Selbyana 21(1,2): 156–164. 2000.

FLORISTICS AND ECOLOGY OF MESOAMERICAN MONTANE CLIMBER COMMUNITIES: MONTEVERDE, COSTA RICA

ALEXANDER KRINGS

Department of Forestry, North Carolina State University, Raleigh, NC 27695. Current address: Herbarium (NCSC), Department of Botany, Campus Box 7612, North Carolina State University, Raleigh, NC 27695-7612 USA. E-mail: alexander_krings@ncsu.edu

ABSTRACT. Dicotyledonous woody climbers (≥2.5 cm diameter at breast height) of the Monteverde Cloud Forest Reserve in Costa Rica were sampled to study their floristics and ecology. Four 0.1 ha sample areas were used to analyze taxonomic composition, species richness, density, dominance, and family importance values. The Monteverde data then were compared to data on woody climbers in four other Mesoamerican montane forests. The Asteraceae are the most species rich family at Monteverde, followed by Sapindaceae and Vitaceae. In sample areas with no records of Fabaceae, either Hydrangeaceae or Piperaceae are always the dominant family in terms of basal area. The dicotyledonous woody climber families with the highest average number of species per sample area among the eight Mesoamerican 0.1 ha sample areas are, in decreasing order, Asteraceae, Sapindaceae, Vitaceae, Asclepiadaceae, and Celastraceae. Families with the highest combined family importance values, however, are in decreasing order: Vitaceae, Celastraceae, Hydrangeaceae, Piperaceae, and Asteraceae. The overall importance of Vitaceae and Celastraceae (shown by their respective combined family importance values) is attributed to the proportionately larger stem and wood production of Mexican representatives of these families.

RESUMEN. Se muestrearon y se analizaron (para composición taxonómica, riqueza de especies, densidad, dominancia y valores de importancia a nivel familia), las trepadoras leñosas dicotiledoneas ≥2.5 cm en diámetro a altura del pecho del Bosque Nuboso de Monteverde, Costa Rica usando cuatro áreas de muestra de 0.1 ha. Luego, los datos de Monteverde se compararon a cuatro otros bosques montañosos mesoamericanos. Los resultados muestran que la familia Asteraceae es, en riqueza de especies, la mas importante en Monteverde. En áreas de muestra sin Fabaceae, ya sea Hydrangeaceae o Piperaceae son las familias dominantes cuando se considera área basál. Las familias dicotiledoneas con lo mayor numero de especies por área de muestra en las ocho áreas de muestras de 0.1 ha mesoamericanas son, de mayor a menor numero de especies, Asteraceae, Sapindaceae, Vitaceae, Asclepiadaceae y Celastraceae. Sin embargo, las familias mas importantes según valores combinados de importancia a nivel familia son, de mayor a menor importancia, Vitaceae, Celastraceae, Hydrangeaceae, Piperaceae y Asteraceae. La importancia de Vitaceae y Celastraceae resulta de la gran producción de tallos y madera en estas familias en las comunidades mexicanas.

INTRODUCTION

Although neglected in both botanical collections (Gentry 1991) and ecological studies (Jacobs 1976, Putz 1984), climbing plants (or "climbers") are significant constituents of tropical forests and, arguably, the most important physiognomic character differentiating tropical and temperate forests (Croat 1978). Vegetation studies of Central and South American forests indicate that climbers can occur on 42–50% of forest trees (Montgomery & Sunquist 1978, Putz 1982, 1984). Studies by Gentry (1991, 1995) considerably increased our floristic understanding of many climber communities, including those of Neotropical montane forests. However, Mesoamerican montane forests remain relatively under-represented in the Gentry data. In addition his analyses of communities primarily compared species richness among sites and discussed familial "dominance" based on familial species richness rather than on stand basal area.

Although species richness comparisons are interesting taxonomically, a broader understanding of the composition of climber communities may be attained by analyzing baseline ecological parameters, such as density and dominance (based on basal area), and by combining them into family importance values. The objectives of this study were threefold: to increase the representation of Mesoamerican montane climber communities in floristic studies by sampling the forests of the Monteverde Biological Reserve in Costa Rica (a site incompletely sampled by Gentry 1995); to analyze the Monteverde climber community in terms of taxonomic composition, species richness, density, dominance, and family importance values; and to compare the Monteverde climber community to other Mesoamerican montane climber communities.

METHODS

Study Site

The dicotyledonous woody climber community of the Monteverde Cloud Forest Reserve

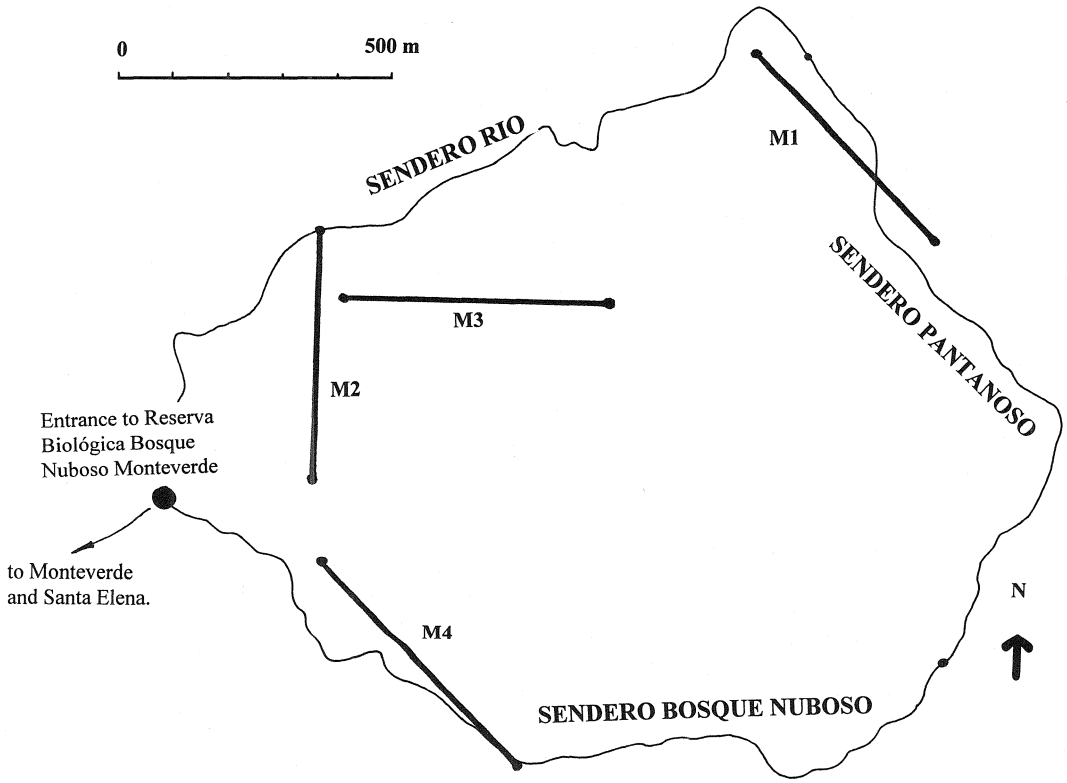

FIGURE 1. Location of four 0.1 ha sample areas (M1–M4) at the Monteverde Cloud Forest Reserve (Reserva Biológica Bosque Nuboso Monteverde) in Costa Rica, June–August 1996.

(Reserva Biológica Bosque Nubosa Monteverde), Cordillera de Tilarán, Costa Rica, was sampled from June to August 1996. Although several Holdridge Life Zones occur at the reserve (See Hartshorn 1983 for a detailed description), only climbers of the Tropical Lower Montane Rain Forest were sampled.

Plot Layout and Data Collection

A sampling technique developed by Gentry (1982) was used because it allows data comparison with previous Neotropical work (Gentry 1988, 1991, 1995) and with broader vegetational trends. The technique samples 0.1 ha areas by using 500 × 2 m belt transects laid out along a compass bearing. The starting point of each sample area was chosen randomly. Following Gentry (1991), all dicotyledonous woody climbers (i.e., lianas and climbing hemi-epiphytes) rooted within each transect and greater than or equal to 2.5 cm were identified, counted, and measured for diameter. Diameter measurements taken at breast height (1.4 m above the ground) were used to estimate dominance. For density calculations, stems branching at or below breast height were considered separate individuals. Four 0.1 ha sample areas were analyzed (FIGURE 1).

Specimen Collection

Voucher specimens were collected using expandable clipper poles and, in some cases, by climbing the host tree with the aid of caving ropes and equipment (Perry 1978, Moffett 1993, Laman 1995). Voucher specimens were deposited at Museo Nacional de Costa Rica (CR) and Field Museum of Natural History (F); see APPENDIX.

Calculation of Importance Values

A family importance value (FIV) was calculated for each recorded family *i* for each 0.1 ha sample area *j*, following Mori et al. (1983). The value is a composite weighting equally the species richness, density, and dominance of each recorded family. To rank families of different sample areas, a combined family importance

TABLE 1. Dicotyledonous woody climbers with number of species ≥2.5 cm diam. per family per 0.1 ha sample area (M1–M4) at Monteverde, Costa Rica, 1996.

Family	Species/family/sample area				Total spp.-site records	Aver. no. spp./area
	M1	M2	M3	M4		
Asteraceae	2	1	1	2	6	1.5
Hydrangeaceae	1	1	1	1	4	1.0
Piperaceae	1	1	1	1	4	1.0
Sapindaceae	1	1	—	1	3	0.75
Marcgraviaceae	1	—	1	—	2	0.5
Polygonaceae	—	—	1	1	2	0.5
Scrophulariaceae	—	1	1	—	2	0.5
Vitaceae	—	1	1	—	2	0.5
Asclepiadaceae	—	—	—	1	1	0.25
Celastraceae	1	—	—	—	1	0.25
Combretaceae	—	—	1	—	1	0.25
Fabaceae	—	1	—	—	1	0.25
Malpighiaceae	—	—	—	1	1	0.25
Moraceae	—	—	—	1	1	0.25
Ranunculaceae	—	1	—	—	1	0.25
Rubiaceae	—	1	—	—	1	0.25
Solanaceae	—	1	—	—	1	0.25
Unknown1*	1	—	—	—	1	0.25
Unknown2**	—	—	1	—	1	0.25
Total spp./area	8	10	9	9		

* Unknown #1 (*Krings 76*, F) could not be placed into a family.
** Unknown #2 (No voucher could be obtained).

value (CFIV) was calculated for each recorded family. The following two equations were used:

$$FIV_{ij} = \left(\frac{SPP_{ij}}{g} + \frac{IND_{ij}}{g} + \frac{BA_{ij}}{g} \right) \times 100 \qquad (1)$$

$$CFIV_i = \left(\frac{\sum_{j=1}^{n} SPP_{ij}}{n\ g} + \frac{\sum_{j=1}^{n} IND_{ij}}{n\ g} + \frac{\sum_{j=1}^{n} BA_{ij}}{n\ g} \right) \times 100 \qquad (2)$$

In the equations, n is the total number of sample areas, g is the total number of families, SPP is the number of species, IND is the number of individuals, and BA is the basal area.

RESULTS

Monteverde

A total of 19 dicotyledonous woody climbing species were found in the four 0.1 ha sample areas at Monteverde. Asteraceae, Hydrangeaceae, and Piperaceae are the only families represented consistently in all four sample areas (TABLE 1). The next most common family is the Sapindaceae, encountered in three of the four sample areas. Nine of the 17 identified families, including Fabaceae and Malpighiaceae, are encountered in no more than one sample area. Although known from Monteverde (Haber 1991), the predominant lowland liana family Bignoniaceae (Gentry 1991) was not recorded in any of the four sample areas.

The most species rich dicotyledonous woody climber families encountered in the 0.1 ha sample areas are Asteraceae (3 spp.), Sapindaceae (2 spp.), and Vitaceae (2 spp.); see APPENDIX 1. All other families are represented by only one species each. The encountered Asteraceae genera are *Pentacalia* Cass. (1 sp.), *Mikania* Willd. (1 sp.), and *Otopappus* Benth. (1 sp.).

Species richness was relatively consistent among sample areas (TABLE 2, FIGURE 2). Eight species were recorded in M1, ten species in M2, and nine species in M3 and M4. The number of

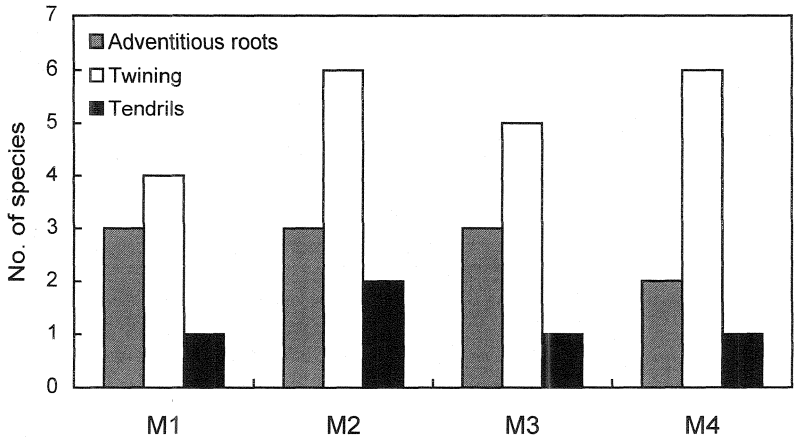

FIGURE 2. Climbing mechanisms of dicotyledonous woody climbers in four 0.1 ha sample areas (M1–M4) at Monteverde, Costa Rica.

individual stems recorded varied from 17 in M1 to 30 in M4. Total basal area varied from 181.80 cm^2 in M1 to 646.78 cm^2 in M2. Almost half of the total basal area of M2 is accounted for by Fabaceae, with *Mucuna urens* (L.) DC accounting for more basal area in this sample area than that of all climbers combined in M1. In the sample areas where no Fabaceae are recorded, either Hydrangeaceae or Piperaceae are the dominant family, constituting at least a third of the total basal area. The highest basal area achieved by the Asteraceae, the most species-rich family at Monteverde (see M4, TABLE 2), was only 12.7% of the total basal area. The average Asteraceae basal area across all four sample areas amounted to 7.55% (SD = 4.21) of the total.

Other Mesoamerican Sites

The Monteverde data were compared to raw data compiled by the late A.H. Gentry for other Mesoamerican dicotyledonous woody climber communities above 1200 m elevation (courtesy of the Missouri Botanical Garden, St. Louis). The comparison shows the Asteraceae to be the most species rich family per site (TABLE 3). Records of Sapindaceae, the most species rich tendrillate liana family above 700 m in Costa Rica (Krings 1997), are absent from only two of the eight Mesoamerican sites. The Bignoniaceae, the predominant lowland Neotropical liana family (Gentry 1991), are only recorded in one of the eight sites—Bosque de Guadalupe, Veracruz, Mexico. The single Bignoniaceae representative, *Pithecoctenium crucigerum* (L.) A.H. Gentry, also is known from Monteverde but occurs more commonly below 1200 m (Haber 1991; Krings pers. obs.) and was not recorded in the sample areas above 1550 m. Absent from Gentry's (1995) Mexican sample areas are Polygonaceae (represented by *Muehlenbeckia*) and Marcgraviaceae (represented by *Marcgravia*), which were only recorded at Monteverde. Gentry's (1995) citation of absence of these two genera in Mexico is likely based on their absence from his 0.1 ha plots and not from the country as a whole. Indeed, both genera have been collected in Mexico (see Breedlove 1986, Ibarra Manríquez & Sinaca Colín 1987, Rzedowski 1996). Previously unrecorded from Costa Rican 0.1 ha plots (Gentry 1995), *Clematis* (Ranunculaceae) was found in the M2 sample area of Monteverde. The three sampled Mexican communities have higher representations of Asclepiadaceae and Celastraceae but no record of Asteraceae. *Toxicodendron* (Anacardiaceae) has been recorded only in Mexican sites. A higher proportion of families are found exclusively at Monteverde than are found exclusively in the Mexican sample areas.

A comparison of FIVs for the eight Mesoamerican sites is given in TABLE 4. The five most important families, in decreasing order, are Vitaceae, Celastraceae, Hydrangeaceae, Piperaceae, and Asteraceae. The Vitaceae, third most important in terms of average number of species per site (TABLE 3), become the most important based on CFIV ranking. The Asteraceae drop from most important in terms of average number of species per site to fifth most important based on CFIV ranking. The Sapindaceae, second most important in terms of average number of species per site, drop to sixth most important in CFIV ranking.

TABLE 2. Dicotyledonous woody climbers ≥2.5 cm diam. in four 0.1 ha sample areas (M1–M4) at Monteverde, Costa Rica, by floristic composition, species richness, number of individuals, basal area, and family importance values.

Families per sample area	No. species	No. individuals	Basal area cm^2	Family importance values (FIVs)
M1				
HYDR*	1	7	83.00	99.33
PIPE*	1	2	51.40	52.54
ASTE**	2	3	16.80	51.89
CELA**	1	2	15.10	32.57
MARC*	1	1	5.30	21.30
UNK1**	1	1	5.30	21.30
SAPI***	1	1	4.90	21.08
M1 totals	8	17	181.80	300.00
M2				
FABA**	1	7	256.00	75.51
PIPE*	1	7	94.01	50.46
RANU**	1	1	84.64	26.79
RUBI**	1	2	59.99	26.68
HYDR*	1	2	58.09	26.39
ASTE**	1	3	31.51	25.98
SAPI***	1	2	11.88	19.24
VITA*/***	1	1	28.26	18.07
SCRO**	1	1	13.85	15.84
SOLA**	1	1	8.55	15.03
M2 totals	10	27	646.78	300.00
M3				
HYDR*	1	7	108.70	79.45
PLGO**	1	6	58.60	58.07
VITA***	1	1	47.80	31.72
PIPE*	1	2	12.80	24.50
ASTE**	1	2	10.20	23.63
MARC*	1	1	21.20	22.78
UNK2**	1	1	18.80	21.97
SCRO**	1	1	13.80	20.29
COMB**	1	1	5.70	17.57
M3 totals	9	22	297.60	300.00
M4				
PIPE*	1	8	145.80	77.50
HYDR*	1	8	94.70	63.58
ASTE**	2	5	46.48	51.55
PLGO**	1	3	22.60	27.27
MORA**	1	2	19.00	22.95
SAPI***	1	2	12.00	21.05
ASCL**	1	1	21.20	20.22
MALP**	1	1	5.30	15.89
M4 totals	9	30	367.08	300.00

M1–M4 Study sites at Monteverde, Costa Rica.

* Adventitious root-climbing species, with *Cissus trianae* (Vitaceae) also tendrillate.

** Twining species.

*** Tendrillate species.

Abbreviations: ACAN = Acanthaceae; ANAC = Anacardiaceae; ASCL = Asclepiadaceae; ASTE = Asteraceae; BIGN = Bignoniaceae; CELA = Celastraceae; COMB = Combretaceae; FABA = Fabaceae; HYDR = Hydrangeaceae; MALP = Malpighiaceae; MARC = Marcgraviaceae; MORA = Moraceae; PIPE = Piperaceae; PLGO = Polygonaceae; RANU = Ranunculaceae; RUBI = Rubiaceae; SAPI = Sapindaceae; SCRO = Scrophulariaceae; SOLA = Solanaceae; UNK1 = Unknown #1 (Krings 76, F); UNK2 = Unknown #2 (no voucher.); VITA = Vitaceae.

DISCUSSION

Family Importance Values

Although interesting taxonomically, analyses of communities based exclusively on species richness (Gentry 1991, 1995) provide different interpretations of "dominance" than do analyses based on FIVs. However, FIVs are useful relative indices in evaluating and comparing the composition of liana communities. A strict species richness evaluation of sample area M4 at Monteverde, for example, shows the Asteraceae as the "dominant" or most important family. While this may be true taxonomically, a more ecologically informative approach using FIVs, shows the Piperaceae as the most important family, followed by Hydrangeaceae, and only then, Asteraceae. When components of the FIV are teased apart, the Piperaceae constitute more than three times the basal area of the Asteraceae in M4. For communities such as Monteverde, where no single family may "dominate" in terms of species richness (see M2 and M3 in TABLE 2), FIVs can become especially useful in evaluating the relative importance of taxa in the community. Although certainly not as expedient as species richness evaluations, additional FIV analysis can provide a more informative picture of a given community.

Monteverde

About one third (30.8%, SD = 6.47) of the recorded dicotyledonous woody climbers per 0.1-ha sample area at Monteverde climb by adventitious roots. Individuals of Hydrangeaceae and Piperaceae are particularly common and numerous (TABLE 2, FIGURE 2). In three of the four sample areas, either Hydrangeaceae or Piperaceae are the dominant family, constituting at least a third of the total basal area. In the single sample area dominated by Fabaceae, Piperaceae is the second most important family.

Adventitious root climbers appear to become more important, both taxonomically and ecologically, at higher elevations. Gentry (1991) found that, next to Asteraceae, adventitious root climbing families, such as Marcgraviaceae, Clusiaceae, and the monocotyledonous Araceae, often constitute the most species rich climbing families in upland Andean forests above 1500 m elevation. The Araceae are also a conspicuous element of the Monteverde flora. In lowland forest communities, adventitious root climbers appear much less species rich. Although recording climbers >1 cm, Putz and Chai (1987) found only one species (constituting 1% of climbers) with adventitious roots in ten 0.1 ha sample ar-

TABLE 3. Dicotyledonous woody climber communities of eight 0.1 ha sample areas from Costa Rica, Nicaragua, and Mexico as number of species ≥2.5 cm diam. per family per site.

	Species/family/sample area									
Family	M1 1600 m	M2 1620 m	M3 1695 m	M4 1560 m	NICI 1400 m	MEX1 1225 m	MEX2 1950 m	MEX3 1800 m	TSSR*	AV**
ASTE	2	1	1	2	1	—	—	—	7	0.875
SAPI	1	1	—	1	—	1	1	1	6	0.750
VITA	—	1	1	—	—	2	1	—	5	0.625
ASCL	—	—	—	1	1	—	1	1	4	0.500
CELA	1	—	—	—	—	1	1	1	4	0.500
HYDR	1	1	1	1	—	—	—	—	4	0.500
PIPE	1	1	1	1	—	—	—	—	4	0.500
MALP	—	—	—	1	—	—	—	1	2	0.250
FABA	—	1	—	—	—	—	—	1	2	0.250
MARC	1	—	1	—	—	—	—	—	2	0.250
PLGO	—	—	1	1	—	—	—	—	2	0.250
RANU	—	1	—	—	—	—	1	—	2	0.250
SCRO	—	1	1	—	—	—	—	—	2	0.250
BIGN	—	—	—	—	—	1	—	—	1	0.125
RUBI	—	1	—	—	—	—	—	—	1	0.125
ACAN	—	—	—	—	1	—	—	—	1	0.125
ANAC	—	—	—	—	—	1	—	—	1	0.125
COMB	—	—	1	—	—	—	—	—	1	0.125
SOLA	—	1	—	—	—	—	—	—	1	0.125
MORA	—	—	—	1	—	—	—	—	1	0.125
UNK1	1	—	—	—	—	—	—	—	1	0.125
UNK2	—	—	1	—	—	—	—	—	1	0.125
Total	8	10	9	9	3	6	5	5	—	—

* Total species-site records.

** Average no. spp./0.1-ha sample area (N = 8).

M1–M4 Monteverde, Costa Rica.

NIC1 Cerro el Picacho, Nicaragua.

MEX1 Bosque de Guadalupe, Veracruz, Mexico.

MEX2 Las Joyas, Jalisco, Mexico.

MEX3 Quince Ocotes, Jalisco, Mexico.

Note: Nicaraguan and Mexican data were collected by the late A.H. Gentry and appear courtesy of the Missouri Botanical Garden, St. Louis.

Abbreviations: ACAN = Acanthaceae; ANAC = Anacardiaceae; ASCL = Asclepiadaceae; ASTE = Asteraceae; BIGN = Bignoniaceae; CELA = Celastraceae; COMB = Combretaceae; FABA = Fabaceae; HYDR = Hydrangeaceae; MALP = Malpighiaceae; MARC = Marcgraviaceae; MORA = Moraceae; PIPE = Piperaceae; PLGO = Polygonaceae; RANU = Ranunculaceae; RUBI = Rubiaceae; SAPI = Sapindaceae; SCRO = Scrophulariaceae; SOLA = Solanaceae; UNK1 = Unknown #1 (Krings 76, F); UNK2 = Unknown #2 (no voucher.); VITA = Vitaceae.

eas in lowland Sarawak. A similar, unexplained rarity of adventitious root climbers was found in Panama (e.g., Putz 1984). Gentry (1991) notes that tendrillate or twining families, such as Bignoniaceae and Fabaceae, are often the most species rich in lowland Neotropical forests. The greater species richness and dominance of adventitious root climbers in higher elevation forests remains unexplained but perhaps is related to moisture and nutrient availability in the stem substrate.

Other Mesoamerican Sites

Except for the single, depauperate Nicaraguan site, the species richness patterns among Mesoamerican dicotyledonous woody climber communities (TABLE 3) follow observations of increased richness in southern Mesoamerican forests versus Mexican forests (Gentry 1995). Since the Nicaraguan sample most likely does not reflect a mean of Nicaraguan communities, it has been excluded from any subsequent statistical analyses.

In comparing the Mexican and Costa Rican sample areas, ANOVA results indicate a highly significant difference in the average species richness between the two regions ($F_{1,5} = 43.21$, $P < 0.001$). Interestingly, no significant differences in the average number of individuals per sample area ($F_{1,5} = 0.0031$, $P > 0.95$) or the average basal area ($F_{1,5} = 0.356$, $P > 0.57$) were found.

TABLE 4. Family importance values (FIVs) in eight Mesoamerican dicotyledonous woody climber communities.

	Family importance value/family/sample area								
Family	M1 1600 m	M2 1620 m	M3 1695 m	M4 1560 m	NICI 1400 m	MEX1 1225 m	MEX2 1950 m	MEX3 1800 m	CFIV*
VITA	—	18.07	29.29	—	—	100.86	121.24	—	45.15
CELA	32.57	—	—	—	—	89.37	91.02	50.86	39.65
HYDR	94.46	26.39	73.57	63.58	—	—	—	—	32.13
PIPE	49.75	50.46	22.38	77.50	—	—	—	—	27.98
ASTE	47.89	25.98	21.56	51.55	57.61	—	—	—	24.24
SAPI	21.08	19.24	—	21.05	—	26.97	30.31	49.30	20.12
FABA	—	75.51	—	—	—	—	—	106.31	20.09
BIGN	—	—	—	—	—	63.66	—	—	15.57
ASCL	—	—	—	20.22	136.14	—	28.72	34.65	12.65
PLGO	—	—	53.54	27.27	—	—	—	—	11.38
RANU	—	26.79	—	—	—	—	28.72	—	7.70
MALP	—	—	—	15.89	—	—	—	58.87	6.20
SCRO	—	15.84	18.53	—	—	—	—	—	5.67
MARC	19.51	—	20.88	—	—	—	—	—	5.64
RUBI	—	26.68	—	—	—	—	—	—	4.92
ACAN	—	—	—	—	106.17	—	—	—	4.00
MORA	—	—	—	22.95	—	—	—	—	3.57
UNK2	—	—	20.12	—	—	—	—	—	3.00
SOLA	—	15.03	—	—	—	—	—	—	2.66
COMB	—	—	15.97	—	—	—	—	—	2.57
UNK1	19.51	—	—	—	—	—	—	—	2.56
ANAC	—	—	—	—	—	19.14	—	—	2.54

* Combined family importance value.

Abbreviations: ACAN = Acanthaceae; ANAC = Anacardiaceae; ASCL = Asclepiadaceae; ASTE = Asteraceae; BIGN = Bignoniaceae; CELA = Celastraceae; COMB = Combretaceae; FABA = Fabaceae; HYDR = Hydrangeaceae; MALP = Malpighiaceae; MARC = Marcgraviaceae; MORA = Moraceae; PIPE = Piperaceae; PLGO = Polygonaceae; RANU = Ranunculaceae; RUBI = Rubiaceae; SAPI = Sapindaceae; SCRO = Scrophulariaceae; SOLA = Solanaceae; UNK1 = Unknown #1 (Krings 76, F); UNK2 = Unknown #2 (no voucher.); VITA = Vitaceae.

TABLE 5. Species richness, number of individuals, and basal area (cm^2) of dicotyledonous woody climbers ≥2.5 cm diam. in eight Mesoamerican 0.1 ha sample areas.

Sample area by country	Species richness	No. individuals	Basal area cm^2
MEXICO			
MEX1 Bosque de Guadalupe	6	52	888.28
MEX2 Las Joyas	5	13	479.48
MEX3 Quince Ocotes	5	9	138.62
Average	5.33	24.67	502.13
NICARAGUA			
NIC1 Cerro el Picacho	3	7	49.06
Average	3	7	49.06
COSTA RICA			
M1 Monteverde	8	17	181.80
M2 Monteverde	10	27	646.78
M3 Monteverde	9	22	297.60
M4 Monteverde	9	30	367.08
Average	9	24.00	373.32

Note: Nicaraguan and Mexican data were collected by the late A.H. Gentry and appear courtesy of the Missouri Botanical Garden, St. Louis.

This lack of significance suggests a constancy in the number of stems and the amount of wood produced in these communities regardless of the community species richness. However, only seven sample areas were analyzed (TABLE 5), the consistency of these results remains unclear for Mesoamerican montane forests as a whole. In addition, as only dicot data were analyzed, inclusion of monocots (e.g., Araceae) could result in a significant difference in the average number of stems and average total basal area between Mexican and Costa Rican sites. Individual dicotyledonous species in the examined Mexican communities, however, do produce proportionately more stems and wood than individual dicotyledonous species in the Costa Rican communities. Specifically, members of the Vitaceae and Celastraceae in Mexico produce so many more stems and so much more wood that they are the top two families by CFIV in Mesoamerica (TABLE 4).

ACKNOWLEDGMENTS

The study was supported by a travel grant and assistantship from the Department of Forestry, North Carolina State University, a fellowship from the Organization for Tropical Studies (OTS), and a visiting scientist scholarship from the Field Museum (F). I thank the Tropical Science Center for permission to conduct research at Monteverde; OTS for help with collecting permits; my advisor, Richard Braham, for his insight and support of the project; and David Hearn for his invaluable help in the field. As well, I appreciate the help of Guenevere Abernathy; William Burger; Bob Carlson; the curators and staff of the following herbaria: CR, DUKE, F, INB, MO, and USJ; William Haber, James Hardin, Richard Lancia, Silvia Lobo, Pedro Rosafa, the staff of La Casona, and Wendy Worley. I also thank Robyn Burnham, Barry Hammel, and José Panero for their review of the manuscript.

LITERATURE CITED

Breedlove, D.E. 1986. Listados florísticos de Mexico IV. Flora de Chiapas. Insituto de Biología, UNAM, Mexico.

Croat, T. 1978. Flora of Barro Colorado Island. Stanford University Press, Stanford, California, USA.

Gentry, A.H. 1982. Patterns of Neotropical plant species diversity. Evolutionary Biology 15: 1–84.

———. 1988. Changes in plant community diversity and floristic composition on environmental and geographical gradients. Ann. Missouri Bot. Gard. 75: 1–34.

———. 1991. Distribution and evolution of climbing plants. Pp. 3–42 *in* F.E. Putz and H.A. Mooney, eds. The Biology of Vines. Cambridge University Press, Cambridge, UK.

———. 1995. Patterns of diversity and floristic composition in Neotropical montane forests. Pp. 103–126 *in* S.P. Churchill, H. Balslev, E. Forero, and J.L. Luteyn, eds. Biodiversity and Conservation of Neotropical Montane Forests. New York Botanical Garden, New York, USA.

Haber, W.A. 1991. Lista provisional de las plantas de Monteverde, Costa Rica. Brenesia 34: 63–120.

Hartshorn, G.S. 1983. Plants. Pp. 141–144 *in* D.H. Janzen, ed. Costa Rican Natural History. University of Chicago Press, Chicago, Illinois, USA.

Ibarra Manríquez, G. and S. Sinaca Colín. 1987. Listados florísticos de Mexico VII. Estación de Biología Tropical Los Tuxtlas, Veracruz. Instituto de Biología, UNAM, Mexico.

Jacobs, M. 1976. The study of lianas. Flora Malesiana Bull. 29: 2610–2618.

Krings, A. 1997. "An Illustrated Guide to the Tendrillate Lianas and Vines from the Mountains of Costa Rica." M.S. thesis, North Carolina State University, Raleigh.

Laman, T.G. 1995. Safety recommendations for climbing rainforest trees with 'single rope technique.' Biotropica 27: 406–409.

Moffett, M.W. 1993. The High Frontier: Exploring the Tropical Rainforest Canopy. Harvard University Press, Cambridge, Massachusetts, USA.

Montgomery, G. and M. Sunquist. 1978. Habitat selection and use by two-toed and three-toed sloths. Pp. 329–359 *in* G. Montgomery, ed. Ecology of Arboreal Folivores. Smithsonian Institute Press, Washington, DC.

Mori, S.A., B.B. Boom, A.M. Carvalino, and T.S. Dos Santos. 1983. Ecological importance of Myrtaceae in an eastern Brazilian wet forest. Biotropica 15: 68–70.

Perry, D.R. 1978. A method of access into the crowns of emergent and canopy trees. Biotropica 10: 155–157.

Putz, F.E. 1982. "Natural history of lianas and their influences on tropical forest dynamics." Ph.D. thesis, Cornell University, Ithaca, New York.

———. 1984. The natural history of lianas on Barro Colorado Island, Panama. Ecology 65: 1713–1724.

Rzedowski, J. 1996. Analisis preliminar de la flora vascular de los bosques mesofilos de montaña de Mexico. Acta Bot. Mexicana 35: 25–44.

APPENDIX. Dicotyledonous woody climbers ≥2.5 cm diam. recorded from four 0.1 ha sample areas at Monteverde, Costa Rica, 1996.

Family	Species	Voucher	Habit
Asclepiadaceae	*Marsdenia* sp.	*Krings 96* (CR, F)	LI
Asteraceae	*Mikania banisteriae* DC.	*Krings 81* (CR, F)	LI
	Otopappus verbesinoides Benth.	*Krings 7* (CR, F)	LI
	Pentacalia parasitica (Hemsl.) H. Rob. & Cuatrecasas	*Krings 91* (CR, F)	LI
Celastraceae	*Celastrus vulcanicola* Donn. Sm.	*Krings 79* (CR, F)	LI
Combretaceae	*Combretum laxum* Jacq.	*Krings 62* (CR, F)	LI
Fabaceae	*Mucuna urens* (L.) DC.	*Krings 4* (CR)	LI
Hydrangeaceae	*Hydrangea peruviana* Moric.	*Krings 88* (CR)	LI
Malpighiaceae	*Tetrapterys* sp.	*Krings 99* (CR, F)	LI
Marcgraviaceae	*Marcgravia brownei* (Triana & Planch.) Krug & Urb.	*Krings 80* (CR, F)	LI/SH
Moraceae	*Ficus* sp.	*Krings 98* (CR, F)	LI
Piperaceae	*Sarcorhachis naranjoana* (C. DC.) Trel.	*Krings 89* (CR, F)	LI
Polygonaceae	*Muehlenbeckia tamnifolia* (Kunth) Meisn.	*Krings 95* (CR, F)	LI
Ranunculaceae	*Clematis dioica* L.	*Krings 37* (CR, F)	LI
Rubiaceae	*Chiococca alba* (L.) Hitchc.	*Krings 93* (CR, F)	LI
Sapindaceae	*Paullinia austin-smithii* Standl.	*Krings 92* (CR, F)	LI
	Paullinia costaricensis Radlk.	*Krings 21* (CR, F)	LI
Scrophulariaceae	*Schlegelia parviflora* (Oerst.) Monach.	*Krings 90* (CR, F)	LI
Solanaceae	*Schultesianthus venosus* (Standl. C.V. Morton) S. Knapp	*Krings 128* (CR, F)	SH
Vitaceae	*Cissus* sp.	(no voucher)	LI
	Cissus trianae Planch.	*Krings 94* (CR)	LI
Indet.	Unknown1	*Krings 76* CR, F)	LI
	Unknown2	(no voucher)	LI

CR, Museo Nacional de Costa Rica, San Jose, Costa Rica; F, Field Museum of Natural History, Chicago, IL, USA; LI, liana (woody vine); SH, scandent hemi-epiphyte.