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Diversidad y endemismo de seis grupos de plantas en la Cordillera Mosetenes, Cochabamba, Bolivia

Diversity and endemism of six plant groups in the Cordillera Mosetenes, Cochabamba, Bolivia

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RESUMEN

Realizamos un inventario de seis grupos de plantas, Acanthaceae, Araceae, Bromeliaceae, Cactaceae, Palmae, y Pteridophyta, en 20 parcelas de 400 m^2 cada una a 1200-1600 m en la hasta entonces botánicamente inexplorada Cordillera Mosetenes, Cochabamba, Bolivia. Encontramos cinco especies de Acanthaceae, 36 Araceae, 16 Bromeliaceae, dos Cactaceae, cuatro Palmae, y 158 Pteridophyta. El número de especies por parcelas así como los niveles de endemismo fueron bajos a intermedios en comparación a localidades a altitudes similares en los Andes bolivianos. Las comunidades de plantas en las crestas de montaña estuvieron compuestas mayormente por especies de elevaciones menores, en ves de contener elementos típicamente montanos. En comparación a otras localidades en Bolivia, la Cordillera Mosetenes es de baja prioridad de conservación para los grupos de plantas estudiados.

Palabras Clave: Acanthaceae, Andes, Araceae, Arecaceae, Bolivia, Bromeliaceae, Cactaceae, conservación, diversidad, endemismo, helechos, palmeras, Pteridophyta

ABSTRACT

We sampled six plant groups, Acanthaceae, Araceae, Bromeliaceae, Cactaceae, Palmae, and Pteridophyta, in 20 plots of 400 m^2 each at 1200-1600 m in the botanically previously unexplored Cordillera Mosetenes, Cochabamba, Bolivia. We recorded five species of Acanthaceae, 36 Araceae, 16 Bromeliaceae, two Cactaceae, four Palmae, and 158 Pteridophyta. Species numbers per plot as well as levels of endemism were low to intermediate compared to other sites at similar elevation in the Bolivian Andes. Plant communities in stunted ridge forests were impoverished subsets of those from lower elevations, rather than containing typical montane taxa from higher elevations. Compared to other sites in Bolivia, the Cordillera Mosetenes is of low conservation priority for the studied plant groups.

Key words: Acanthaceae, Andes, Araceae, Arecaceae, Bolivia, Bromeliaceae, Cactaceae, Conservation, Diversity, Endemism, Ferns, Palms, Pteridophyta

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INTRODUCTION

Tropical forests are well known for their high plant diversity that makes botanical surveys very time consuming and expensive (Terborgh, 1992; Kier *et al*., 2005). Accordingly, many researchers have restricted their surveys to parts of the flora, either focusing on specific life forms such as trees (e.g., Gentry, 1988; Valencia *et al*., 1994; Smith & Killeen, 1998) or epiphytes (e.g., Ingram *et al*., 1996; Arévalo & Betancour, 2004; Krömer *et al*., 2005), or on selected taxonomic groups. Among the latter, recent studies have shown that ferns and lycophytes, as well as palms and melastomes, are valuable indicators of overall diversity and community composition of Amazonian forests (Ruokolainen *et al*., 1997; Vormisto *et al*., 2000; Tuomisto *et al*., 1995, 2003). In other vegetation types, other plant groups also are useful indicators (Kessler & Bach, 1999).

This paper deals with six plant groups, namely Acanthaceae (acanthus family), Araceae (aroids), Bromeliaceae (bromeliads), Cactaceae (cacti), Palmae (palms), and Pteridophyta (ferns and lycophytes), which have been the focus of our research for almost a decade (e.g., Kessler *et al*., 1999, 2000, 2001a, b; Krömer *et al*., 1999; Smith *et al*., 1999; Ibisch *et al*., 2000; Kessler, 2000, 2001a, b, 2002a, b; Kessler & Krömer, 2000; Krömer & Kessler, 2004; Krömer *et al*., 2006). We have methodologically identical surveys from 65 other sites in the Bolivian Andes, ranging from the Amazonian lowlands to timberline, and from dripping wet montane forests to cactus-dominated thorn forests. For the purpose of the present analysis, three of these surveys are particularly useful as comparative sites: Carrasco National Park to the south, where we have surveyed the only complete elevational transect in Bolivia (Kessler *et al*., 1999, 2001; Kessler, 2001b, 2002a), and Serranía Bellavista and Cerro Asunta Pata to the north. The latter two sites are located on mountain ranges of similar elevation and climate as the Cordillera Mosetenes.

Focusing on the six selected plant groups, our main research questions were:

- Which species occur on the Cordillera Mosetenes?

- How does the diversity at the Cordillera Mosetenes compare to the other sites in the Bolivian Andes? Our hypothesis was that species richness should be comparable or higher, given the extreme humidity at Mosetenes.

- How does the endemism at the Cordillera Mosetenes compare to the other sites in the Bolivian Andes? We expected that endemism should be very high, considering the isolation of the Cordillera Mosetenes.

- How does the species composition of the plant communities of the six study groups at the Cordillera Mosetenes compare to other sites in the Bolivian Andes? Our assumption was that the climatic extremes at the ridge of the cordillera should favor the presence of more montane elements than is typical for this elevation.

MATERIALS AND METHODS

The Cordillera Mosetenes in the department of Cochabamba, Bolivia, is a semi-isolated mountain range about 130 km long, 20-25 km wide, and up to about 2050 m high. The present study was conducted in the immediate vicinity of a small lagoon, which we called Laguna Carachupa, located at an elevation of 1310 m at the following geographical coordinates: 16°13'58"S, 66°24'54"E (UTM 0776352, 8203586). Studies were mainly conducted in a radius of 1 km around the lagoon, with several trails reaching from stream valleys at about 1200 m elevation to a mountain ridge at 1600 m. A detailed description of the study region is provided by Macía & Fuertes (2008).

Field work was conducted from 27 August to 17 September 2003. We surveyed 20 plots of 400 m², mostly of square shape in zonal forests but often in other shapes in linear habitats such as in ravines or on ridges. This size corresponds to the minimum area required for representative surveys of the study groups in the vegetation types sampled and is small enough to keep environmental factors more or less uniform throughout the plot (Kessler & Bach, 1999). Plot location was chosen so as to include ecologically homogeneous and physiognomically representative forest samples. Presence/absence of all species was registered in each plot, treating terrestrial and epiphytic plants separately. Epiphytic species were collected from fallen-down branches, sampled up to heights of 10 m with trimming poles, and observed through binoculars at greater heights. All species encountered in the survey area (but not in every single plot) were collected in triplicate and have been deposited at the Herbario Nacional de Bolivia (including all unicates), at the Herbarium Göttingen,

Germany, and with the respective specialists: T.B. Croat (St. Louis, Missouri; Araceae), M. Lehnert (Göttingen, tree ferns), H. Luther (Sarasota, Florida; Bromeliaceae), J.T. Mickel and R.C. Moran (New York; *Elaphoglossum*), M. Moraes (La Paz; Palmae), A.R. Smith (Berkeley, California; most pteridophyta), and D. Wasshausen (Washington, D.C.; Acanthaceae).

For the analysis, zonal forest at 1250-1400 m and ridge forest at 1500-1600 m were treated separately. Data analysis is based on the protocols detailed in Kessler (2001a, b, 2002a, b) and Kessler *et al*. (2001). Point-diversity was calculated as the mean number of species in zonal forest per plot. Because sampling intensity (number of plots) differed between study sites, no total species numbers are presented. Previous analyses have shown that relative differences in point diversity closely reflect differences in total species numbers between study sites (Kessler, 2001a, b). An endemism index was calculated as the mean inverse geographic range size of all species of each group recorded per site (Williams & Humphries, 1994). This index gives stronger weighting to narrowly distributed taxa while not being based on subjective cut-off limits (Usher, 1986; Fjeldså & Rahbek, 1997). The global ranges of all species encountered were mapped in a 1°-grid map based on herbarium and literature sources. The resulting dot maps were interpolated on the basis of the species' ecological requirements and the distribution of main vegetation types (Hueck & Seibert, 1981; Dinerstein *et al*., 1995) to obtain maps of the presumed natural ranges of the species. Some subjective element was unavoidable in this process, but since range map interpolation was carried out in a consistent manner, we assume that the resulting error is randomly distributed across the data and does not lead to systematic biases. Total range size was then expressed as the number of 1°-squares occupied by the global range of each species.

RESULTS AND DISCUSSION

Taxonomic records

Species recorded in the six study groups at Mosetenes were overall mostly rather widespread and well known. We had expected a large number of undescribed species, but the only new species was the weakly differentiated fern *Asplenium mosetenense* M. Kessler & A.R. Sm. (Kessler & Smith, 2006). Numerous collections, especially among the orchids, remain unidentified and we expect additional undescribed species among them. One aroid (*Philodendron* cf. *palacioanum* Croat & Grayum) and three ferns (*Ceradenia jungermannioides* (Klotzsch) L.E. Bishop, *Megalastrum vastum* (Kunze) A.R. Sm. & R.C. Moran, and *Polytaenium brasilianum* (Desv.) Benedict) were first records for Bolivia. The record of *Ceradenia jungermannioides* is particularly surprising, since it was previously only known from the Azores, the West Indies, and Mexico to northern Venezuela and Colombia.

The paucity of localized endemic species is paralleled by a conspicuous absence of some fern genera that are typically encountered in humid forest at this elevation. Despite specific searches in suitable habitats, we were unable to locate any species of *Adiantum* or *Polystichum* (Table 1).

Table 1. Comparison of the number of species recorded in two selected fern genera at 1250-1600 m at Cordillera Mosetenes and three other sites on the east Andean slope in Bolivia.

	Carrasco 17°10'S	Mosetenes 16°14'S	Bellavista 15°40'S	Asunta Plata 15°10'S
Adiantum	2	0	4	2
Polystichum	3	0	2	2

Diversity

In total, in the 20 study plots we recorded five species of Acanthaceae, about 36 Araceae, 16 Bromeliaceae, two Cactaceae, four Palmae, and 158 Pteridophyta (App. 1). Compared to three other sites at similar elevation and in similar habitats on the east Andean slope of Bolivia, point diversity in the zonal forest at our study site was low for Bromeliaceae and Palmae, intermediate for Acanthaceae, Araceae, Cactaceae, and epiphytic Pteridophyta, and high for terrestrial Pteridophyta (Table 2A). The high richness of terrestrial ferns may reflect the rather low and open forest structure that may increase light levels in the understory and hence the development of the herb layer.

The ridge forest had low point diversity of Acanthaceae, Araceae, Palmae, and Pteridophyta, and intermediate diversity of Bromeliaceae (Table 2B). The low diversity of most taxa at 1500-1600 m above Laguna Carachupa certainly reflects the low habitat quality on the ridge, with stunted forest on nutrient-poor soils. This situation is paralleled at Asunta Pata, where the upper plots were also located on a ridge (M. Kessler, unpubl. data). At both Mosetenes and Asunta Pata, Araceae and Pteridophyta had much lower point diversity than at

Carrasco and Bellavista, where the study forest was a tall zonal slope forest on rich soils. However, whereas palms were abundant and species-rich at Asunta Pata, they were almost non-existent on the ridge above Laguna Carachupa. This, however, is not necessarily the typical situation in the Cordillera Mosetenes, since most ridges seen from the air, even just a few kilometers from the study area, were covered in dense palm-dominated forest.

Table 2. Comparison of point diversity (mean number of species recorded per 20 x 20 m^2 plot) at Cordillera Mosetenes and three other sites on the east Andean slope in Bolivia at (A) 1250-1400 m and (B) 1500-1600 m.

A	**latitude plots N=**	**Carrasco 17°10'S 6**	**Mosetenes 16°14'S 11**	**Bellavista 15°40'S 6**	**Asunta Plata 15°10'S 5**
Acanthaceae	terr	1.2	1.6	2.3	2.0
Araceae	epi + terr	10.0	12.9	8.5	14.0
Bromeliaceae	epi + terr	5.3	2.9	4.7	11.0
	epi	5.3	2.9	4.3	11.0
	terr	0	0	0.8	0.4
Cactaceae	epi	0.3	0.4	0.2	1.4
Palmae	terr	4.2	1.2	2.7	3.8
Pteridophyta	epi + terr	39.3	42.4	41.7	44.4
	epi	27.0	27.7	28.8	31.0
	terr	17.3	19.2	15.2	17.4
B					
	plots N=	**5**	**5**	**2**	**3**
Acanthaceae	Terr	2.4	0	0	0.3
Araceae	epi + terr	8.8	6.4	14.0	8.7
Bromeliaceae	epi + terr	6.0	6.0	6.0	7.0
	epi	6.0	5.6	6.0	6.7
	terr	0.2	1.6	0.5	0.3
Palmae	terr	4.0	0.2	3.0	5.3
Pteridophyta	epi + terr	50.2	25.0	50.0	29.7
	epi	33.8	20.7	41.0	18.0
	terr	21.8	7.3	19.5	12.3

Endemism

The endemism indices obtained at Laguna Carachupa in zonal forest at 1250-1400 m were low for Bromeliaceae, Palmae, and Pteridophyta, and intermediate for Acanthaceae and Araceae compared to the three other study areas (Table 3A). Interestingly, Acanthaceae and Araceae show clear latitudinal gradients of endemism, with endemism decreasing southward in Araceae (as also documented by Kessler & Croat, 1999) and increasing in Acanthaceae. In the ridge forest, endemism was low in Pteridophyta and intermediate in Araceae and Bromeliaceae (Table 3B).

Species composition and elevational zonation

Comparing the species composition of fern communities in the zonal forests at 1250-1400 with those along the Carrasco elevational transect (Kessler *et al*., 1999; Kessler, 2001b), the greatest similarity is found with forests at exactly the same elevation (128 species recorded at Laguna Carachupa, 105 in Carrasco, 62 shared species, qualitative Sorensen similarity index: 0.54; Sorensen indices for adjacent elevational steps are 0.40 and 0.41). Interestingly, the ridge forest at 1500-1600 m at Mosetenes also shares the highest similarity with the 1250-1400 m belt in Carrasco (56 species at Laguna Carachupa, 105 in Carrasco, 26 species shared, Sorensen index: 0.32), rather than with belts at higher elevations (1450-1600 m: Sorensen index: 0.26; 1650-1800 m: Sorensen index: 0.21). Similar results, albeit with more diffuse values due to lower species numbers, were obtained for Bromeliaceae (data not shown). For the other plant groups, such analyses were not possible

due to their absence or low species richness in the ridge forest. This shows that in contrast to the tree flora (Macía *et al*., 2008), the fern and bromeliad communities of the ridge forest are mostly a subset of those at lower elevation and are not primarily composed of montane elements. They do, however, contain a number of species adapted to depauperate soils, such as the gleichenioid ferns *Dicranopteris* and *Sticherus*.

Table 3. Comparison of endemism indices (mean inverse range size of all species recorded at a site) at Cordillera Mosetenes and three other sites on the east Andean slope in Bolivia at (A) 1250-1400 m and (B) 1500-1600 m. In B, Acanthaceae, Cactaceae and Palmae were excluded due to low species numbers. Higher values indicate a higher representation of species with small ranges.

A		**Carrasco**	**Mosetenes**	**Bellavista**	**Asunta Plata**
	latitude	**17°10'S**	**16°14'S**	**15°40'S**	**15°10'S**
	plots N=	**6**	**11**	**6**	**5**
Acanthaceae	terr	0.194	0.076	0.062	0.035
Araceae	epi + terr	0.031	0.060	0.166	0.169
Bromeliaceae	epi + terr	0.107	0.028	0.055	0.056
Palmae	terr	0.009	0.002	0.009	0.007
Pteridophyta	epi + terr	0.088	0.037	0.085	0.056
B					
	plots N=	**5**	**5**	**2**	**3**
Araceae	epi + terr	0.025	0.059	0.187	0.201
Bromeliaceae	epi + terr	0.131	0.048	0.032	0.040
Pteridophyta	epi + terr	0.126	0.044	0.099	0.047

Conclusions and conservation implications

Because of its isolated geographical position and high precipitation levels, we expected that the plant communities of the Cordillera Mosetenes should be very species-rich, should harbor a large number of endemics, and contain a high proportion of montane taxa. These expectations were only partly met. Species richness of the six plant groups was low to intermediate and characterized by the absence of some elements usually found at similar elevations in the Bolivian Andes. Levels of endemism were among the lowest we have found in Bolivia. Furthermore, montane taxa were not very conspicuous, probably due to the distance from potential source habitats from where the Cordillera Mosetenes might be colonized. Instead, the ridge communities were mostly impoverished versions of the zonal forests at lower elevations.

The unremarkable levels of diversity and endemism as well as the natural protection of the area imply that for the six plant groups we studied conservation of at least this site of the Cordillera Mosetenes is of low priority in Bolivia.

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Appendix 1. Species of six selected plant groups recorded at the Laguna Carachupa study site at the Cordillera Mosetenes, distinguishing zonal forest habitats at 1250-1400 m and ridge forest at 1500-1600 m. LF = Life form, e = epiphytic, t = terrestrial.

	LF	1250-1400	1500-1600	voucher
ACANTHACEAE				
Aphelandra sp.	t	x		MK 13065
Justicia tenuistachys (Rusby) Wassh. & Wood	t	x		MK 13016
Ruellia brevifolia (Pohl) Ezcurra	t	x		MK 13294
Ruellia sp.	t	x		MK 12980
Stenostephanus krukofii Wassh.	t	x		MK 13295
ARACEAE				
Anthurium croatii Madison	t	x		MK 12961
Anthurium ernestii Engler	e	x		MK 13027
Anthurium flavescens Poepp.	e	x		MK 13108
Anthurium gracile (Rudge) Schott	e, t	x		MK 13084
Anthurium grande N.E. Br. ex Engl.	e		x	MK 13206
Anthurium kunthii Poepp.	e	x		MK 13076
Anthurium macleanii Schott	e	x	x	MK 12962
Anthurium ottobuchtienii Croat & Acebey	e		x	MK 13215
Anthurium scandens (Aubl.) Engl. s.l. sp. 1	e	x	x	MK 13026
Anthurium scandens (Aubl.) Engl. s.l. sp. 2	e	x	x	MK 13104
Anthurium scandens (Aubl.) Engl. s.l. sp. 3	e	x		MK 13125
Anthurium scandens (Aubl.) Engl. s.l. sp. 4	e	x	x	MK 13153
Anthurium triphyllum Brongn. ex Schott	e, t		x	MK 13213
Anthurium versicolor Sodiro	e, t	x	x	MK 12966
Anthurium yungasense Croat & Acebey	e	x	x	MK 13107
Anthurium sp.	e, t	x		MK 12965
Dieffenbachia sp.	t	x		MK 12968
Monstera lechleriana Schott	e, t	x		MK 12963
Monstera sp.	e	x		MK 13406
Philodendron cf. *heterophyllum* Poepp.	e	x		MK 12970
Philodendron kroemerii Croat & Acebey	e	x	x	MK 13031
Philodendron lechlerianum Schott	e	x		MK 12972
Philodendron ornatum Schott	e	x	x	MK 13105
Philodendron cf. *palacioanum* Croat & Grayum	e	x		MK 12967
Philodendron sp. 1	e	x	x	MK 12971
Philodendron sp. 2	e	x		MK 13245
Rhodospatha sp.	e, t	x		MK 12964
Stenospermation killipii Croat & A.P. Gomez	e	x		MK 13309
Stenospermation reticulinervium Croat & Acebey	e	x	x	MK 13140
Stenospermation cf. *reticulinervium* Croat & Acebey	e	x		MK 13332
Stenospermation sp. 1	e	x	x	MK 13025
Stenospermation sp. 2	e, t		x	MK 13189
Stenospermation sp. 3	e, t		x	MK 13214
Stenospermation sp. 4	e	x		MK 13331
Syngonium podophyllum Schott	e, t	x		MK 12969
Xanthosoma sp.	t	x		MK 13298
BROMELIACEAE				
Fosterella albicans (Griseb.) L.B. Sm.	t		x	MK 13251
Guzmania killipiana L.B. Sm.	e	x	x	MK 13402
Guzmania madisonii H. Luther	e	x		MK 12959
Guzmania marantoidea (Rusby) H. Luther	e, t	x	x	MK 13178
Guzmania roezlii (E. Morren) Mez	e	x		MK 12960
Guzmania sphaeroidea (André) André ex Mez	e	x	x	MK 13132
Guzmania squarrosa (Mez & Sodiro) L.B. Sm. & Pittendr.	e, t		x	MK 13155
Guzmania sp. 1	e	x		s.n.
Guzmania sp. 2	e	x		s.n.
Mezobromelia pleiosticha (Griseb.) Utley & H. Luther	e	x	x	s.n.
Pitcairnia cf. *brittoniana* Mez	e, t		x	MK 13154
Pitcairnia riparia Mez	e	x		MK 13400
Pitcairnia sp.	t	x		MK 13299
Racinaea schumanniana (Wittm.) J.R. Grant	e	x	x	MK 13126
Racinaea spiculosa (Ruiz & Pav.) M.A. Spencer & L.B. Sm.	e	x	x	MK 13399

Cont. Appendix 1.

	LF	1250-1400	1500-1600	voucher
Vriesea heterandra (André) L.B. Sm.	e	x	x	MK 13401
CACTACEAE				
Epiphyllum phyllanthus (L.) Haw.	e	x		s.n.
Lepismium sp.	e	x		MK 13425
PALMAE				
Chamaedorea pinnatifrons (Jacq.) Oerst.	t	x		s.n.
Geonoma sp.	t	x		MK 13014
Iriatea deltoidea R. & P.	t	x		s.n.
Gen. sp.	t	x	x	MK 13134
PTERIDOPHYTA				
Alsophila erinacea (H. Karst.) D.S. Conant	t	x		MK 12926
Alsophila mostellaria M. Lehnert	t	x		MM 7217
Ananthacorus angustifolius (Sw.) Underw. & Maxon	e	x		MK 13103
Asplenium alatum Humb. & Bonpl. ex Willd.	t	x		MK 12993
Asplenium auriculatum Sw.	e	x		MK 12944
Asplenium cirrhatum Rich. ex Willd.	t	x	x	MK 13116
Asplenium cuspidatum Lam.	e	x	x	MK 12996
Asplenium feei Kunze ex Fée	e	x		MK 13060
Asplenium harpeodes Kunze	e	x		MK 12945
Asplenium incurvatum Fée vel aff.	e	x	x	MK 13121
Asplenium mosetenense M. Kessler & A.R. Sm.	e		x	MK 13142
Asplenium pteropus Kaulf.	e	x		MK 13064
Asplenium repandulum Kunze	t	x		MK 13063
Asplenium repens Hook.	e	x		MK 12953
Asplenium rutaceum (Willd.) Mett.	e, t	x		MK 12987
Asplenium tricholepis Rosenst.	e	x		MK 13059
Asplenium uniseriale Raddi	t	x		MK 13119
Blechnum acutum (Desv.) Mett.	e	x		MK 12928
Blechnum cordatum (Desv.) Hieron.	t	x		MK 12986
Blechnum divergens (Kunze) Mett.	t	x		MK 12936
Blechnum ensiforme (Liebm.) C. Chr.	e	x	x	MK 13147
Blechnum fragile (Liebm.) C.V. Morton & Lellinger	e	x		MK 13005
Blechnum gracile Kaulf.	t	x		MK 13394
Blechnum probable hybrid: *occidentale* x *polypodioides*	t	x		MK 13457
Blechnum violaceum (Fée) C. Chr.	t	x		MK 13115
Blotiella lindeniana (Hook.) R.M. Tryon	t		x	MK 13234
Bolbitis oligarchica (Baker) Hennipm.	t	x		MK 13067
Campyloneurum asplundii (C. Chr.) Ching	e	x		MK 13010
Campyloneurum aff. *phyllitidis* (L.) C. Presl	e	x		MK 13075
Campyloneurum repens (Aubl.) C. Presl	e	x		MK 13106
Ceradenia jungermannioides (Klotzsch) L.E. Bishop	e	x		MK 13326
Ceradenia pilipecten L.E. Bishop ex M. Kessler & A.R. Sm.	e		x	MK 13146
Cnemidaria speciosa C. Presl	t	x		MK 12925
Cochlidium serrulatum (Sw.) L. E. Bishop	e	x	x	MK 13172
Cyathea bipinnatifida (Baker) Domin	t	x	x	MK 13111
Cyathea caracasana (Klotzsch) Domin var. *boliviensis* (Rosenst.) R.M. Tryon	t	x	x	MK 13151
Cyathea conjugata (Hook.) Domin	t	x		MK 13285
Cyathea delgadii Sternb.	t	x		MK 13380
Cyathea dintelmannii M. Lehnert	t	x		MK 13012
Cyathea lasiosora (Kuhn) Domin	t	x		MK 13379
Cyathea pungens (Willd.) Domin *vel aff.*	t	x		MK 12935
Danaea elliptica Sm.	t	x		MK 13454
Danaea moritziana C. Presl	t	x		MK 12939
Danaea sellowiana C. Presl	t	x		MK 13000
Dennstaedtia cornuta (Kaulf.) Mett.	t	x		MK 12942
Dicranopteris flexuosa (Schrad.) Underw.	t		x	MK 13165
Gleichenella pectinata (Willd.) Ching	t	x		seen only
Diplazium alienum (Mett.) Hieron.	t	x		MK 13102
Diplazium andicola (Stolze) comb. ined.	t	x		MK 13056
Diplazium bicolor Stolze	t	x		MK 13009

Cont. Appendix 1.

	LF	1250-1400	1500-1600	voucher
Diplazium divergens Rosenst.	t	x		MK 12991
Diplazium lindbergii (Mett.) H. Christ	t	x		MK 12992
Diplazium macrophyllum Desv.	t	x		MK 13136
Diplazium pinnatifidum Kunze	t	x		MK 12988
Diplazium striatum (L.) Presl	t	x		MK 13350
Diplazium cf. *stuebelianum* (Hieron.) Stolze	t	x		MK 13321
Elaphoglossum acutifolium Rosenst.	e	x	x	MK 13185
Elaphoglossum andicola (Fée) T. Moore	e		x	MK 13173
Elaphoglossum ballivianii Rosenst.	e	x	x	MK 12997
Elaphoglossum blandum Rosenst.	e	x	x	MK 13152
Elaphoglossum buchtienii Rosenst.	e	x	x	MK 13020
Elaphoglossum crispipalea M. Kessler & Mickel	e	x		MK 13049
Elaphoglossum eatonianum (E. Britton) C. Chr.	e	x	x	MK 13019
Elaphoglossum erinaceum (Fée) T. Moore	e	x		MK 12929
Elaphoglossum guentheri Rosenst.	e	x	x	MK 13170
Elaphoglossum lechlerianum (Mett.) T. Moore	e, t		x	MK 13145
Elaphoglossum lingua (C. Presl) Brack.	e	x		MK 13124
Elaphoglossum lloense (Hook.) T. Moore	e	x		MK 12947
Elaphoglossum molle (Sodiro) C. Chr.	e	x		MK 13353
Elaphoglossum moorei (E. Britton) H. Christ	t		x	MK 13212
Elaphoglossum nigrescens (Hook.) T. Moore ex Diels	e	x	x	MK 12941
Elaphoglossum orbignyanum (Fée) T. Moore	e	x	x	MK 12932
Elaphoglossum productum Rosenst.	e	x	x	MK 13112
Elaphoglossum puberulentum M. Kessler & Mickel	e	x		MK 13007
Eriosorus orbignyanus (Kuhn) A.F. Tryon	t		x	MK 13167
Hemidictyum marginatum (L.) C. Presl	t	x		MK 13306
Histiopteris incisa (Thunb.) J. Sm.	t		x	MK 13233
Hymenophyllum elegans Sprengel	e	x	x	MK 13175
Hymenophyllum fendlerianum J.W. Sturm	e	x		MK 13327pp
Hymenophyllum hirsutum (L.) Sw.	e	x		MK 13382
Hymenophyllum interruptum Kunze	e	x	x	MK 13053
Hymenophyllum microcarpum Desv.	e	x	x	MK 12984
Hymenophyllum polyanthos (Sw.) Sw.	e	x	x	MK 13278
Hymenophyllum cf. *trichomanoides* Bosch	e	x	x	MK 13327pp
Hymenophyllum undulatum (Sw.) Sw.	e		x	MK 13171
Hypolepis nigrescens Hook.	t		x	MK 13186
Hypolepis parallelogramma (Kunze) C. Presl	t	x		MK 13054
Lastreopsis amplissima (C. Presl) Tindale	t		x	MK 13232
Lellingeria subsessilis (Baker) A.R. Sm. & R.C. Moran	e		x	MK 13148
Lindsaea arcuata Kunze	t	x	x	MK 13229
Lomagramma guianensis (Aubl.) Ching	t	x		MK 13303
Lophosoria quadripinnata (J.F. Gmel.) C. Chr.	t	x	x	MK 13058
Macrothelypteris torresiana (Gaudich.) Ching	t	x		MK 13458
Megalastrum connexum (Kaulf.) A.R. Sm. & R.C. Moran vel aff.	t	x		MK 13070
Megalastrum honestum (Kunze) A.R. Sm. & R.C. Moran	t	x		MK 12948
Megalastrum subincisum (Willd.) A.R. Sm. & R.C. Moran	t	x		MK 12950
Megalastrum vastum (Kunze) A.R. Sm. & R.C. Moran	t	x		MK 12995
Melpomene melanosticta (Kunze) A.R. Sm. & R.C. Moran	e	x		MK 13386
Melpomene pilosissima (M. Martens & Galeotti) A. R. Sm. & R. C. Moran	e	x	x	MK 13150
Melpomene xiphopteroides (Liebm.) A.R. Sm. & R.C. Moran	e	x	x	MK 13149
Micrograma fuscopunctata (Hook.) Vareschi	e, t	x		MK 12937
Micrograma percussa (Cav.) de la Sota	e	x	x	MK 12943
Micropolypodium truncicola (Klotzsch) A.R. Sm.	e		x	MK 13275
Nephrolepis pendula (Raddi) J. Sm.	e	x	x	MK 12994
Niphidium crassifolium (L.) Lellinger	e	x		MK 13011
Oleandra articulata (Sw.) C. Presl	e, t		x	MK 13166
Olfersia cervina (L.) Kunze	e, t	x		MK 13001
Ophioglossum palmatum L.	e	x	x	MK 13095
Pecluma perpinnata M. Kessler & A.R. Sm.	e	x		MK 13055
Pecluma pilosa (A. M. Evans) M. Kessler & A.R. Sm. ined.	e	x		MK 13461
Polybotrya attenuata R.C. Moran	e, t	x	x	MK 13101
Polybotrya fractiserialis (Baker) J. Sm.	e, t	x		MK 13002
Polybotrya cf. *hickeyi* R.C. Moran	e, t	x		MK 12933

Cont. Appendix 1.

	LF	1250-1400	1500-1600	voucher
Polytaenium brasilianum (Desv.) Benedict	e	x		MK 12940
Pteris altissima Poir. in Lam.	t	x		MK 13236
Pteris inermis (Rosenst.) de la Sota	t	x		MK 13003
Pteris podophylla Sw.	e	x		MK 12990
Radiovittaria stipitata (Kunze) E.H. Crane	e	x	x	MK 13144
Saccoloma inaequale (Kunze) Mett.	t	x		MK 13282
Salpichlaena volubilis (Kaulf.) Hook.	e, t	x	x	MK 12927
Selaginella flagellata (L.) Spring	t	x		MK 13073
Selaginella haematodes (Kunze) Spring	t	x		MK 13113
Selaginella haenkeana Spring	t	x		MK 13072
Selaginella novae-hollandiae (Sw.) Spring	t	x		MK 13395
Selaginella trisulcata Asplund	t	x		MK 13238
Serpocaulon fraxinifolium (Jacq.) A.R. Sm.	e	x	x	MK 13099
Serpocaulon giganteum (Desv.) A.R. Sm.	e, t	x		MK 13135
Serpocaulon latipes (Langsd. & Fisch.) A.R. Sm.	e	x	x	MK 12951
Serpocaulon latissimum (R.C. Moran & B. Øllg.) A.R. Sm.	e, t	x		MK 12938
Serpocaulon levigatum (Cav.) A.R. Sm.	e		x	MK 13169
Serpocaulon sessilifolium (Desv.) A.R. Sm.	e	x	x	MK 13174
Sticherus lanosus (H. Christ) J. Gonzales ined.	t		x	MK 13188
Sticherus nervatus J. Gonzales ined.	t		x	MK 13164
Stigmatopteris lechleri (Mett.) C. Chr.	t	x		MK 13322
Stigmatopteris longicaudata (Liebm.) C. Chr.	t	x		MK 13069
Tectaria lizarzaburui (Sodiro) C. Chr.	t	x		MK 13074
Tectaria sodiroi (Baker) Maxon	t	x		MK 13004
Terpsichore chrysleri (Proctor ex Copel.) A.R. Sm.	e	x	x	MK 13120
Terpsichore mollissima (Fée) Proctor	e	x		MK 13021
Terpsichore taxifolia (L.) A.R. Sm.	e	x		MK 13307
Thelypteris biformata (Rosenst.) R.M. Tryon	t	x		MK 13354
Thelypteris decussata (L.) Proctor var. *decussata*	t	x		MK 12934
Thelypteris ensiformis (C. Chr.) R.M. Tryon	t	x		MK 12930
Thelypteris exuta A.R. Sm. vel aff.	t	x		MK 13308
Thelypteris leprieurii (Hook.) R.M. Tryon var. *glandifera* A.R. Sm.	t	x		MK 12949
Thelypteris linkiana (C. Presl) R.M. Tryon	t	x		MK 13391
Thelypteris serrata (Cav.) Alston	t	x		MK 13462
Trichomanes angustatum Carm.	e	x	x	MK 12957
Trichomanes angustifrons (Fée) W. Boer	e	x		MK 13071
Trichomanes debile Bosch	e	x		MK 13052
Trichomanes plumosum Kunze	e, t	x	x	MK 13114
Trichomanes polypodioides L.	e	x		MK 13051pp
Trichomanes radicans Sw.	e	x		MK 13048
Trichomanes reptans Sw.	e	x		MK 12954
Trichomanes rigidum Sw.	t	x		MK 12955
Trichomanes rupestre (Raddi) Bosch	t	x		MK 13396
Vittaria graminifolia Kaulf.	e	x	x	MK 13008