970). The slope exposed to the dominant winds allows for the entry of humid winds coming from the Gulf and also the cold northerlies, and prevents the passage of these winds to the protected opposite slope. The average annual temperature is greater than 20 °C and the average annual precipitation varies between 1 500 y 3 000 mm.

The studied zone is located in the San Martín Pajapán volcano at an average altitude of 600 m. Two forest stands of 40 000 m2 (400 x 100 m) were studied, one being in an exposed situation and the other protected. They were some two kilometres apart. In each stand four plots were sampled, each of one hectare in area and arranged contiguously forming a strip. The sampling was undertaken between 1995 and 2000, following the methodology used by the majority of vegetation ecologists in Mexico, Central America and other places in the Neotropic (Miranda *et al.* 1967, Vazquez-Torres *et al.* 1995, Ramírez 1999).

Species of trees of a diameter greater than 20 cm at a height of 1.30 m above the ground were identified using characteristic flora (Rzedowski 1991, Vázquez Torres 2003) and the number of individuals of each species in each plot were counted. The approximately 2 000 botanical specimens herborized were deposited in the herbariums of the Instituto de Investigaciones Biológicas de la Universidad Veracruzana (CIB) and of the Instituto de Ecología (XAL).

The indices of diversity of Shannon (H´) (Whittaker 1972, Magurran 1988) and of affinity of Jaccard (Zar 1984) were calculated using the data obtained to calculate affinities between plots and between stands of different environmental exposures. The statistical analysis of t-Student (Abacus concepts 1996) was applied for a comparison of the averages of the studied variables between stands and plots.

RESULTS

There were identified 115 species of trees and the most important species in the composition of the upper arboreal canopy were: Pseudolmedia oxyphyllaria, Rheedia edulis, Sterculia mexicana, Pouteria torta, Psychotria chiapensis, Roupala montana, Tapirira macrophylla, Ilex discolor, Ocotea dendrodaphne, Guarea grandifolia, Inga quaternata, Pouteria lucentifolia, Clethra macrophylla, Virola guatemalensis, Dendropanax arboreus, Alchornea latifolia y Dialium guianense.

In the exposed stand the total number of species was 101 whereas in the protected stand it was 83. Some 49 families were registered, 19 of which were found to be represented by a single species and 33% of the tree species belonged to five families. There were 69 species common to both zones (60%). There were 32 species exclusive to the exposed stand and 14 exclusive to the protected stand. A notable fact is that 16 of the 115 species of the upper canopy were found to be represented by a single individual, of these ten were located in the exposed stand and 6 were in the protected one (Annexe 1).

In the case of the exposed stand the species total was 101 and for each plot the results were 45, 52, 60 and 62 respectively for an average of 54.75 species per hectare. In the protected stand we found 83 species corresponding to 50, 53, 49 and 49 respectively giving an average of 50.25 species per hectare.

In terms of the diversity values, the average value of the index of Shannon was 3.391 ±0.121 for the exposed zone and 3.511 ±0.53 for the protected one. The statistical analysis doesn't show a significant difference between them. The variations between the values of the diversity indices obtained in each of the plots within each stand are very small and not statistically significant.

The index of Jaccard values between the plots within each stand varied between 0.295 and 0.469, with an average of 0.402 ±0.026. In the case of the protected stand the values varied between 0.471 and 0.571, the average being 0.516 ±0.017 (Table 1). In comparing the plots two by two within each stand, significant differences were observed between them, that being that the similarity between the plots in the protected stand was significantly greater

than between those in the exposed one (Table 2). The distribution of the values between the 16 possible combinations of pairs between the plots in the exposed and protected varied between 0.346 and 0.521, the average being 0.431 ± 0.012.

DISCUSSION

There is a great concentration of vegetation richness in these forests with very different species numbers between plots in a single stand and between zones of different exposure. However, there is a greater species number and density of trees in the exposed stand compared to the protected one. One of the reasons for this difference could be caused be different orientation to dominant winds. The preponderance of any of these factors over others would demand detailed studies of the dynamics of the plots in different environmental conditions. On the other hand, the diversity index value is high and is similar between the stands, which indicates that the diversity pattern is similar in dif-

TABLE 1
Values for the indices of similarity of Jaccard for pairs of plots within each stand

	Exposed stands			Protected stands		
	plot 1	plot 2	plot 3	plot 1	plot 2	plot 3
plot 2	0.385	-		0.471	-	
plot 3	0.381	0.417	-	0.523	0.500	-
plot 4	0.465	0.295	0.469	0.571	0.478	0.555

TABLE 2
Values for the indices of similarity of Jaccard by pairs of plots between stands: exposed and protected

		Protected stand			
		plot 1	plot 2	plot 3	plot 4
Exposed stand	plot 1	0.397	0.380	0.437	0.460
	plot 2	0.360	0.360	0.360	0.360
	plot 3	0.466	0.466	0.466	0.466
	plot 4	0.455	0.455	0.455	0.455

TABLE 3
Comparison of the results obtained in this study with others undertaken in various mountain rainforests of Mexico and the New World tropics

Authors	Place	Studied area	Diameter of trees (DBH)	Number of trees	Number of species	Number of trees. Ha^{-1}	Number of species. Ha^{-1}
Black, *et al.*, 1950	Amazonas, Brasil	5 Ha	≥20 cm	195	62	39	12
Vera Caletti, 1988	Chimalapa, Oaxaca	5 Ha	≥27.5 cm	654	62	130	12
Wendt, 1989	Uxpanapa, Veracruz	5 Ha	≥28.5 cm	534	80	106	16
Vázquez Torres, 1991	Uxpanapa, Veracruz	5 Ha	≥28.5 cm	546	69	109	14
Vázquez-Torres y Onaindia	Volcán San Martín Pajapan, Veracruz	8 Ha	≥20 cm	1666	115	208	14

ferent stands although the species composition is very different. Also there is great similarity between the area studied and other areas in the Neotropics in terms of species density per hectare and the number of trees. The values of the studied area are similar to those obtained for the Uxpanapa zone (Wedt 1989, Vázquez Torres 1991) and for Los Chimalapas (Vera Calletti 1988), all being part of the Tehuantepec Isthmus (Table 3). In comparison with some zones in Amazonia in Brazil (dry land jungles) (Black *et al.* 1950) they are similar in terms of species richness but the number of individuals is greater in the Mexican zones (Table 3).

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RESUMEN

El objetivo de este trabajo fue conocer la composición arbórea del bosque tropical lluvioso en el volcán de San Martín Pajapán. Se comparan dos áreas en diferente exposición: expuesta a los vientos dominates y protegida de los vientos. El valor medio del índice de diversidad de Shannon es de 3.391 +0.121 para la zona expuesta y 3.511 +0.53 para la protegida. El número de especies y la densidad de árboles por hectárea es mayor en la zona expuesta y la composición de especies es muy diferente entre las parcelas.

Palabras clave: copa arbórea, diversidad de plantas, neotrópico, selva lluviosa, Tuxtlas.

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ANNEXE 1

Tree species, indicating the families to which they belong by alphabetical order of family. The total number of individuals in the exposed and protected stands are indicated

Family	Genus	Species	Exposed stand	Protected stand	Total
ACTINIDIACEAE	*Saurauia*	*scabrida* Hemsl.	11		11
ANACARDIACEAE	*Astronium*	*graveolens* Jacq.	6		6
	Spondias	*radlkoferi* Donn. Sm.	5	6	11
	Tapirira	*macrophylla* Lundell	11	25	36
	T.	*mexicana* Marchand	8		8
ANNONACEAE	*Cymbopetalum*	*baillonii* R.E. Fries	11	14	25
	C.	*penduliflorum* (Dunal) Baill.	5		5
	Guatteria	*anomala* R.E. Fries	3		3
	Rollinia	*jimenezii* Saff.	9	5	14
APOCYNACEAE	*Stemmadenia*	*donnell-smithii* (Rose) Woodson	2	1	3
	Aspidosperma	*megalocarpon* Müll. Arg		1	1
AQUIFOLIACEAE	*Ilex*	*discolor* Hemsl.	15	20	35
	I.	*valeri* Standl.	8	4	12
	Ilex	sp.	2		2
ARALIACEAE	*Dendropanax*	*arboreus* (L.) Decne. & Planch.	29	9	38
BOMBACACEAE	*Quararibea*	*funebris* (Lllave) Vischer	1		1
BORAGINACEAE	*Cordia*	*gerascanthus* L.	10	1	11
	C.	*megalantha* Blake	1	1	2
CAPPARIDACEAE	*Crataeva*	*tapia* L.	1	8	9
CECROPIACEAE	*Cecropia*	*obtusifolia* Bertol.	7	2	9
CHRYSOBALANACEAE	*Couepia*	*polyandra* (Kunth) Rose	2	3	5
CLETHRACEAE	*Clethra*	*macrophylla* Mart. & Gal.	16	22	38
COMBRETACEAE	*Terminalia*	*amazonia* (J.F. Gmel) Exell	5	5	10
CYATHEACEAE	*Nephelea*	*mexicana* (Schltdl. & Cham.) R.M. Tryron		1	1
ELAEOCARPACEAE	*Sloanea*	*medusula* K. Schum. & Pittier	1	4	5
	S.	*tuerckheimii* Donn. Sm.		1	1
EUPHORBIACEAE	*Alchornea*	*latifolia* Sw.	22	13	35
	Croton	*draco* Schltdl.	2		2
	C.	*schiedeanus* Schltdl.	15	15	30
	Tetrorchidium	*rotundatum* Standl.	1	2	3
FLACOURTIACEAE	*Caseria*	*commersoniana* Cambess.	5	9	14
	Lunania	*mexicana* Brandegee	4	6	10
	Pleuranthodendron	*lindenii* (Turcz.) Sleumer	5	1	6

Family	Genus	Species	Exposed stand	Protected stand	Total
	Zuelania	*guidonia* (Sw.) Britton & Millsp.	20	14	34
GUTTIFERAE	*Calophyllum*	*brasiliense* Cambess	4	7	11
	Rheedia	*edulis* Triana & Planch	54	37	91
HAMAMELIDACEAE	*Liquidambar*	*styraciflua* L.	6		6
ICACINACEAE	*Calatola*	*laevigata* Standl.	19	8	27
LAURACEAE	*Beilschmiedia*	*mexicana*	2		2
	Nectandra	*ambigens* (Blake) C.K. Allen	2		2
	N.	*heydeana* Mez et Donnel Smith	12	14	26
	N.	*rubriflora* (Mez) C.K. Allen	3		3
	N.	*salicifolia* (H.B.K.) Nees	4		4
	N.	sp.	9		9
	Ocotea	*dendrodaphne* Mez	9	34	43
	O.	*rubriflora* Mez		1	1
	Phoebe	*ambigens* S.F. Blake	2		2
LEGUMINOSAE	*Bauhinia*	*guianensis* Aubl.	1		1
	Cynometra	*retusa* Britton & Rose	16	14	30
	Dialium	*guianense* (Aubl.)	10	29	39
	Dussia	*mexicana* (Standley) Harms.	1	1	2
	Inga	*pavoniana* G. Don	3		3
	I.	*quaternata* Poepp. & Endl.	19	23	42
	Lonchocarpus	*guatemalensis* Berth	1	10	11
	Myroxylon	*balsamum* L. (Harms.)	2	1	3
	Pithecellobium	*arboreum* (L.) Urb	2		2
	Platymiscium	*pinnatum* (Jacq.) Dugand		2	2
	Pterocarpus	*rohrii* Vahl	8	8	16
	Swartzia	*guatemalensis* (Donn. Sm.) Pittier	3	1	4
	Vatairea	*lundellii* (Standley) Killip. Ex Record	1		1
MAGNOLIACEAE	*Magnolia*	*schiedeana* Schltdl.	17	1	18
MELASTOMATACEAE	*Miconia*	*elata* (Sw.) DC.	10		10
	M.	*trinervia* (Sw.) D. Don ex Loudon.	9	13	22
MELIACEAE	*Guarea*	*bijuga* C. DC.		3	3
	G.	*glabra* Vahl	45	6	51
	G.	*grandifolia* DC.	14	20	34
	Trichilia	*martiana* C. DC.	4	8	12
MORACEAE	*Brosimum*	*guianense* (Aubl.) Huber	5	11	16
	Ficus	*yoponensis* Dsv.	3	1	4
	Ficus	sp.	3	1	4

Family	Genus	Species	Exposed stand	Protected stand	Total
	Pseudolmedia	*oxyphyllaria* Donn. Sm.	38	60	98
	Trophis	*racemosa* (L.) Urb.	1		1
MYRISTICACEAE	*Virola*	*guatemalensis* (Hemsl.) Warb.	28	30	58
MYRSINACEAE	*Parathesis*	sp.	2		2
MYRTACEAE	*Calyptranthes*	*millspaughii* Urb.	1	2	3
	Myrcia	*splendens* (Sw.) DC.	3		3
	Myrciaria	*floribunda* (H. West ex Willd.) O. Berg	11	1	12
OLEACEAE	*Chionanthus*	*domingensis* Lam.		2	2
POLYGONACEAE	*Coccoloba*	*barbadensis* Jacq.	7	8	15
	C.	*belizensis* Standl.	1	3	4
	C.	*hondurensis* Lundell	8	2	10
PROTEACEAE	*Roupala*	*montana* Aubl.	35	14	49
RUBIACEAE	*Chione*	*chiapensis* Standl.	10		10
	Chomelia	sp.		3	3
	Psychotria	*chiapensis* Standl.	28	21	49
	P.	*faxlucens* Lorence & Dwyer	3		3
	P.	*simiarum* Standl.	1	3	4
	Simira	*salvadorensis* (Standl.) Steyerm.	3		3
RUTACEAE	*Esenbeckia*	*pentaphylla* (Macfad.) Griseb	1		1
	Zanthoxylon	sp.		1	1
SAPINDACEAE	*Allophylus*	*camptostachys* Radek.	3	3	6
	Cupania	*dentata* Moc et Sessé ex D.C.	1		1
	Matayba	*oppositifolia* (A. Rich.) Britt.	2	1	3
	Thounidium	*decandrum* Melero	3	2	5
SAPOTACEAE	*Achras*	*chicle* Pittier		3	3
	Pouteria	*campechiana* (H.B.K.) Baehni	1		1
	P.	*durlandii* (Standl.) Baehni	3	2	5
	P.	*lucentifolia* (Standl.) Baehni	17	24	41
	P.	*torta* (Mart.) Radlk.	25	30	55
SCROPHULARIACEAE	*Uroskinnera*	*hirtiflora* var. *breviloba* (T. Wendt)	1	1	2
SIMAROUBACEAE	*Simarouba*	*glauca* DC.		2	2
STAPHYLEACEAE	*Turpinia*	*occidentalis* (Sw.) G. Don	4	20	24
	T.	*paniculata* Vent		6	6
STERCULIACEAE	*Sterculia*	*mexicana* R. Br.	37	38	75
THEACEAE	*Freziera*	*guatemalensis* (Donn. Sm.) Kobuski		9	9
	Laplacea	*grandis* Brand	1	16	17
TILIACEAE	*Belotia*	*mexicana* (DC.) K. Schum.	2	3	5

Family	Genus	Species	Exposed stand	Protected stand	Total
	Heliocarpus	*appendiculatus* Turcz.	33	4	37
ULMACEAE	*Ampelocera*	*hottlei* (Standl.) Standl.	2	1	3
	Aphanante	*monoica* (Hemsley) Leroy	1		1
	Ulmus	*mexicana* (Liebm.) Planch.	1		1
VIOLACEAE	*Orthion*	*oblanceolatum* Lundell	16	1	17
VOCHYSIACEA	*Vochysia*	*hondurensis* Sprague	16	5	21
		not known	1		1
		not known		1	1
		Total number of trees	897	769	1666
		Total number of species	101	83	115