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Does Tree Height Determine Epiphyte Diversity?

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Abstract. In Central Guatemala, emergent trees and trees with high epiphytic loads (temperate subtropical forest, cloud forest, and evergreen tropical forest) were examined to determine if tree height or emergent status determined high species diversity. Height did not correlate with epiphyte diversity, nor did any of the other examined parameters. Isolated trees, however, in contrast to those in forests supported fewer epiphyte species, although numbers of plants were greater. The emergent trees hosted the most epiphytic life forms, 35% of all rare epiphytic species, and the highest proportion of non-vascular epiphytes. Of the rare epiphytes, 71% were non-vascular species. Emergent trees, therefore, may host the most rare species and the highest life-form diversity. Non-vascular diversity increased as did humidity or dryness. Lichen species diversity apparently depended on specific phorophyte species, on branch strata, and on the emergent status of the host tree. Rare species were correlated with non-vascular species. Microclimate, especially humidity, appeared to be the major determinant of epiphyte diversity in Central Guatemala.

Key words: Vascular epiphytes, non-vascular epiphytes, diversity, Guatemala, emergent trees, remnant trees

Resumen. En Guatemala árboles sobresalientes y árboles con gran carga de epífitas se examinaron (bosque templado subtropical, bosque nuboso subtropical y bosque tropical siempre verde) para averiguar si es la altura o el hecho de sobresalir el dosel lo que determina alta diversidad. Ni altura fue correlacionado con alta diversidad de epífitas ni ningún otro determinante examinado. Pero los árboles aislados llevaban una diversidad de epífitas más baja en comparación con árboles dentro del bosque, no obstante la cantidad de plantas fue más alta. Los árboles sobresalientes alojan la variedad más alta de formas de vida de epífitas, un 35% de especies raras y el más alto porcentaje de epífitas no vasculares. Un setenta y un porciento de las especies raras son no vasculares. Por esto los árboles sobresalientes representan el potencial más alto de epífitas raras y una alta diversidad de formas de vida de epífitas. La diversidad de briofitas aumenta con un incremento de húmedad y de sequía. La diversidad de especies de líquenes parece depender más de la especie del forofito y de la cantidad de pisos de ramas y el facto de sobresalir el docel del forofito. Especies raras fueron correlacionadas con especies no vasculares. Concluyendo se puede decir que el factor microclimático, especialmente la humedad es el parámetro más importante para determinar la diversidad de epífitas.

Palabras clave: Epífitas vasculares, epífitas no vasculares, diversidad, Guatemala, árboles sobresalientes, árboles remanentes

Introduction

The Convention on the Conservation of Biological Diversity (World Summit in Rio 1992) has initiated a great deal of research to discover the hot spots of species diversity (UNEP-WCMC 2000). Indicators determining priority areas for in situ conservation of biological richness and rarity, however, await identification. The neotropical cloud forest, already identified as an ecosystem with a high degree of endemism, is botanically the richest worldwide (Lewis 1971, Madison 1977, Gentry 1982, Henderson et al. 1991, Barthlott et al. 1996).

Tropical forests continue to decrease in size, because deforestation remains linked to the survival of many people in Central America, especially indigenous people (Tole 1998). As a result, conservationists need to identify hot spot indicators in order to select the most valuable plots of identified forest types for preservation. Vertical diversity may be one such indicator, as it supplements horizontal diversity indices and may lead to a refinement of priority area identification for conservation.

The tree canopy of the tropics contains a large proportion of tropical biodiversity yet belongs to the "last biological frontier" (Stuntz 1999, Stork 2001). Epiphytes make a considerable contribution to overall biodiversity, especially in the neotropics (Pike et al. 1975, Pócs 1980, Gentry & Dodson 1987, Porembski & Barthlott 2000). In addition, diversity of fauna in a specific region strongly depends upon plant diversity (Huston 1994). Above all, epiphytes provide a rich habitat for a range of floristic and faunal species (Picardo 1913, Pittendrigh 1948, Murdock et al. 1972, Gibson & Robins 1976, Frank 1983, Benzing 1990, Nadkarni 1992, Wittman 2000, Gradstein 2002).

TABLE 1. Overall diversity per tree.

Measures	Spp. #	Lichen spp.	Bryophyte spp.	Vasc./non-vasc.	Vasc. spp.	Non-vasc. spp.
Mean	33.8	9.5	8.1	1.1	16.1	17.6
SD	8.8	5.3	3.8	0.7	5.3	7.3
Minimum	20	2	3	0.4	6	6
Maximum	56	21	16	2.9	28	35

Bennett (1986) assumed higher epiphyte diversity among tall trees. Species stratification does exist with respect to epiphytic flora (Johansson 1974, Terborgh 1985, Benzing 1990) as well as to vertebrate and invertebrate fauna (Pearson 1977, Sutton et al. 1983, Longino & Nadkarni 1990, McKey 1991, Francis 1994, Kato et al. 1995, Taylor & Lowman 1996). The search for a smaller scale to define high species diversity below the level of forest type classification motivated this study, which was designed to examine whether tree height or emergent status may be helpful indicators of biodiversity. If so, remote sensing, satellite images, or aerial photography may simplify the necessary identification of priority areas for conservation.

Parameters indicating high epiphyte diversity have been identified. Bark acidity and roughness have only been proved to be evident for non-vascular epiphytes (Barkman 1958, ter Steege & Cornelissen 1988, Sipman & Harris 1989, Komposch & Hafellner 2000, Schnittler & Stephenson 2000). A correlation between tree stem diameter at breast height and epiphyte diversity has been stressed by Engwald (1999) and Dunn (2000). Others correlated specific Johansson zones (3 & 4) with high epiphyte diversity (Nieder et al. 1999). These parameters, however, require extensive fieldwork for selection of priority areas in contrast to the parameters of tree height or emergent tree status.

Materials and Methods

Surveys were conducted in 2002 at three sites representing temperate subtropical forest (TSF) at National Park Las Victorias in Cobán at ca. 1100–1300 m elevation (tierra templada with mean temperatures of 16–23°C and 2000–2500 mm precipitation), cloud forest (CF) at ca. 1700 m elevation outside Cobán (tierra fría with a mean temperature of 19°C and >4000 mm precipitation), and evergreen tropical forest (ETF) (tierra caliente with mean temperatures of 24–27°C and 2100–4300 mm of precipitation) at about 600 m elevation on borders of the river Sachichaj. All three sites lie in the Department of Alta Verapaz within 20 km distance of one another.

The vegetation of these sites was not primary vegetation. The National Park Las Victorias, a former cattle farm abandoned since the beginning of the Second World War, had been planted in 1980 to complement the older stock of trees. At the cloud forest site, forest relicts were surrounded by pastureland, and the tropical site was a strip of riverside vegetation alongside a road, adjacent to coffee and cardamom plantations.

To reach the epiphytes, the "European" single-rope technique (SRT, Barker 1997) was used, as described in Barker and Standridge (2002). Vascular and non-vascular epiphyte species were sampled. At each site, ten trees representing different genera were sampled. The selected trees were emergents or those that supported a high load of epiphytes. Five trees of each description were sampled at each site, except at Sachichaj, where none of the trees qualified as emergents. Trees were defined as emergents when their complete crown lay outside the main closed canopy layer.

Epiphyte species per tree were recorded as well as tree height (using a trigonometric altimeter, Suunto Model #PM-5/1520 TCB) and number of branch strata on the examined trees. Each branch stratum represented a specific height above ground. Solitary trees were included, if they fulfilled one of the selection criteria. Solitary trees were defined as trees outside the forest, which were growing on a pasture or adjacent land, and did not have any direct contact with any forest tree.

Analyses were conducted using a one-way ANOVA with the LSD-test and single-sided Spearman-Rho correlation (SPSS 11.0). The Shannon-Weaver Index H′ (Shannon & Weaver 1949) and species richness (Magurran 1996) were calculated by BioDiversityPro (Program by McAleece 1997).

Results and Discussion

As few as 20 and as many as 56 species of vascular and non-vascular epiphytes occurred per tree (mean 33.8±8.8 SD, TABLE 1). No studies were available to provide total numbers of vascular and non-vascular epiphytes together per tree for comparison. The species numbers of vascular epiphytes per tree varied from 0–30 in Liberia (Johansson 1974), 12–34 in a tropical

TABLE 2. Frequency (%) of the most abundant families at different locations.

Families	TSF	CF	ETF	Emergent trees	Solitary trees	Overall
Bromeliaceae	16	13	6	0	6	12
Orchideaceae	5	12	6	13	0	9
Polypodiaceae	10	0	6	13	0	8
Lejeuneaceae	5	6	9	15	12	7
Parmeliaceae	9	5	0	11	0	6

TSF = temperate subtropical forest. CF = cloud forest. ETF = evergreen tropical forest.

forest in Bolivia (Acebey & Krömer 2001), 35 in subtropical highlands of Peru (Ibisch 1996), and 74 species on an emergent 52 m tall *Virola* tree in tropical French Guyana (Freiberg 1999). Vascular epiphytes found in this study numbered 6–28 (see TABLE 1).

The survey recorded 339 epiphytic species, including hemiepiphytes, belonging to 91 families (184 genera). Of the total, 112 species were bryophytes (61 moss spp. belonging to 26 families and 51 liverwort spp. belonging to 14 families), 100 lichen spp. belonging to 31 families, 78 angiosperm spp. belonging to 11 families (an additional 21 angiosperm spp. could not be identified), and 50 fern spp. belonging to 8 families. Orchideaceae were represented by the largest number of species (35), followed by Lejeuneaceae (liverworts, 24), Bromeliaceae (19), Polypodiaceae (ferns, 19), and Parmeliaceae (lichens, 19). Bromeliads and polypodiaceas were most abundant in the TSF, while orchids, lejeuneaceas, and parmeliaceas were more numerous on emergent trees (see TABLE 2).

The frequency of families, i.e., the percentage of species belonging to one family, varied clearly with the specific habitat (see TABLE 2). Regarding microhabitat, the significance of bryophytes, especially lejeuneaceas and lichens, increased at the drier sites, which had solitary and emergent trees (see FIGURE 1). Diversity of epiphyte families was highest in the cloud forest with a total of 65 families. Factoring in the percentage of less abundant families, however, put the highest diversity in the evergreen tropical forest with 67% of the epiphytes from families other than the four dominant ones. The non-vascular epiphytes clearly prevailed on the emergent trees (71%), followed by the tropical site with 61%. Solitary trees and the complete data set showed the same frequency distribution of 55% non-vascular to 45% vascular epiphytes (see FIGURE 2).

Of the 339 species, 158 were unique (found only once in this study) and thus were designated as rare. Most of these rare species were discovered in the CF (43%), 30% in the ETF, and 27% in the TSF. Distribution of the rare species among the different tree types was 47% on heavily epiphyte-loaded trees within the canopy, 35% on emergents, and 18% on solitary trees (see TABLE 3). Rare species were correlated with only one of the parameters measured in this study, and that was their negative correlation with solitary trees (see TABLE 4).

Alpha-diversity according to the Shannon-Weaver-Index H′ lies between 1.26 and 1.66 (see FIGURE 3). Compared with values for cloud forests in Venezuela (Barthlott et al. 2001), this diversity is low. Barthlott and coauthors (2001) reported values of 3.15 in primary forest, 2.84 in secondary forest, and 1.61 and 1.7 in relict forests. In contrast, the vegetation at the study sites in Central Guatemala did not represent primary vegetation. Only one other study of epiphytes in Guatemala was found (Catling & Lefkovitch 1989), in which the authors reported 68 vascular epiphyte species in a typical cloud forest in the Sierra de las Minas, Baja Verapaz, at 2225 m elevation on 2 ha. The current study found 72 vascular epiphytes on 10 trees at 1700 m elevation. Species richness tends to peak between 1000 and 2000 m elevation (Gentry & Dodson 1987). The alpha-diversity for epiphytes in Guatemala may be lower than that in Venezuela.

To compare the diversity between emergent trees and trees supporting high epiphytic loads, a height limit of 35 m was set for the latter ones to exclude a possible species increase with height. Mean height of emergent trees was 36 m. No correlation between tree height and epiphyte species diversity was found; neither for the whole data set, nor within any of the tree types (emergent trees, solitary trees, or shorter trees with high epiphytic load). The tree with the highest species number (56) was only 24 m tall. No significant difference in diversity was recorded between emergents and shorter trees supporting high epiphytic loads.

The large number of epiphytic species in emergent trees taller than 35 m resulted from nearly a doubling of the number of non-vascular epiphytes in relation to the vascular epiphytes (mean vasc./non-vasc. is 0.65), while among

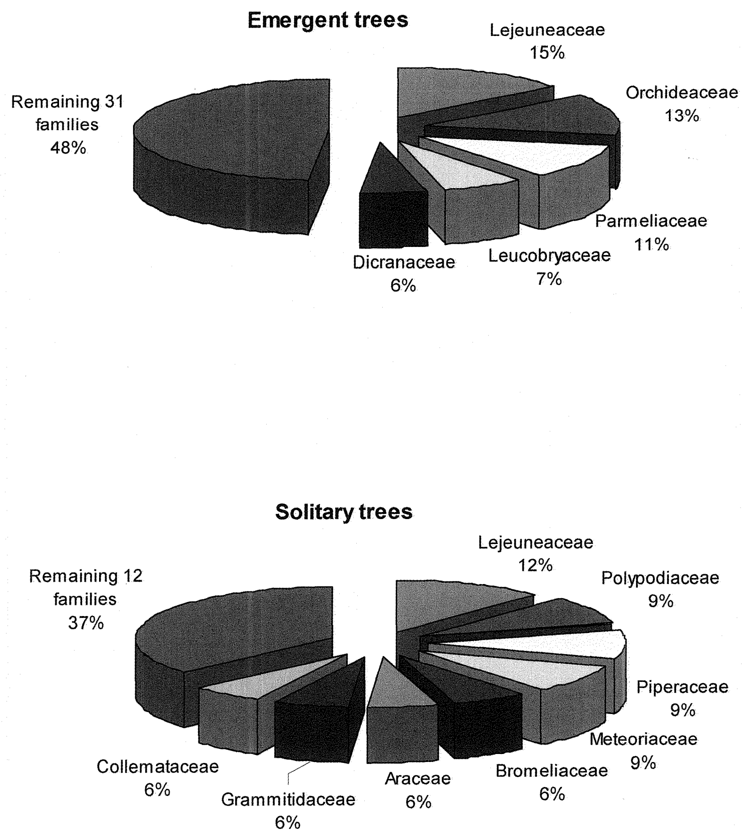

FIGURE 1. Mean frequency of epiphyte families on emergents and solitary trees.

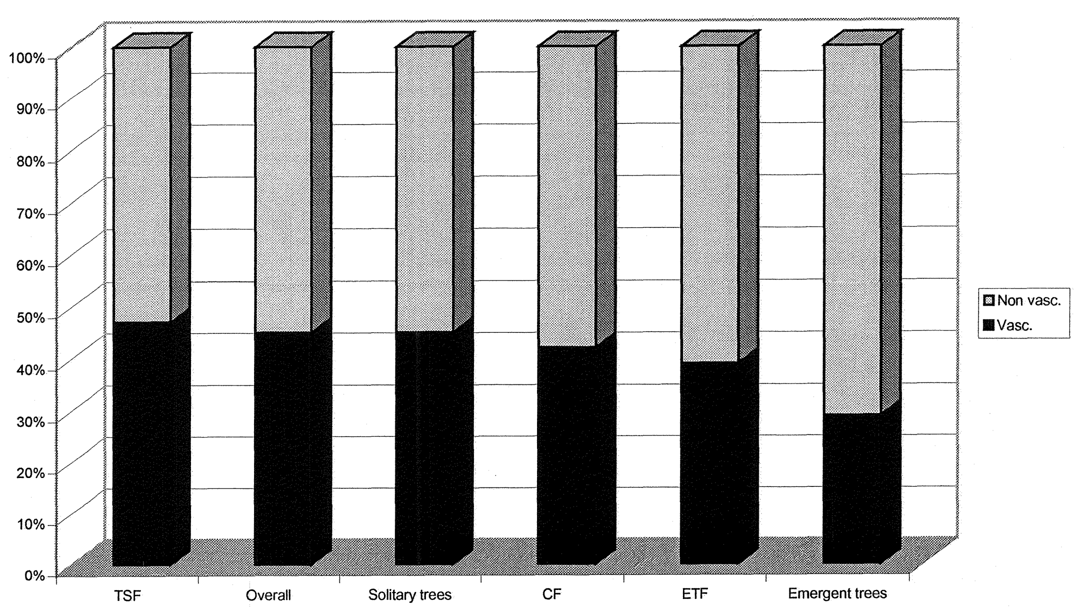

FIGURE 2. Frequency of vascular and non-vascular plants in different survey locations.

TABLE 3. Rare species distribution.

Location	Spp. no.	Rare spp. %	Vasc. %	Non-vasc. %
TSF	42	27	33	67
CF	68	43	30	70
ETF	48	30	27	73
Emergent trees	55	35	23	77
Shorter trees	74	47	34	66
Solitary trees	29	18	36	64
Total	158	46*	30	70

* Percent of all species.

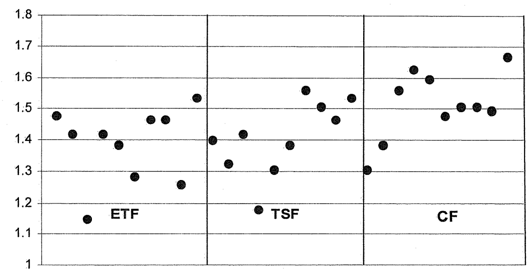

FIGURE 3. Shannon-Weaver Index H′ for all trees and survey sites. TSF = temperate subtropical forest; ETF = evergreen tropical forest, and CF = cloud forest.

shorter trees with high epiphytic loads the mean vasc. to non-vasc. ratio equalled 1.22 (see TABLE 5). The comparison of the ratio of vasc./non-vasc. epiphytes on all trees taller than 35 m (0.75) and emergent trees taller than 35 m (0.74) led to the conclusion that this relationship again shifts in favor of non-vascular epiphytes on emergent trees. If emergent trees are excluded from the data set, the overall mean changes from 1.1 vasc./non-vasc. to 1.77 vasc./non-vasc. A correlation was found between emergent trees and the ratio of vascular to non-vascular epiphytes (see TABLE 4), but no correlation was found for either vascular or non-vascular species.

This result confirmed the significance of the climatic influence on species composition by distance to the soil surface and evaporation. The extreme climate above the canopy, without any buffer effect of soil or transpiration humidity, favors poikilohydric species, capable of surviving under very dry conditions. Among such specialists are bryophytes and lichens (van Leerdam et al. 1990). The microclimatic influence appeared to be magnified when the trees emerged through the canopy. The climate above the main canopy is less humid because of higher wind turbidity and greater solar radiation. Kira and Yoda (1989) found a difference of 7°C between the canopy air and the air near the forest floor of an emergent tree and a difference of up to 50% in the relative humidity (50–60% in the canopy compared to 96–100% near the forest floor). With respect to the canopy climate in trees that do not emerge from the forest canopy, Freiberg (1996) found only 2–5°C of difference between canopy and ground temperature. The difference in humidity was only 15% (85% in the canopy to 100% on the ground).

As numbers of branch strata increased (2–7), so did the number of lichen species. The mean number of lichen species on trees with 6–7 branch levels was 14 species, while the overall mean was 9.5 lichen species (compare with TABLE 1).

The criterion "solitary tree" was the only one that significantly correlated with the number of species and rare species (see TABLE 4), although the correlation was twice as negative. Solitary trees showed a distinctly smaller overall number of species but at the same time a clearly higher portion of vascular species. The ratio of vascular and non-vascular species with a mean on solitary trees of 1.54 was evidently higher than the overall mean of 1.1 (see TABLE 6). The load of vascular epiphytes on solitary trees is remarkably luxuriant. These findings correspond to the findings of Hietz-Seifert et al. (1995) and Dunn (2000).

Bryophyte diversity is favored by extreme dryness and extreme humidity. The percentage of bryophytes in the CF with a mean of 26.9%

TABLE 4. Correlations between species diversity and structural characteristics of host trees.

Characteristic	Rare spp.	Spp. no.	Bryophyte spp.	Lichen spp.	Vasc./non-vasc.
Solitary trees	−0.391*	−0.345*	−0.516**	—	0.375*
Emergent trees	—	—	—	—	−0.391*
Shorter trees***	—	—	—	—	—
Branch strata no.	—	—	—	0.334*	—
Tree height	—	—	—	—	—

* Significant ($P = 0.05$).
** Highly significant ($P = 0.01$).
*** Trees shorter than 35 m (Limit set, because mean height of emergents was 36 m).

TABLE 5. Comparison of mean diversities on species level in solitary trees (N = 8), shorter trees <35 m with heavy epiphytic load (N = 16), and emergent trees >35 m (N = 5).

Tree	Spp. no.	Families	Genera	Vasc. spp.	Non-vasc. spp.	Vasc./ non-vasc.	Lichen spp.	Moss spp.	Liverwort spp.
Solitary	30.5	15.9	19.3	16.5	12.4	1.54	7.3	2.1	3.1
Shorter	34.5	19.3	25.4	16.6	16.6	1.22	8.4	3.5	4.7
Emergent	35.4	19.4	26.4	13.2	13.8	0.65	9.8	5.8	6.2

was significantly higher than at other sites. In ETF, the percentage of bryophytes was 24.3% and in the TSF, 23.1%. The number of bryophytes/tree was highest at the CF site with a mean of 10.7 against 7.1 in the ETF and 3.5 species in the TSF. The liverworts in particular are favored by the high humidity in the CF with a mean of 6.3 species in contrast to 3.8 species in the ETF and 3 in the TSF. Lejeuneaceae were found on the drier sites, 15% on emergent trees, 12% on solitary trees, and 9% at the ETF (see TABLE 2). In contrast, the number of branch strata, the emergent status, and apparently host tree species are the determinant factors for lichen diversity. The greatest number of lichens (21) was found on a *Liquidambar styraciflua* in the TSF. With respect to the diversity of vascular epiphytes, deductions could not be made on basis of this study. Even though 80% of the vascular epiphytes are monocotyledons (Kress 1989), this group includes ferns and dicotyledons, all of which have developed individual ecophysiological adaptations. Vascular epiphytes, therefore, belong to no homogenous group.

No correlation was found between the number of branch strata and species diversity (see TABLE 4). This finding may be biased by the method used in the survey. SRT makes it difficult to reach all of the branches and the outer zones. Lichens and bryophytes thus could not be surveyed completely. Aptroot (1997), for instance, found 173 lichen species on a single tree in Papua New Guinea. Outer branch zones have a different microclimate than branch zones closer to the trunk (Nadkarni & Longino 1990, Lowman et al. 1993, Moffett & Lowman 1995) and thus should host different epiphytic species. Only larger vascular epiphytes, however, could be recorded from outer zones; but even if such vascular epiphytes could be detected, unequivocal determination is difficult if the plants are not in flower (Whitmore et al. 1985). Bryologists examine trees by cutting off whole branches to determine species. Crustaceous lichens generally are insufficiently authenticated (Sipman & Aptroot 1992, Komposch & Hafellner 2000). Often such lichens extend over a large area and are difficult to recognize; and in additon, if they are sterile, identification becomes near impossible.

A comparison of solitary, emergent, and shorter trees with high epiphytic loads revealed significant differences in the ratio of vascular to non-vascular epiphyte species (see TABLE 5 and FIGURE 2). The significant difference recorded between bryophytes on solitary and those on emergent trees (sign. 0.012) was primarily because of differences in the number of bryophytes. Appendices I–V present detailed information on the epiphytes surveyed for this study.

CONCLUSIONS

Although the study did not identify conclusively an epiphyte diversity indicator, the emergent status of host trees has potential as an indicator of high diversity because of the diverse habitat that such trees provide to epiphytes. Additionally most rare epiphytes recorded in the study were non-vascular species favored on emergent trees. He (1999), for example, described the genus *Pycnolejeunea,* a liverwort found only in the crowns of tall emergent trees. A limiting factor in confirming the significance of emergent trees for biodiversity was the difficulty encountered in accessing the upper zone of the canopy using SRT. Canopy access problems

TABLE 6. Total diversity at species level.

Site	Spp. no.	Families	Genera	Vasc. spp.	Non-vasc. spp.	Vasc./ non-vasc.*	Lichen spp.	Moss spp.	Liverwort spp.
TSF	151	57	102	62	89	1.1	43	27	19
CF	186	68	112	72	114	1.0	57	27	30
ETF	142	56	89	52	90	1.3	42	24	24
Total	339	91	184	128	211	1.1	100	61	50

* Mean ratio per tree

might be resolved by using booms or high-cost equipment, such as cranes and other apparatus (Moffett & Lowman 1995). The assumption of Bennett (1986) that taller trees carry more epiphytes and the weak correlations of height and species diversity in other studies (Hietz-Seifert et al. 1995, Hietz & Hietz-Seifert 1995a) could not be proved or disproved. Tree height is indeed one factor indicating differentiated microclimate, but whether the tree top lies within the canopy or emerges through the canopy itself still makes a climatic difference (compare Kira & Yoda 1989 with Freiberg 1996). The results of my study suggest that the Johansson zone system (Johansson 1974) should be qualified according to whether the tree crown is situated within or above the main canopy (see also Engwald 1999). All studies relating epiphytes to various zones on the host tree (Johansson 1974, Kelly 1985, ter Steege & Cornelissen 1989, van Leerdam et al. 1990) establish that epiphytes evidently are influenced by the microclimate (Cachan 1963, Hietz & Hietz-Seifert 1995b). Kessler (2001) found a correlation between species-richness of ferns and mean annual precipitation in a study carried out in Bolivia. Bryophyte diversity apparently is optimized by both extreme dryness as well as extreme humidity. Lejeuneaceas play a major role at the driest sites. The number of branch strata, emergent status, and apparently host tree species determine lichen diversity. Non-vascular diversity was correlated with number of rare species (0.501, sign. 0.002), but with regard to vascular epiphytes, no conclusion was possible.

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APPENDIX I. Epiphytic generalists found at all survey sites, Central Guatemala, 2002.

No.	Epiphytes	Abundance* %
1	*Ceradenia jungermannoides*	13
2	*Anthurium scandens*	10
3	*Clusia* sp.	17
4	*Sphyrospermum majus*	33
5	*Catopsis wangerinii*	17
6	*Tillandsia filifolia*	40
7	*Tillandsia* sp.	43
8	*Leucomium strumosum*	37
9	*Macrocoma* sp. 2	10
10	*Frullania* sp. 1	40
11	*Bazzania* sp. 1	15
12	*Metzgeria* sp.	27
13	*Lejeunea laetevirens*	17
14	*Plagiochila raddiana*	43
15	*Cryptothecia rubrocincta*	63
16	*Cryptothecia striata*	63
17	*Graphis afzelii*	10
18	*Lepraria lobificans*	23
19	*Hypotrachyna* sp. 1	17
20	*Parmotrema endosulphureum*	30
21	*Xanthoria tenax*	17
22	*Phlyctella* sp. 1	20
23	*Thrypethelium* sp.	17

* Percent of examined trees with listed epiphyte species.

Note: Survey data revealed the following percentages of total epiphytes (23 species) occurring at all sites: one fern (4%), one *Aracea* (4%), two other angiosperms (9%), two mosses (9%), three bromeliads (13%), five liverworts (22%), and nine lichens (39%). Epiphytes made up 6% of all plants surveyed. Of these, 30% were vascular, and 70% non-vascular.

APPENDIX II. Rare epiphytic species found only once in the survey, Central Guatemala, 2002.

No.	Epiphytes	Site	Host tree
1	*Enterosora parietina*	TSF	*Pinus strobulus* var. *chiapensis*
2	*Melopomene moniliformis*	TSF	*Juglans guatemalensis*
3	*Hymenophyllum lanatum*	CF	*Persea donnell-smith*
4	*Hymenophyllum myriocarpum*	CF	*Liquidambar styraciflua*
5	*Elaphaglossum piloseloides*	CF	*Cornus disciflora*
6	*Elaphaglossum amygdalifolium*	CF	*Liquidambar styraciflua*
7	*Elaphaglossum glaucum*	CF	*Cornus disciflora*
8	*Elaphaglossum paleaceum*	TSF	*Pouteria viridis*
9	*Campyloneurum amphostenon*	TSF	*Spondias purpurea*
10	*Laxogramme mexicana*	TSF	*Spondias purpurea*
11	*Microgramma lycopodioides*	ETF	*Parathesis* sp.
12	*Microgramma nitida*	ETF	*Eugenia* sp.
13	*Microgramma reptans*	ETF	*Inga rodrigueziana*
14	*Pleopeltis macrocarpa*	ETF	*Clusia salvinii*
15	*Polypodium rhodopleuron*	ETF	*Eugenia* sp.
16	*Dictyoxiphium panamense*	TSF	*Pinus strubulus* var. *chiapensis*
17	*Anthrophyllum ensiforme*	ETF	*Eugenia* sp.
18	*Vittaria lineata*	CF	*Persea donnell-smith*
19	*Anthurium microspadix*	TSF	*Juglans guatemalensis*
20	*Philodendron anisotomum*	TSF	*Juglans guatemalensis*
21	*Monstera pertusa*	ETF	*Eugenia* sp.
22	*Philodendron radiatum*	ETF	*Eugenia* sp.
23	*Cyanchum schlechtendalii*	CF	n.i. Rutaceae
24	*Clusia rosea*	CF	*Liquidambar styraciflua*
25	*Tradescantia* sp. 2	TSF	*Juglans guatemalensis*
26	*Fevellea cordifolia*	TSF	*Juglans guatemalensis*
27	*Peperomia cobana*	ETF	*Inga rodrigueziana*
28	*Peperomia suchitanensis*	ETF	*Pouteria viridis*
29	*Peperomia* sp.	TSF	*Pinus strobulus* var. *chiapensis*
30	*Myriocarpa izabelensis*	ETF	*Eugenia* sp.
31	*Aechmea* sp.	ETF	*Hymenea courbaril*
32	*Tillandsia schiediana*	ETF	*Hymenea courbaril*
33	*Dichaea muricata*	CF	*Magnolia guatemalensis*
34	*Encyclia pygmeae*	CF	*Cornus disciflora*
35	*Epidendrum arbuscula*	CF	*Pinus pseudostrobus*
36	*Epidendrum mixtum*	CF	*Magnolia guatemalensis*
37	*Epidendrum repens*	CF	n.i. Rutaceae
38	*Maxillaria meleagris*	CF	*Magnolia guatemalensis*
39	*Maxilaria acutifolia*	ETF	*Clusia salvinii*
40	*Maxillaria* sp.	CF	*Pinus pseudostrobus*
41	*Osmoglossum egertonii*	CF	*Liquidambar styraciflua*
42	*Pleurothallis hirsuta*	CF	*Quercus pilicaulis*
43	*Pleurothallis fuegii*	CF	*Quercus pilicaulis*
44	*Pleurothallis grobyi*	ETF	*Pouteria mammosa*
45	*Platystele pedicellaris*	TSF	*Pouteria viridis*
46	*Prescotia stachyoides*	CF	*Liquidambar styraciflua*
47	*Sigmatostalix guatemalensis*	CF	*Liquidambar styraciflua*
48	*Brachymenium* sp.	CF	*Magnolia guatemalensis*
49	*Bryum* sp.	TSF	*Juglans guatemalensis*
50	*Syrrhopodon* sp.	TSF	*Persea schiediana*
51	*Atractolycarpus* sp.	TSF	*Pinus strobulus* var. *chiapensis*
52	*Campylopus* sp.	TSF	*Pinus strobulus* var. *chiapensis*
53	*Dicranodontium* sp.	CF	*Magnolia guatemalensis*
54	*Entodon* sp.	TSF	*Pinus strobulus* var. *chiapensis*
55	*Erpodium* sp.	CF	*Cornus disciflora*
56	*Braunia* sp.	CF	*Cornus disciflora*
57	*Hydropogonella* sp.	ETF	*Inga rodrigueziana*
58	*Lopidium* sp.	ETF	*Inga rodrigueziana*
59	*Hypopterygium tamarisci*	CF	*Liquidambar styraciflua*
60	*Lepyrodon* sp.	CF	*Liquidambar styraciflua*
61	*Leskea* sp.	CF	*Liquidambar styraciflua*
62	*Holomitriopsis* sp.	CF	*Pinus pseudostrobus*

APPENDIX II. Continued.

No.	Epiphytes	Site	Host tree
63	*Macrocoma* sp. 3	ETF	*Clusia salvinii*
64	*Macromitrium* sp. 2	CF	*Eugenia jambos*
65	*Macromitrium* sp. 3	ETF	*Inga rodrigueziana*
66	*Macromitrium* sp. 4	TSF	*Juglans guatemalensis*
67	*Aerobryopsis* sp.	ETF	*Inga rodrigueziana*
68	*Floribundaria* sp. 1	TSF	*Pouteria viridis*
69	*Floribundaria* sp. 2	TSF	*Persea schiediana*
70	*Lepyrodontopsis* sp. 1	TSF	*Juglans guatemalensis*
71	*Lepyrodontopsis* sp. 2	TSF	*Pinus strobulus* var. *chiapensis*
72	*Meteorium* sp. 1	CF	*Persea donnell-smith*
73	*Meteorium* sp. 2	ETF	*Pouteria mammosa*
74	*Pilotrichella* sp. 1	CF	*Cornus disciflora*
75	*Pilotrichella* sp. 2	ETF	*Clusia salvinii*
76	*Schlotheimia* sp.	ETF	*Inga rodrigueziana*
77	*Papillaria* sp. 2	ETF	*Pouteria mammosa*
78	*Mniomalia viridis*	TSF	*Pouteria viridis*
79	*Lethotheca boliviana*	CF	*Magnolia guatemalensis*
80	*Donnellia commutata*	ETF	*Pouteria campechiana*
81	*Rhizogonium spiniforme*	ETF	*Inga rodrigueziana*
82	*Pinnatella minuta*	CF	*Liquidambar styraciflua*
83	*Rauiella* sp.	CF	n.i. Rutaceae
84	*Lethocolea* sp.	ETF	*Eugenia* sp.
85	*Mnioloma* sp.	TSF	*Juglans guatemalensis*
86	*Calypogeia* sp.	CF	*Persea donnell-smith*
87	*Cephalozia crassifolia*	CF	*Persea donnell-smith*
88	*Cephalozia* sp.	ETF	*Pouteria mammosa*
89	*Leptoscyphus porphyrius*	CF	*Persea donnell-smith*
90	*Chonecolea* sp.	CF	*Eugenia jambos*
91	*Herbertus* sp.	CF	*Liquidambar styraciflua*
92	*Frullania ericoides*	ETF	*Inga rodrigueziana*
93	*Jamesoniella rubricaria*	CF	*Quercus pilicaulis*
94	*Aphanolejeunea* sp.	CF	*Liquidambar styraciflua*
95	*Archilejeunea* sp.	CF	n.i. Rutaceae
96	*Bryopteria diffusa*	CF	n.i. Rutaceae
97	*Cheilolejeunea adnata*	ETF	*Inga rodrigueziana*
98	*Cheilolejeunea acutangula*	ETF	*Inga rodrigueziana*
99	*Cheilolejeunea trifaria*	ETF	*Pouteria mammosa*
100	*Cheilolejeunea* sp. 2	ETF	*Hymenea courbaril*
101	*Harpalejeunea* sp.	TSF	*Pinus strobulus* var. *chiapensis*
102	*Lejeunea cancellata*	CF	n.i. Rutaceae
103	*Lepidolejeunea involuta*	CF	*Liquidambar styraciflua*
104	*Lepidolejeunea* sp.	ETF	*Clusia salvinii*
105	*Lopholejeunea subfusca/nigricans*	TSF	*Pinus strobulus* var. *chiapensis*
106	*Marchesinia brachiata*	TSF	*Persea schiediana*
107	*Odontolejeunea lunata*	TSF	*Juglans guatemalensis*
108	*Omphalantus filiformis*	TSF	*Juglans guatemalensis*
109	*Taxilejeunea* sp. 2	ETF	*Inga rodrigueziana*
110	*Odontoschisma* sp.	CF	*Persea donnell-smith*
111	*Trichocolea* sp.	CF	*Magnolia guatemalensis*
112	*Brigantiaea leucoxantha*	CF	*Cornus disciflora*
113	*Candelariella* sp.	TSF	*Pinus strobulus* var. *chiapensis*
114	*Chrysotrix* sp. (yellow)	CF	*Pinus pseudostrobus*
115	*Chrysotrix* sp. (ocher)	CF	*Pinus pseudostrobus*
116	*Coccocarpia* sp.	TSF	*Liquidambar styraciflua*
117	*Coccotrema* sp.	TSF	*Liquidambar styraciflua*
118	*Leptogonium azureum*	TSF	*Persea schiediana*
119	*Leptogonium coralloideum*	TSF	*Juglans guatemalensis*
120	*Leptogonium corticola*	CF	n.i. Rutaceae
121	*Leptogonium marginellum*	ETF	*Parathesis* sp.
122	*Crocynia pyxinoides*	ETF	*Hymenea courbaril*
123	*Calopadia fusca*	CF	n.i. Rutaceae
124	*Graphis* sp. 3	ETF	*Hymenea courbaril*

APPENDIX II. Continued.

No.	Epiphytes	Site	Host tree
125	*Dimerella* sp.	TSF	*Pouteria viridis*
126	*Loxospora cismonica*	CF	*Liquidambar styraciflua*
127	*Lecanora* sp.	CF	*Cornus disciflora*
128	*Tephromela atra*	CF	*Liquidambar styraciflua*
129	*Lepraria* (yellow-green)	ETF	*Inga rodrigueziana*
130	*Lepraria* sp. 2 (red)	CF	*Pinus pseudostrobus*
131	*Pseudocyphellaria* sp.	TSF	*Persea schiediana*
132	*Sticta* sp. 2	TSF	*Juglans guatemalensis*
133	*Sticta* sp. 3	ETF	*Inga rodrigueziana*
134	*Sticta* sp. 4	CF	*Magnolia guatemalensis*
135	*Sticta* sp. 5	TSF	*Pouteria viridis*
136	*Dictyonema sericeum*	CF	*Quercus pilicaulis*
137	*Opegrapha herbarum*	ETF	*Inga rodrigueziana*
138	*Parmelinopsis* sp. 2	TSF	*Pinus strobulus* var. *chiapensis*
139	*Parmotrema cristiferum*	TSF	*Persea schiediana*
140	*Parmotrema michauxianum*	CF	*Eugenia jambos*
141	*Parmotrema* sp.	CF	*Pinus pseudostrobus*
142	*Rimelia* sp.	ETF	*Inga rodrigueziana*
143	*Usnea* sp. 2	CF	*Liquidambar styraciflua*
144	*Phyllopsora corallina* var. *ochroxantha*	CF	*Liquidambar styraciflua*
145	*Phyllopsora* sp. 1	CF	*Liquidambar styraciflua*
146	*Phyllopsora* sp. 2	CF	*Pinus pseudostrobus*
147	*Heterodermia albicans*	ETF	*Inga rodrigueziana*
148	*Heterodermia speciosa*	CF	*Quercus pilicaulis*
149	*Heteroderma* sp. 2	ETF	*Inga rodrigueziana*
150	*Physcia* sp.	CF	*Pinus pseudostrobus*
151	*Physcia atrostriata*	TSF	*Juglans guatemalensis*
152	*Physcia neogaea*	TSF	*Pouteria viridis*
153	*Ramalina* sp.	CF	*Liquidambar styraciflua*
154	*Ramulina nervulosa*	CF	*Pinus pseudostrobus*
155	*Myriotrema* sp.	ETF	*Parathesis* sp.
156	*Ocellularia* sp.	CF	*Liquidambar styraciflua*
157	*Porina heterospora*	ETF	*Pouteria mammosa*
158	*Porina* sp.	ETF	*Clusia salvinii*

Note: CF = cloud forest, ETF = evergreen tropical forest, and TSF = temperate subtropical forest. Survey data revealed the following percentages of total rare epiphytes (158 species): 2 bromeliads (1%), 4 *Aracea* (3%), 8 other angiosperms (5%), 15 orchids (9%), 18 ferns (11%), 28 liverworts (18%), 36 mosses (23%), and 47 lichens (30%). Rare epiphytes were vascular (29%) and non-vascular (71%).

APPENDIX III. Epiphytic species found only on emergent trees, Central Guatemala, 2002.

No.	Epiphyte	Rare species	Site/s
1	*Nephrolepis bisserata*		TSF, CF
2	*Enterosora parietina*	●	TSF
3	*Melopomene moniliformis*	●	TSF
4	*Hymenophyllum myriocarpum*	●	CF
5	*Elaphaglossum guatemalense*		TSF, CF
6	*Elaphaglossum amygdalifolium*	●	CF
7	*Pecluma alfredii*		TSF
8	*Dictyoxiphium panamense*	●	TSF
9	*Clusia rosea*	●	CF

APPENDIX III. Continued.

No.	Epiphyte	Rare species	Site/s
10	*Tillandsia lucida*		TSF, CF
11	*Dichaea muricata*	•	CF
12	*Epidendrum arbuscula*	•	CF
13	*Epidendrum mixtum*	•	CF
14	*Lockhartia oerstedii*		TSF, CF
15	*Maxillaria meleagris*	•	CF
16	*Maxillaria* sp.	•	CF
17	*Osmoglossum egertonii*	•	CF
18	*Prescotia stachyoides*	•	CF
19	*Sigmatostalix guatemalensis*	•	CF
20	*Brachymenium* sp.	•	CF
21	*Atractolycarpus* sp.	•	TSF
22	*Campylopus* sp.	•	TSF
23	*Dicranodontium* sp.	•	CF
24	*Holomitrium* sp.		CF
25	*Entodon* sp.	•	TSF
26	*Hypopterygium tamarisci*	•	CF
27	*Lepyrodon* sp.	•	CF
28	*Leskea* sp.	•	CF
29	*Barbella trichophora*		TSF, CF
30	*Holomitriopsis* sp.	•	CF
31	*Leucobryum* sp.		TSF, CF
32	*Macromitrium* sp. 4	•	TSF
33	*Lepyrodontopsis* sp. 1	•	TSF
34	*Lepyrodontopsis* sp. 2	•	TSF
35	*Lepthoteca boliviana*	•	CF
36	*Pinnatella minuta*	•	CF
37	*Herbertus* sp.	•	CF
38	*Anoplolejeunea conferta*		TSF, CF
39	*Aphanolejeunea* sp.	•	CF
40	*Ceratolejeunea* sp. 1		CF, ETF
41	*Harpalejeunea* sp.	•	TSF
42	*Lejeunea cancellata*	•	CF
43	*Lepidolejeunea involuta*	•	CF
44	*Lopholejeunea subfusca/nigricans*	•	TSF
45	*Microlejeunea* sp.		TSF, CF
46	*Trichocolea* sp.	•	CF
47	*Candelariella* sp.	•	TSF
48	*Cladonia* sp.		TSF, CF
49	*Chrysothrix* sp. (yellow)	•	CF
50	*Chrysothrix* sp. (ocher)	•	CF
51	*Coccotrema* sp.	•	TSF
52	*Loxospora cismonica*	•	CF
53	*Tephromela atra*	•	CF
54	*Lepraria* sp. 2 (red)	•	CF
55	*Sticta* sp. 4	•	CF
56	*Parmelinopsis* sp. 2	•	TSF
57	*Parmotrema* sp.	•	CF
58	*Parmotrema xanthium*		TSF
59	*Usnea baileyi*		TSF, CF
60	*Usnea* sp. 1		TSF
61	*Usnea* sp. 2	•	CF
62	*Phyllopsora corallina* var. *ochroxantha*	•	CF
63	*Phyllopsora* sp. 1	•	CF
64	*Phyllopsora* sp. 2	•	CF
65	*Physcia* sp.	•	CF
66	*Ramalina nervulosa*	•	CF
67	*Ramalina* sp.	•	CF
68	*Ocellularia* sp.	•	CF

Note: The 68 epiphytic species found only on emergent trees made up 20% of all species surveyed. Of these epiphytes, 55 were rare and represented 35% of all rare species surveyed. The 68 species consisted of 8 ferns, 1 angiosperm, 1 bromeliad, 9 orchids, 17 mosses, 10 liverworts, and 22 lichens.

APPENDIX IV. Epiphytic species found only on solitary trees, Central Guatemala, 2002.

No.	Epiphyte	Rare species	Site/s
1	*Enterosora trichosora*		TSF, CF
2	*Campyloneurum amphostenon*	●	TSF
3	*Laxogramme mexicana*	●	TSF
4	*Microgramma lycopodioides*	●	ETF
5	*Anthurium microspadix*	●	TSF
6	*Philodendron anisotomum*	●	TSF
7	*Tradescantia* sp. 2	●	TSF
8	*Fevellea cordifolia*	●	TSF
9	*Peperomia quadrifolia*		ETF
10	*Peperomia* sp.	●	TSF
11	*Aechmea* sp.	●	ETF
12	*Tillandsia schiediana*	●	ETF
13	*Pleurothallis grobyi*	●	ETF
14	*Bryum* sp.	●	TSF
15	*Meteorium* sp. 2	●	ETF
16	*Papillaria* sp. 1		TSF, ETF
17	*Papillaria* sp. 2	●	ETF
18	*Mnioloma* sp.	●	TSF
19	*Cephalozia* sp.	●	CF
20	*Cheilolejeunea trifaria*	●	ETF
21	*Cheilolejeunea* sp. 2	●	ETF
22	*Odontolejeunea lunata*	●	TSF
23	*Omphalanthus filiformis*	●	TSF
24	*Leptogium coralloideum*	●	TSF
25	*Leptogium marginellum*	●	ETF
26	*Crocynia pyxinoides*	●	ETF
27	*Graphis* sp. 3	●	ETF
28	*Sticta* sp. 2	●	TSF
29	*Physcia atrostriata*	●	TSF
30	*Myriotrema* sp.	●	ETF
31	*Porina heterospora*	●	ETF

Note: These epiphytic species found only on solitary trees made up 8% of all species found. Among the 31 species, 29 were rare and made up 18% of all rare species found. They were 4 ferns, 2 Araceae, 4 other angiosperms, 2 bromeliads, 1 orchid, 4 mosses, 6 liverworts, and 8 lichens.

APPENDIX V. All species surveyed, Central Guatemala, 2002.

Family	List no.	Plant name
Davalliaceae	1	*Nephrolepis bisserata*
	2	*Nephrolepis cordifolia*
Grammitidacae	3	*Grammitis moniliformis*
	4	*Grammitis* sp.
	5	*Ceradenia jungermannoides*
	6	*Cochlidium serrulatum*
	7	*Lellingeria myosuroides*
	8	*Enterosora trichosora*
	9	*Enterosora parietina*
	10	*Melopomene moniliformis*
	11	*Melopomene pilossisima*
Hymenophyllaceae	12	*Hymenophyllum asplenoides*
	13	*Hymenophyllum lanatum*
	14	*Hymenophyllum polyanthos*
	15	*Hymenophyllum myriocarpum*
Lomariopsidaceae	16	*Elaphaglossum auricomum*
	17	*Elaphaglossum tectum*

APPENDIX V. Continued.

Family	List no.	Plant name
Lomariopsidaceae (Continued)	18	*Elaphaglossum guatemalense*
	19	*Elaphaglossum piloseloides*
	20	*Elaphaglossum setigerum*
	21	*Elaphaglossum amygdalifolium*
	22	*Elaphaglossum glaucum*
	23	*Elaphaglossum paleaceum*
	24	*Elaphaglossum latifolium*
	25	*Peltapteris peltata*
Polypodiaceae	26	*Campyloneurum angustifolium*
	27	*Campyloneurum amphostenon*
	28	*Laxogramme mexicana*
	29	*Microgramma lycopodioides*
	30	*Microgramma nitida*
	31	*Microgramma reptans*
	32	*Niphidum crassifolium*
	33	*Pecluma alfredii*
	34	*Pleopeltis macrocarpa*
	35	*Pleopeltis astrolepis*
	36	*Pleopeltis angusta*
	37	*Polypodium pseudoaureum*

APPENDIX V. Continued.

Family	List no.	Plant name
Polypodiaceae (Continued)	38	*Polypodium cryptocarpon*
	39	*Polypodium dissimile*
	40	*Polypodium triseriale*
	41	*Polypodium subpetiolatum*
	42	*Polypodium loriceum*
	43	*Polypodium rhodopleuron*
	44	*Polypodium furfuraceum*
	45	*Polypodium* sp.
Tectariaceae	46	*Dictyoxiphium panamense*
Thelypteridaceae	47	*Thelypteris* sp.
Vittariaceae	48	*Anthrophyllum ensiforme*
	49	*Vittaria gramnifolia*
	50	*Vittaria lineata*
Araceae	51	*Anthurium microspadix*
	52	*Anthurium scandens*
	53	*Philodendron anisotomum*
	54	*Monstera pertusa*
	55	*Philodendron radiatum*
	56	*Philodendron tripartitum*
Araliaceae	57	*Dendropanex arboreus*
Asclepiaceae	58	*Cynanchum schlechtendalii*
Cluisaceae	59	*Clusia guatemalensis*
	60	*Clusia rosea*
	61	*Clusia* sp.
Commelinaceae	62	*Tradescantia* sp. 1
	63	*Tradescantia* sp. 2
Cucurbitaceae	64	*Fevellea cordifolia*
	65	*Pterosicyos lacinatus*
Ericaceae	66	*Cavendishia laurifolia*
	67	*Cavendishia guatemalensis*
	68	*Sphyrospermum majus*
Piperaceae	69	*Peperomia cobana*
	70	*Peperomia praetenuis*
	71	*Peperomia quadrifolia*
	72	*Peperomia suchitanensis*
	73	*Peperomia tacticana*
	74	*Peperomia* sp.
Urticariaceae	75	*Myriocarpa izabelensis*
Bromeliaceae	76	*Androlepis skinneri*
	77	*Aechmea tillandsoides*
	78	*Aechmea* sp.
	79	*Catopsis subulata*
	80	*Catopsis nitida*
	81	*Catopsis hahnii*
	82	*Catopsis wangerinii*
	83	*Catopsis* sp.
	84	*Guzmania* sp.
	85	*Tillandsia punctulata*
	86	*Tillandsia tricolor*
	87	*Tillandsia butzii*
	88	*Tillandsia schiediana*
	89	*Tillandsia filifolia*
	90	*Tillandsia lucida*
	91	*Tillandsia juncea*
	92	*Tillandsia yunckeri*
	93	*Tillandsia rodrigueziana*
	94	*Tillandsia* sp.
Orchideaceae	95	*Dichaea muricata*
	96	*Encyclia pygmeae*
	97	*Encyclia ocheracea*
	98	*Epidendrum arbuscula*
Orchideaceae (Continued)	99	*Epidendrum chlorocorymbos*
	100	*Epidendrum comayaguense*
	101	*Epidendrum diforme*
	102	*Epidendrum mixtum*
	103	*Epidendrum repens*
	104	*Jacquiniella cobanensis*
	105	*Lockhartia oerstedii*
	106	*Maxillaria uncata*
	107	*Maxillaria eliator*
	108	*Maxillaria neglecta*
	109	*Maxillaria meleagris*
	110	*Maxillaria variabilis*
	111	*Maxillaria cucullata*
	112	*Maxillaria anceps*
	113	*Maxillaria densa*
	114	*Maxillaria acutifolia*
	115	*Maxillaria rhombea*
	116	*Maxillaria* sp.
	117	*Nidema boothii*
	118	*Osmoglossum egertonii*
	119	*Pleurothallis pansamalae*
	120	*Pleurothallis correllii*
	121	*Pleurothallis hirsuta*
	122	*Pleurothallis fuegii*
	123	*Pleurothallis grobyi*
	124	*Platystele pedicellaris*
	125	*Prescotia stachoyoides*
	126	*Scaphyglottis minutiflora*
	127	*Scaphyglottis gramnifolia*
	128	*Sigmatostalix guatemalensis*
Adoletheciaceae	129	*Adelothecium bogotense*
Anomodontaceae	130	*Herpetineuron* sp.
Bryaceae	131	*Brachymenium* sp.
	132	*Bryum* sp.
Calymperaceae	133	*Syrrhopodon* sp.
Catagoniaceae	134	*Catagonium brevicaudatum*
Dicranaceae	135	*Atractolycarpus* sp.
	136	*Campylopus* sp.
	137	*Dicranodontium* sp.
	138	*Holomitrium* sp.
	139	*Leucoloma* sp.
Entodontaceae	140	*Entodon* sp.
Erpodiaceae	141	*Erpodium* sp.
Hedwigiaceae	142	*Braunia* sp.
Hydropogonaceae	143	*Hydropogonella* sp.
	144	*Lopidium* sp.
Hypopterygiaceae	145	*Hypopterygium tamarisci*
Lepyrodontraceae	146	*Lepyrodon* sp.
Leskeaceae	147	*Leskea* sp.
Leucobryaceae	148	*Barbella trichophora*
	149	*Holomitriopsis* sp.
	150	*Leucobryum* sp.
	151	*Octoblepharum albidum*
	152	*Octoblepharum cocuiense*
Leucodontaceae	153	*Leucodon* sp.
Leucomiaceae	154	*Leucomium strumosum*
	155	*Rhynchostegiopsis* sp.

APPENDIX V. Continued.

Family	List no.	Plant name
Macromitriaceae	156	*Groutiella* sp.
	157	*Macrocoma* sp. 1
	158	*Macrocoma* sp. 2
	159	*Macrocoma* sp. 3
	160	*Macromitrium scoparium*
	161	*Macromitrium guatemalense*
	162	*Macromitrium* sp. 1
	163	*Macromitrium* sp. 2
	164	*Macromitrium* sp. 3
	165	*Macromitrium* sp. 4
Meteoriaceae	166	*Aerbryopsis* sp.
	167	*Floribundaria* sp. 1
	168	*Floribundaria* sp. 2
	169	*Lepyrodontopsis* sp. 1
	170	*Lepyrodontopsis* sp. 2
	171	*Meteorium deppei*
	172	*Meteorium* sp. 1
	173	*Meteorium* sp. 2
	174	*Orthostichella pentasticha*
	175	*Pilotrichella* sp. 1
	176	*Pilotrichella* sp. 2
	177	*Schlotheimia* sp.
	178	*Papillaria* sp. 1
	179	*Papillaria* sp. 2
Orthotrichaceae	180	*Orthotrichum* sp.
Phyllodrepaniaceae	181	*Mniomalia viridis*
Pilotrichaceae	182	*Crossomitrium* sp.
Racopilaceae	183	*Racopilum tomentosum*
Rhizogoniaceae	184	*Rhizogonium spiniforme*
	185	*Lepthoteca boliviana*
Sematophyllaceae	186	*Donnellia commutata*
Thamnobryaceae	187	*Pinnatella minuta*
Thuidiaceae	188	*Cyrto-hypnum* sp.
	189	*Rauiella* sp.
Acrobolaceae	190	*Lethocolea* sp.
Calypogeiaceae	191	*Mnioloma* sp.
	192	*Calypogeia* sp.
Cephaloziellaceae	193	*Cephalozia crassifolia*
	194	*Cephalozia* sp.
	195	*Leptoscyphus porphyrius*
Chonecoleaceae	196	*Chonecolea* sp.
Herbetaceae	197	*Herbertus* sp.
Jubulaceae	198	*Frullania apiculata*
	199	*Frullania brasiliensis*
	200	*Frullania caulisequa*
	201	*Frullania ericoides*
	202	*Frullania* sp. 1
	203	*Frullania* sp. 2
Jungermanniaceae	204	*Jamesoniella rubricaria*
Lejeuneaceae	205	*Anoplolejeunea conferta*
	206	*Aphanolejeunea* sp.
	207	*Archilejeunea* sp.
	208	*Bryopteris diffusa*
	209	*Ceratolejeunea* sp. 1
	210	*Ceratolejeunea* sp. 2
	211	*Cheilolejeunea adnata*
Lejeuneaceae (Continued)	212	*Cheilolejeunea acutangula*
	213	*Cheilolejeunea trifaria*
	214	*Cheilolejeunea* sp. 1
	215	*Cheilolejeunea* sp. 2
	216	*Cololejeunea* spp.
	217	*Drepanolejeunea* sp.
	218	*Harpalejeunea* sp.
	219	*Lejeunea cerina*
	220	*Lejeunea laetevirens*
	221	*Lejeunea cancellata*
	222	*Lejeunea* sp.
	223	*Lepidolejeunea involuta*
	224	*Lepidolejeunea* sp.
	225	*Lopholejeunea subfusca/nigricans*
	226	*Microlejeunea* spp.
	227	*Marchesinia brachiata*
	228	*Odontolejeunea lunata*
	229	*Omphalanthus filiformis*
	230	*Symbiezidium* sp.
	231	*Taxilejeunea* sp. 1
	232	*Taxilejeunea* sp. 2
Lepidoceaceae	233	*Bazzania* sp. 1
	234	*Bazzania* sp. 2
Metzgeriaceae	235	*Metzgeria* sp.
Odontoschismataceae	236	*Odontoschisma* sp.
Plagiochilaceae	237	*Plagiochila raddiana*
Trichocoleaceae	238	*Trichocolea* sp.
Radulaceae	249	*Radula* sp.
Arthoniaceae	240	*Cryptothecia rubrocincta*
	241	*Cryptothecia striata*
Brigantiaeaceae	242	*Brigantiaea leucoxantha*
Candelariaceae	243	*Candelariella* sp.
Cladoniaceae	244	*Cladonia ceratophylla*
	245	*Cladonia* sp.
Chrysotrichaceae	246	*Chrysothrix* sp. (yellow)
	247	*Chrysothrix* sp. (ocher)
Coccocarpiaceae	248	*Coccocarpia* sp.
Coccotremaceae	249	*Coccotrema* sp.
Collemataceae	250	*Collema* sp.
	251	*Leptogium azureum*
	252	*Leptogium coralloideum*
	253	*Leptogium corticola*
	254	*Leptogium marginellum*
Crocyniaceae	255	*Crocynia pyxinoides*
Ectolechiaceae	256	*Calopadia fusca*
Graphidaceae	257	*Graphis afzelii*
	258	*Graphis* sp. 1
	259	*Graphis* sp. 2
	260	*Graphis* sp. 3
	261	*Phaeographis* sp.
Gyalectaceae	262	*Coenogonium* sp.
	263	*Dimerella* sp.
	264	*Gyalecta* sp.
Haematommataceae	265	*Loxospora cismonica*
Lecanoraceae	266	*Lecanora thysanophora*
	267	*Lecanora* sp.
	268	*Pyrrospora russula*

APPENDIX V. Continued.

Family	List no.	Plant name
Lecideaceae	269	*Tephromela atra*
Leprariaceae	270	*Lepraria lobificans*
	271	*Lepraria* sp. (white)
	272	*Lepraria* (yellow-green)
	273	*Lepraria* sp. 1 (red)
	274	*Lepraria* sp. 2 (red)
Lobariaceae	275	*Pseudocyphellaria* sp.
	276	*Pseudocyphellaria aurata*
	277	*Sticta* sp. 1
	278	*Sticta* sp. 2
	279	*Sticta* sp. 3
	280	*Sticta* sp. 4
	281	*Sticta* sp. 5
	282	*Sticta weigelii*
Meruliaceae	283	*Dictyonema sericeum*
Opegraphaceae	284	*Opegrapha herbarum*
Pannariaceae	285	*Parmeliella pannosa*
Parmeliaceae	286	*Bulbothrix* sp.
	287	*Bulbothrix laevigatula*
	288	*Hypotrachyna* sp. 1
	289	*Hypotrychyna* sp. 2
	290	*Parmelinopsis* sp. 1
	291	*Parmelinopsis* sp. 2
	292	*Parmelinopsis spumosa*
	293	*Parmotrema cristiferum*
	294	*Parmotrema endosulphureum*
	295	*Parmotrema michauxianum*
	296	*Parmotrema* sp.
	297	*Parmotrema xanthium*
	298	*Pseudoparmelia uleana/cubensis/floridensis*
	299	*Punctelia* sp.
	300	*Rimelia* sp.
	301	*Usnea antiqua*
	302	*Usnea baileyi*
	303	*Usnea* sp. 1
	304	*Usnea* sp. 2
Pertusariaceae	305	*Pertusaria amara*
Pertusariaceae (Continued)	306	*Pertusaria* sp. 1
	307	*Pertusaria* sp. 2
	308	*Pertusaria* sp. 3
	309	*Pertusaria* sp. 4
	310	*Pertusaria* sp. 5
Phyllopsoraceae	311	*Phyllopsora isidiotyla*
	312	*Phyllopsora glabella*
	313	*Phyllopsora buettneri* var. *glauca*
	314	*Phyllopsora corallina* var. *ochroxantha*
	315	*Phyllopsora* sp. 1
	316	*Phyllopsora* sp. 2
Physciaceae	317	*Buellia stillingiana*
	318	*Dirinaria picta*
	319	*Heterodermia albicans*
	320	*Heterodermia speciosa*
	321	*Heterodermia* sp. 1
	322	*Heterodermia* sp. 2
	323	*Phaeophyscia* sp.
	324	*Physcia atrostriata*
	325	*Physcia neogaea*
	326	*Physcia* sp.
	327	*Pyxine* sp.
Pyrenulaceae	328	*Pyrenula* sp.
Ramalinaceae	329	*Ramalina nervulosa*
	330	*Ramalina* sp.
Teloschistaceae	331	*Xanthoria tenax*
Thelotremataceae	332	*Phlyctella* sp. 1
	333	*Phyctella* sp. 2
	334	*Myriotrema* sp.
	335	*Ocellularia* sp.
Tricholomataceae	336	*Omphalina* sp.
Trichotheliaceae	337	*Porina heterospora*
	338	*Porina* sp.
Trypetheliaceae	339	*Trypethelium* sp.
Unidentified plants		21 Angiospermae