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DIVERSITY AND PHYTOGEOGRAPHY OF THE VASCULAR FLORA OF THE *POLYLEPIS* FORESTS OF THE CORDILLERA DE COCHABAMBA, BOLIVIA

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Resumen. La composición florística de algunos bosques de *Polylepis* del centro-sur de Bolivia (Cordillera de Cochabamba) fue analizada considerando riqueza de especies, endemismo y patrones de distribución. Cada bosque fue evaluado mediante transectos de 100–500 m² que incluyeron 16-43 especies de plantas vasculares (promedio = 29.3, n = 65), de las cuales 0–12 fueron helechos o afines. La mayor riqueza de especies de helechos y afines así como para todas las plantas vasculares se encontró en Lope Mendoza, la localidad más húmeda de todas las investigadas. De las 231 especies analizadas, ocho fueron endémicas para la Cordillera de Cochabamba, 30 especies y una subespecie fueron endémicas de los Andes de Bolivia. La mayoría de las especies, 64.5%, están distribuidas en los Andes sobre los 1500 m de altitud entre Venezuela y el norte de Argentina/Chile. Los helechos y afines por lo general tienen distribuciones más amplías, solamente una tercera parte de las especies está restringida a los Andes. Cincuenta y nueve especies estuvieron distribuidas únicamente entre los Andes de Bolivia y Perú, mientras que solamente 12 especies fueron exclusivas para Bolivia y el norte de Argentina/Chile. De las especies ampliamente distribuidas, más de la mitad (34) ocurren en regiones extra tropicales de América del Sur.

Abstract. The floristic composition of some *Polylepis* forests in south-central Bolivia (Cordillera de Cochabamba) are analyzed with regard to species richness, endemism, and distribution patterns. Each stand was investigated in transects comprising 100–500 m² and included 16–43 species of vascular plants (mean = 29.3, n = 65), 0–12 of which were ferns or fern allies. The highest species richness, both for fern and fern allies and for vascular plants as a whole, was found at Lope Mendoza, which is the most humid locality of those investigated. Of 231 species analysed, eight were endemic to Cordillera de Cochabamba, and an additional 30 species and one subspecies were endemic to the Bolivian Andes. A majority of the species, 64.5%, have an Andean distribution occurring above 1500 m altitude somewhere between Venezuela and northern Argentina/Chile. Fern and fern allies generally have wider distributions with only a third of the species restricted to the Andes. Fifty-nine of the species were shared exclusively between the Andes of Bolivia and Peru, whereas only 12 were shared exclusively between Bolivia and northern Argentina/Chile. Among the widespread species, more than half (34) occur in extra-tropical South America. *Accepted 05 November 2001.*

Key words: Polylepis *forests, phytogeography, species richness, diversity, endemism, Andes, Bolivia.*

INTRODUCTION

Compared with most other vegetation types in South America, the *Polylepis* forests can be considered well studied. Many studies have been dedicated to the floristics, structure, distribution, conservation, and biology of *Polylepis* forests (e.g., Hensen 1993, 1995; Kessler 1995a, b; Fjeldså & Kessler 1996 and references therein). In addition, the taxonomy of the genus *Polylepis* has attracted much attention compared with most other groups of vascular plants in South America (Bitter 1911, Simpson 1979, Kessler 1995c, Romoleroux 1996). However, apart from the genus *Polylepis* itself, little is known about the distribution and endemism of the accompanying flora of these forests.

In this paper we present an analysis of the vascular plant flora recorded from eight localities with *Polylepis* forest in the Cordillera de Cochabamba in south-central Bolivia, focusing on species richness, endemism, and distribution. The Cochabamba area was identified as a top priority area for conservation by Fjeldså & Kessler (1996). Some of the localities were also considered as „key-areas" for the conservation of Neotropical birds (Wege & Long 1995). It was therefore considered interesting to investigate if these conditions were paralleled by a similar situation for vascular plants.

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MATERIAL AND METHODS

Study sites and collections. The original data set used for the present study was collected by E. Fernández for a phytosociological thesis work, which was presented to the Universidad Mayor de San Simón, Cochabamba, in 1995 (Fernández 1997). Species data were collected in transects covering 1–2 x 100–500 m^2. The length of the transects was determined by standard practices of the Braun-Blanquet school of phytosociology (Braun-Blanquet 1964).

A total of 65 transects was made at eight localities (Table 1). All localities are situated in the Cordillera de Cochabamba south of the Andean divide towards the dry intermontane valleys. Four of the localities, Parque Nacional Tunari, Laphia, Liriuni, and Cuenca Taquiña, are situated on the inside of the Cochabamba basin on the southern slopes of the Tunari massive, just north of the town of Cochabamba, whereas the other four localities are situated in the mountains south and southwest of Tiraque, i.e., outside of the actual Cochabamba basin. All localities north of Cochabamba are dominated by *Polylepis besseri* ssp. *subtusalbida*. Cerro Kewiñal is populated by *P. tomentella* ssp. *nana*, a subspecies known from this area only (Kessler 1995c), Quebrada Mojón and Lope Mendoza by *P. racemosa* ssp. *lanata*, and Zapata Rancho by *P. tomentella* ssp. *incanoides* (nomenclature according to Kessler 1995c). None of the localities are situated far from rural populations and the vegetation is heavily influenced by human activities, usually through burning and firewood collecting (Hensen 1995). Additional information and photographs of some of the sites are presented by Andersen *et al.* (1999), Fernández (1997), Hensen (1993, 1995), and Kessler (1995b).

The entire data set includes 261 species of vascular plants, 35 of which are ferns or fern allies (*Lycopodium* spp.). For the phytogeographical analysis, all determinations presented in Fernández (1997) were revised, both by comparing the material with collections in the herbaria of Cochabamba (BOLV), Göteborg (GB), La Paz (LPB), and Stockholm (S), and by consulting new or additional publications. Some material was also sent to specialists in Århus (AAU), New York (NY), Stockholm (S), and Berkeley (UC), but at the time of writing only a few identifications had been returned. Unidentified species and species for which distribution records were unavailable or considered unreliable were excluded, leaving a set of 230 species (including 26 species of ferns and fern

TABLE 1. Localities of *Polylepis* forests in this study, with number of species of vascular plants and ferns and fern allies, taxon of *Polylepis* present, and number of transects made [(coordinates extracted from Andersen *et al.* (1999) and Kessler (*in litt.*)].

Locality	Altitude (m)	Coordinates	Taxon of *Polylepis*	No. of transects	No. of species of vascular plants	No. of species of ferns and fern allies
Parque Nac. Tunari, Km 12 (PT)	3500-3700	66°08'W, 17°19'S	*P. besseri* ssp. *subtusalbida*	4	24–39 ($\bar{x}$ = 32.5)	0– 2 ($\bar{x}$ = 0.8)
Liriuni (Li)	3600-3750	66°17'W, 17°17'S	*P. besseri* ssp. *subtusalbida*	3	16–33 ($\bar{x}$ = 23.3)	1– 2 ($\bar{x}$ = 1.7)
Cuenca Taquiña (CT)	3600-4050	66°12'W, 17°18'S	*P. besseri* ssp. *subtusalbida*	9	19–37 ($\bar{x}$ = 29.0)	0– 2 ($\bar{x}$ = 1.3)
Laphia/Lapia (La)	3250-3400	66°13'W, 17°18'S	*P. besseri* ssp. *subtusalbida*	5	19–31 ($\bar{x}$ = 25.0)	0– 3 ($\bar{x}$ = 1.6)
Cerro Kewiñal/ Kehuiñal (CK)	3250-3500	65°42'W, 17°33'S	*P. tomentella* ssp. *nana*	13	20–31 ($\bar{x}$ = 24.2)	0– 2 ($\bar{x}$ = 0.9)
Quebrada Mojón (QM)	2950-3350	65°25'W, 17°29'S	*P. racemosa* ssp. *lanata*	8	19–35 ($\bar{x}$ = 28.9)	1– 5 ($\bar{x}$ = 2.9)
Lope Mendoza (LM)	3050-3450	65°22'W, 17°30'S	*P. racemosa* ssp. *lanata*	20	25–43 ($\bar{x}$ = 34.2)	3–12 ($\bar{x}$ = 7.0)
Zapata Rancho (ZR)	3200	65°40'W, 17°27'S	*P. tomentella* ssp. *incanoides*	3	25–34 ($\bar{x}$ = 30.0)	0– 3 ($\bar{x}$ = 1.3)

allies). This list, along with distribution data and references, is presented in Appendix.

Dried vouchers are preserved in the herbaria of Cochabamba (BOLV) and La Paz (LPB).

Data analyses. The data matrix was analyzed using present/absent values only. The figures appearing in the original, phytosociological work represent subjective estimates of abundance and covering, not the number of individuals. The data set is accordingly not well suited for diversity estimates including abundance values. Therefore, the simplest estimate of diversity, species richness, is used here. This is also the measure that permits most comparisons with investigations from other localities.

Distributions were recorded from the most recent primary sources, such as monographs, revisions, and critical flora treatments. When these sources were unavailable the distributions were recorded or extrapolated after consulting different kinds of compilations such as checklists and the Tropicos database (Tropicos 2000). In a few cases, only records from the La Paz or Stockholm herbarium were used.

Focusing on montane areas, the presence/absence of each species was recorded for the following areas: Cordillera de Cochabamba; Andes of Bolivia above 1500 m alt.; Andes of Peru above 1500 m alt.; Andes of Ecuador above 1500 m alt.; Andes of Colombia and Sierra Nevada de Santa Marta above 1500 m alt.; Andes of Venezuela and Cordillera de la Costa above 1500 m alt.; extra-tropical Andes of Chile and Argentina above 1500 m alt.; Guayana Highlands above 1500 m alt.; Mesoamerica (Mexico-Panama); tropical lowland South America below 1500 m alt.; extra-tropical lowland South America below 1500 m alt.; West Indies; North America (north of Mexico); Paleotropics (or cosmopolitan).

RESULTS

Species richness. The total number of vascular plants found at the studied transects varied between 16 and 43 (Table 1). Although not significant, the species richness decreases slightly with altitude (Fig. 1). The richest localities were Lope Mendoza and Parque Nacional Tunari with an average of 34 and 32 species

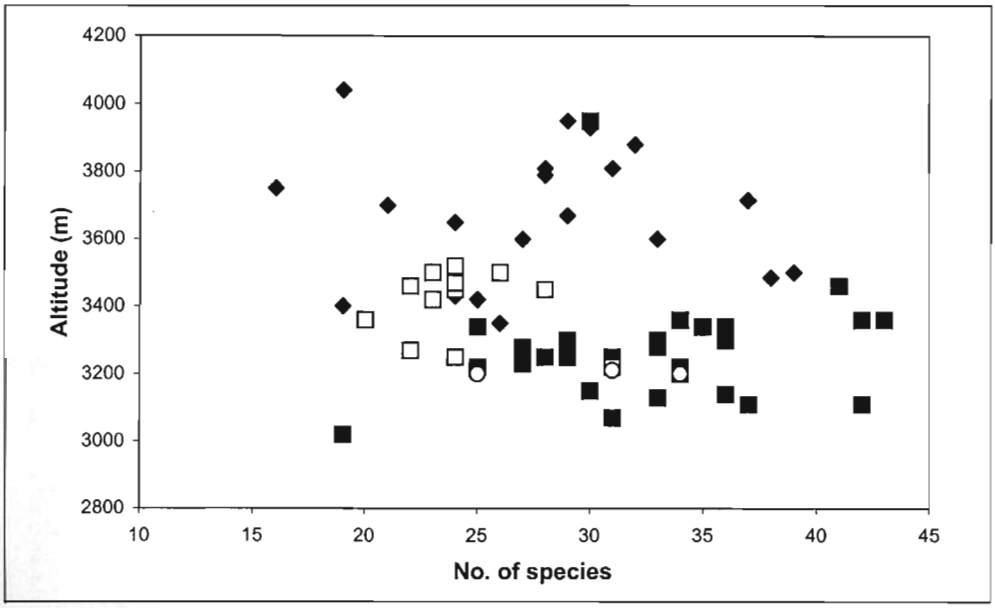

FIG. 1. Species richness of vascular plants vs. altitude in 65 transects of *Polylepis* forest in Cordillera de Cochabamba. Symbols indicate different taxa of *Polylepis* forming the forests (◆ *P. besseri* ssp. *subtusalbida*; ■ *P. racemosa* ssp. *lanata*; ○ *P. tomentella* ssp. *incanoides*; ❑ *P. tomentella* ssp. *nana*).

TABLE 2. Vascular plant taxa endemic to the Cordillera de Cochabamba, showing habit, ecology, and localities (for abbreviations, see Table 1).

Taxon	Habit	Habitat	No. of transects and localities	Reference
Bartsia crenata Molau	Herb 8-40 cm tall.	Grassy slopes in shrubby puna, 3750-3950 m	15 (PT, CT, QM, CK)	Molau 1991
Begonia baumannii Lemoine	Herb.	Moist sites, 3200-3400 m	2 (La)	Smith & Schubert 1944
Calceolaria aquatica Braun & Bouché	Herb 0.1-0.7 m tall.	Moist sites, 2000-3700 m	3 (LM)	Molau 1988
Fuchsia nana P. Berry	Subshrub 0.3-1 m tall/long.	Cloud forest, 2000-3700 m	1 (LM)	Berry 1985
Polylepis racemosa R. & P. ssp. *lanata* (O. Kuntze) M. Kessler	Tree to 8 m tall.	2800-3900 m	28 (QM, LM)	Kessler 1995b
Polylepis tomentella Weddel ssp. *incanoides* M. Kessler	Shrub or tree to 5 m tall.	2500-3400 m	3 (ZR)	Kessler 1995b
Polylepis tomentella Weddel ssp. *nana* M. Kessler	Shrub to 1.5 m tall.	3000-3500 m	13 (CK)	Kessler 1995b
Puya glabrescens L.B. Smith	Herb 0.6-0.8 m tall.	Rocky slopes, 2550-3700 m	2 (CK)	Smith & Downs 1974, Krömer *et al.* 1999
Puya herzogii Wittm.	Herb 1-2 m tall.	Rocky and grassy slopes, 2800-3950 m	5 (Li, La, QM)	Smith & Downs 1974, Krömer *et al.* 1999
Puya tunarensis Mez	Herb.	Rocky slopes and cliffs, 2000-3800 m	6 (CK, ZR)	Smith & Downs 1974, Krömer *et al.* 1999
Trichocereus tunariensis Cárdenas	Columnar cactus.	Dry scrub, 3800 m	2 (CK)	Cárdenas 1959

respectively, and the poorest Liriuni, Cerro Kewiñal, and Laphia with average species numbers of 23–25. When considering fern and fern allies only, Lope Mendoza is by far the richest locality with an average of 7 species per transect, followed by Quebrada Mojón with close to 3 species per transect. All the other localities had averages of less than 2 species of ferns and fern allies per transect.

General distribution. As expected, the flora of the *Polylepis* forests in Cordillera de Cochabamba is chiefly Andean (Appendix, Table. 3). In all, 149 (64.8%) out of 230 species for which distribution records were available are confined to the Andes; they occur in the Andes above 1500 m altitude somewhere from Venezuela through northern Argentina/Chile, but not outside of this area. However, an opposite pattern is shown by fern and fern allies, of which 17 species have wide distributions and only 11 are confined to the Andes. A total of 45 species (19.6%) reaches as far as Mesoamerica, and many of those occur also in North America and the West Indies. Only 11 species have been recorded from the Guayana Highlands.

Among the species restricted to the Andes, a large group consists of those species shared exclusively between Bolivia and Peru (59 spp.). By contrast, only 12 species are shared exclusively between the Bolivian Andes and northern Argentina/Chile.

In the group of species occurring outside of the Andes, many (34 spp.) occur also in extra-tropical South America. Many of these (16 spp.) are also distributed outside of the Americas, sometimes as cosmopolitan weeds.

Endemism. Of the 230 species surveyed, eight are endemic to the Cordillera of Cochabamba (Tabs. 2 and 3). In addition, three geographical races of *Polylepis*, recognized as three subspecies by Kessler (1995c), are also endemic to this area. *Polylepis tomentella* ssp. *incanoides* and *P. tomentella* ssp. *nana* constitute the two northernmost populations of a species distributed to northern Argentina, whereas *P. racemosa* ssp. *lanata* constitutes the southernmost population of a species distributed from central Peru (Kessler 1995c).

The locality richest in endemics is Cerro Kewiñal with five taxa, followed by Quebrada Mojón with three. The other localities have one or two endemics each.

Twenty-nine species (12.6%) and one subspecies of *Polylepis, P. besseri* ssp. *subtusalbida*, can be considered subendemics in as much as they have been recorded from the Andes of Bolivia only. Two of these subendemics are ferns.

TABLE 3. Number of species of vascular plants shared between *Polylepis* forests of Cordillera de Cochabamba and other geographical areas.

	No. of species(%)
Endemics	8 (3.5)
Andes of Peru above 1500 m alt.	170 (73.9)
Andes of Ecuador above 1500 m alt.	102 (44.3)
Andes of Colombia above 1500 m alt.[1]	66 (28.7)
Andes of Venezuela above 1500 m alt.[2]	47 (20.4)
N Andes of Chile/Argentina above 1500 m alt.	83 (36.1)
Guayana Highlands	11 (4.8)
Mesoamerica	45 (19.6)
Lowland tropical South America below 1500 m alt.	40 (17.4)
Extra-tropical South America	34 (14.8)
West Indies	17 (7.4)
North America	18 (7.8)
Cosmopolitan or Pantropical	16 (7.0)

[1] Including Sierra Nevada de Santa Marta.
[2] Including Cordillera de la Costa.

DISCUSSION

Species richness. Although largely undocumented, a general opinion by botanists working in the neotropics is that *Polylepis* forests are comparatively poor in vascular plant species, a notion suggested by the uniform tree species composition and the high altitude at which they occur. This conclusion is also supported by an analysis of checklist data from Ecuador (Jørgensen & Ulloa 1994). In addition, comparing the data presented here with those of Gentry (1995) for three Andean mixed forest sites at around 3000 m elevation strongly support this view. Gentry's samples of 0.1 ha include about 35 species of vascular plants with a stem diameter of ≥ 2.5 cm. The sample plots are more than twice the size of those used here, but a quick look through the species lists (Appendix) reveals that less than 10% of the plants in our samples have a stem diam. of ≥ 2.5 cm.

If compared with data from other *Polylepis* forests, the species numbers found here compares fairly well with those from other investigations in Bolivia. Mercado (1998) found 20–40 species of vascular plants

(including 3–8 species of ferns) in *Polylepis* forests northwest of Monte Puncu in the Carrasco National Park, about 15 km east of the Lope Mendoza locality. The fact that Mercado used considerably larger survey areas (0.25–1 ha) indicates that the smaller survey areas used here are sufficient to record alpha-diversity in *Polylepis* forests. Using the same methods, Hensen (1993), whose more extensive data are partly from the same localities as those used for this study, enumerates 14–47 species in transects covering at least 100 m^2.

The species richness values can also be compared to a few other studies, but only with regard to ferns and fern allies. At Saila Pata and Cocapata, northwest of the Tunari Higlands, Kessler (1999) recorded between 12 and 17 pteridophyte species in 20 x 20 m *Polylepis* forest plots. In Ecuador, Øllgaard & Navarrete (1997) found 26 species of ferns in a 240 x 5 m transect of *Polylepis* forest at 3500 m altitude. The higher species richness of ferns at these localities is largely explained by more humid conditions, especially at the Ecuadorian site, but the experience of the field workers may also have been of some importance.

The slightly negative correlation between altitude and species richness recorded in the present study (Fig. 1) may have less to do with altitude than with humidity. Lope Mendoza, which has the largest species numbers in this study is also the most humid locality („húmedo a hiperhúmedo" according to Fernández 1997), but it is also situated at a lower altitude than the drier, species-poorer localities on the southern slopes of the Tunari highland and at Cerro Kewiñal.

Distribution and endemism. The present phytogeographical analysis should be considered preliminary, mainly because of poor taxonomic and ecological knowledge of the taxa included. Nevertheless, some patterns and trends are obvious and need further comments. First of all, the analysis clearly demarcates the large floristic difference between *Polylepis* forests and lowland forests. In addition, most of the 36 species occurring in lowland tropical South America are also distributed in extra-tropical South America, and some of these are weedy with distributions outside the Americas. Using data from Ecuador, the distinctiveness of the montane Andean flora was also well documented by Jørgensen & León-Yánez (1999). The opposite pattern shown by ferns and fern allies is no doubt connected to the high dispersal capacity in these groups of plants (Tryon 1986).

It is also obvious that the flora of the *Polylepis* forests of Cordillera de Cochabamba is mainly Andean. A total of 170 (73.9%) species is shared with the Andes of Peru, 102 (44.3%) with the Andes of Ecuador, and 83 (36.1%) with the Andes of northern Argentina-Chile (Table.3). Some of the Andean species reach also areas of high altitude in Mesoamerica and the Greater Antilles. However, only a few species have been reported from the Guayana Highlands, which further stresses the biogeographic uniqueness of this area. The larger number of species shared with Peru than with Chile/Argentina may give validity to Hueck's distinction (1966) between the „Tucuman-Bolivian" and „mid-Andean" regions, although further analysis should be made, which also takes ecological parameters into account, before that classification can be properly evaluated.

Since most figures on endemism in the Neotropics are rare or unreliable, we cannot state whether the figures found in this study, eight species (3.5%) and three subspecies, is low or comparable with other sites of similar size and topography. Also, most other figures published in the literature are from areas that are much larger, such as the Chocó floristic province (20% endemism according to Gentry 1992), or areas delimited by political borders of little or no biological relevance. However, figures on endemism from smaller areas, such as Cerro del Torá in Colombia (5.2% according to Silverstone-Sopkin & Ramos-Pérez 1995), suggest that vascular plant endemism in the *Polylepis* forests of Cordillera de Cochabamba is probably not higher than other Andean forests of similar extension.

Conservation. From the point of view of conservation it is worth mentioning that, with the exception of *Polylepis* taxa forming the actual forests, none of the vascular plants endemic to Cordillera de Cochabamba seems to be restricted to *Polylepis* forests as such. However, these forests are remnants of once much larger stands (Kessler 1995a), and given the lack of other kinds of forest or scrub in the vicinity it may well be that the species here recorded as endemic could become severely threatened should the last *Polylepis* forests be destroyed. Given the fact that all sites investigated have been heavily influenced by human activity, probably for a very long time, their vascular flora may already be depauperate. However, the higher accumulation of endemics at Cerro Kewiñal and Quebrada Mojón compared with the other localities indicates that any action to preserve the *Polylepis* forest at these two sites should be taken seriously and uncompromisingly.

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APPENDIX. List of species and their distributions.

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
ALSTROEMERIACEAE																
Bomarea aurantiaca Herb.	x	x	x												EF 230	Braco & Zarucchi 1993
B. crocea (R. & P.) Herb.	x	x	x												EF 193, 240	Braco & Zarucchi 1993
B. dulcis (Hook.) Beauverd	x	x	x												EF 188, 624	Braco & Zarucchi 1993
AMARANTHACEAE																
Gomphrena bicolor C. Martius	x	x	x												EF 215, 312	Braco & Zarucchi 1993
ANACARDIACEAE																
Schinus microphyllus I.M. Johnston	x	x	x												EF 447, 464	Braco & Zarucchi 1993
APIACEAE																
Azorella biloba (Schltdl.) Wedd.	x	x	x	x	x	x	x		x						EF 258B	Mathias & Constance 1976
Bowlesia lobata R. & P.	x	x	x	x				x							EF 184, 645	Mathias & Constance 1976
Eryngium nudicaule Urb.	x	x	x												EF 342, 425	Braco & Zarucchi 1993
AQUIFOLIACEAE																
Ilex mandonii Loes.	x	x													EF 526, 535	LPB
ARALIACEAE																
Oreopanax rusbyi Britton	x	x	x												EF 537, 628	Braco & Zarucchi 1993
ASCLEPIADACEAE																
Sarcostemma campanulatum Lindl.	x	x	x												EF 448	Braco & Zarucchi 1993
S. lysimachioides (Wedd.) R.W. Holm	x	x	x												EF 316, 607	Braco & Zarucchi 1993
ASTERACEAE																
Achyrocline alata (Kunth) DC.	x	x	x	x	x		x			x					EF471, 579	Dillon & Sagástegui 1991
A. flaccida (Weinm.) DC.	x	x					x			x	x				EF 210, 528	Cabrera 1978
A. ramosissima Rusby	x	x	x				x								EF 611	Dillon & Sagástegui 1991
A. satureoides (Lam.) DC.	x	x	x	x	x	x	x	x	x	x	x				EF 362	Dillon & Sagástegui 1991, Pruski 1997
Ageratina azangaroensis (Wedd.) R.M. King & H. Rob.	x	x	x	x			x								EF 178, 182	Jørgensen & León-Yánez 1999, Cabrera 1978
A. sternbergiana (DC.) R.M. King & H. Rob.	x	x	x												EF 437	Braco & Zarucchi 1993

Baccharis caespitosa (R. & P.) Pers. var. *alpina* (Kunth in H.B.K.) Cuatr.	x	x	x	x	x													EF 259B	Cuatrecasas 1967
B. dracunculifolia DC.	x	x	x				x			x	x							EF 356, 463	Cabrera 1978, Braco & Zarucchi 1993
B. genistelloides (Lam.) Pers.	x	x	x	x	x		x											EF 422	Cuatrecasas 1967, Cabrera 1978
B. nitida (R. & P.) Pers.	x	x	x	x	x	x												EF 252, 500	Cuatrecasas 1967
B. obtusifolia Kunth	x	x	x	x														EF 341	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
B. pentlandii DC.	x	x	x															EF 234, 251	Braco & Zarucchi 1993
B. pflanzii Perkins	x	x																EF 570A	Perkins 1913
B. polycephala Wedd.	x	x					x											EF 227, 338	Cabrera 1978
B. subalata Wedd.	x	x	x															EF 407, 496	Braco & Zarucchi 1993
B. volubilis Kunth	x	x	x	x														EF 410, 518	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
Barnadesia berberoides Sch. Bip.	x	x	x															EF 503	Braco & Zarucchi 1993
Bidens andicola Kunth	x	x	x	x	x		x											EF 375	Cabrera 1978
B. cosmantha Griseb.	x	x					x											EF 405	Burkart 1978
B. pseudocosmos Sherff	x	x	x				x											EF 262	Cabrera 1978
Cosmos peucedanifolius Wedd.	x	x	x				x											EF 270	Cabrera 1978
Gamochaeta sphacelata (Kunth) Cabrera	x	x	x	x	x	x	x		x									EF 347	Cabrera 1978
Gnaphalium gaudichaudianum DC.	x	x		x														EF 294, 641	Cabrera 1978
Gynoxys glabriuscula Rusby	x	x																EF 225, 400	Rusby 1896, S
Hieracium lagopus D. Don	x	x	x	x														EF 322	Braco & Zarucchi 1993, Jørgensen & León-Yánez 1999
H. leptocephalium Benth.	x	x	x															EF 493	Braco & Zarucchi 1993
H. streptochaetum Zahn	x	x					x											EF 181	Cabrera 1978
Hypochoeris chilensis Britton	x	x	x	x														EF 359	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
Mutisia mandoniana Sch. Bip.	x	x																EF 426	Cabrera 1965
Perezia pungens (Bonpl.) Less.	x	x	x	x	x													EF 427, 638	Vuilleumier 1970
Plazia daphnoides Wedd.	x	x	x															EF 363	Braco & Zarucchi 1993
Stevia chamaedrys Griseb.	x	x					x											EF 189, 274B	Cabrera 1978
S. samaipatensis B.L. Rob.	x	x																EF 213, 274	LPB, S
Taraxacum officinale Weber	x	x	x	x	x	x	x		x	x	x	x	x	x				EF 383	Cabrera 1978

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Verbesina cinerea Rusby	x	x													EF 218	LPB
Viguiera fusiformis S.F. Blake	x	x													EF 320	LPB
V. procumbens (Pers.) S.F. Blake	x	x	x				x								EF 219	Cabrera 1978
BEGONIACEAE																
Begonia baumannii Lemoine	x														EF 449	Smith & Shubert 1944
B. veitchii Hook. f.	x	x	x												EF 272	Smith & Shubert 1944, Braco & Zarucchi 1993
BERBERIDACEAE																
Berberis commutata Eichler	x	x	x												EF 192, 232	Braco & Zarucchi 1993
B. paucidentata Rusby	x	x													EF 165, 401	Ahrendt 1961
B. rariflora Lechler	x	x													EF 301, 346	Ahrendt 1961
B. weddellii Lechler	x	x													EF 497, 620	Ahrendt 1961
BETULACEAE																
Alnus acuminata Kunth	x	x	x	x	x	x	x								EF 378	Furlow 1979
BROMELIACEAE																
Puya glabrescens L.B. Sm.	x														GN 885, 887	Smith & Downs 1974
P. herzogii Wittm.	x														GN 880	Smith & Downs 1974
P. tunariensis Mez	x														EF 565	Smith & Downs 1974
Tillandsia recurvata (L.) L.	x	x	x	x	x	x	x	x	x	x	x	x	x		EF 466	Smith & Downs 1977, Holst 1997
CACTACEAE																
Echinopsis obrepanda (Salm-Dyck) Schum.	x	x													EF 391	Nee 1999
Lobivia maximiliana (Heyder) Backeb.	x	x	x												EF 307	Eggli *et al.* 1995
Opuntia chuquisacana Cárdenas	x	x													EF 382	LPB
O. sulphurea G. Don	x	x					x								EF 613	Eggli *et al.* 1995
Sulcorebutia steinbachii (Werderm.) Backeb.	x														EF 606	LPB
Trichocereus tunariensis Cárdenas	x														CA 767	Eggli *et al.* 1995
CAMPANULACEAE																
Lobelia nana Kunth in H.B.K.	x	x	x	x			x		x						EF 369	Wimmer 1956

CARYOPHYLLACEAE																	
Arenaria lanuginosa (Michx.) Rohrb.	x	x	x	x	x	x	x		x	x	x		x		EF 323, 374	Tropicos database, Kiesling *et al.* 1994	
Cerastium arvense L.	x	x	x	x	x		x				x			x	EF 261, 311	Tropicos database, Kiesling *et al.* 1994	
Silene genovevae Bocquet	x	x	x												EF 177	Braco & Zarucchi 1993	
Stellaria weddellii Pedersen	x	x					x								EF 253	Pedersen 1983	
CELASTRACEAE																	
Maytenus verticillata (R. & P.) DC.	x	x	x	x	x										EF 600	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993	
CLETHRACEAE																	
Clethra cuneata Rusby	x	x	x												MM 503	Braco & Zarucchi 1993	
COMMELINACEAE																	
Commelina elliptica Kunth	x	x	x												EF 209, 271	Braco & Zarucchi 1993	
CONVOLVULACEAE																	
Dichondra sericea Sw.	x	x		x					x	x		x	x		EF 614	Boelcke 1992, Nee 1999	
CUNONIACEAE																	
Weinmannia fagaroides Kunth	x	x	x	x	x	x		x	x						EF 504	Bradford & Berry 1998, Harling 1999	
CUSCUTACEAE																	
Cuscuta odorata R. & P.	x	x	x	x											EF 452	Braco & Zarucchi 1993, Jørgensen & León-Yánez 1999	
CYPERACEAE																	
Bulbostylis juncoides (Vahl) Osten	x	x	x	x	x	x	x	x	x	x	x	x	x		EF 325, 365	Foster 1965, Kearns *et al.* 1998	
Uncinia phleoides (Cav.) Pers.	x	x	x	x	x		x				x				EF 439, 508	Foster 1965, Nee 1999	
EPHEDRACEAE																	
Ephedra americana Willd.	x	x	x	x			x								EF 608	Hunziker 1949, Jørgensen & León-Yánez 1999	
Ephedra rupestris Benth.	x	x	x	x			x								EF 186	Hunziker 1949	
ELAEOCARPACEAE																	
Vallea stipularis L. f.	x	x	x	x											EF 441, 489	Braco & Zarucchi 1993, Jørgensen & León-Yánez 1999	
ERICACEAE																	
Gaultheria glomerata (Cav.) Sleumer	x	x	x	x	x	x									EF 399, 498	Luteyn 1996	
Pernettya prostrata (Cav.) A. DC.	x	x	x	x	x	x	x		x						EF 413, 474	Lutyen 1996	
Polyclita turbinata (Kuntze) A.C. Sm.	x	x													EF 548	Nee 1999	

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
ESCALLONIACEAE																
Escallonia myrtilloides L. f.	x	x	x	x	x		x								EF 384, 495	Sleumer 1968
E. patens (R. & P.) Killip	x	x	x	x	x	x			x						EF 555	Sleumer 1968
E. resinosa (R. & P.) Pers.	x	x	x	x											EF 326, 446	Sleumer 1968
FABACEAE																
Adesmia miraflorensis Remy	x	x	x				x								EF 362	Ulibarri 1986
Amicia fimbrinata Harms	x	x													EF 470	Burkart 1943
Dalea boliviana Britton	x	x	x				x								EF 245	Macbride 1943
Cologania broussonetii (Balb.) DC.	x	x	x	x	x		x		x						EF 333	Tropicos database
Lathyrus magellanicus Lam.	x	x	x	x			x				x				EF 217, 462	Tropicos database, Moore 1983
Lupinus altimontanus C.P. Sm.	x	x													EF 321	Tropicos database
Trifolium amabile Kunth	x	x	x	x	x	x	x		x		x				EF 293, 332	Boelcke 1992
Vicia graminea Sm.	x	x	x	x	x		x		x		x				EF 306, 455	Macbride 1943
FLACOURTIACEAE																
Azara salicifolia Griseb.	x	x					x								EF 517, 586	Nee 1999
GENTIANACEAE																
Gentianella neomandonii (R.C. Foster) T.N. Ho & S.W. Liu	x	x													EF 406	Tropicos database
GERANIACEAE																
Geranium bolivianum R. Knuth	x	x													EF 453, 525	Aedo *et al.* 1998
G. sessiliflorum Cav.	x	x	x				x				x			x	EF 195	Aedo *et al.* 1998
G. soratae R. Knuth	x	x													EF 196, 201	Aedo *et al.* 1998
GROSSULARIACEAE																
Ribes brachybotrys (Wedd.) Jancz.	x	x	x												EF 166	Janczewski 1907
GUNNERACEAE																
Gunnera magellanica Lam.	x	x	x	x	x		x								EF 429	Molina 1978

HYPERICACEAE																	
Hypericum brevistylum Choisy	x	x	x	x												EF 281, 315	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
IRIDACEAE																	
Alophia lahue (Molina) Espinosa	x	x					x									EF 297	Tropicos database
Olsynium junceum (Presl.) Goldblatt	x	x	x													EF 164	Braco & Zarucchi 1993
Orthrosanthus chimboracensis (Kunth in H.B.K.) Baker	x	x	x	x	x	x			x							EF 185	Tropicos database
Sisyrinchium jamesoni Baker	x	x	x	x	x	x										EF 352, 372	Tropicos database
S. palustre Diels	x	x	x	x												EF 275	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
JUNCACEAE																	
Luzula excelsa Buchenau	x	x	x				x									EF 412, 485	Balslev 1996
L. racemosa Desv.	x	x	x	x	x	x	x		x							EF 160, 256	Balslev 1996
LAMIACEAE																	
Hedeoma mandoniana Wedd.	x	x	x													EF 199	Pestalozzi 1998
Lepechinia meyenii (Walp.) Epling	x	x	x				x									EF 284	Epling 1937
Minthostachys andina (Rusby) Epling	x	x	x													EF 221, 273	Epling 1937
Salvia haenkei Benth.	x	x	x													EF 465, 568	Epling 1937
Satureja boliviana (Benth.) Briq.	x	x	x				x									Ef 223, 260B	Epling 1937
LILIACEAE																	
Nothoscordum andicola Kunth	x	x	x													EF 282	Braco & Zarucchi 1993
N. bivalve (L.) Britton	x	x	x						x			x				EF 211, 292	Tropicos database
LOASACEAE																	
Caiophora canarinoides (Lenné & K. Koch) Urb. & Gilg	x	x	x													EF 179, 231	Braco & Zarucchi 1993
C. horrida Urb. & Gilg	x	x	x													EF 269	Braco & Zarucchia 1993
LORANTHACEAE																	
Tristerix penduliflorus Kuijt	x	x	x													EF 241, 445	Kuijt 1988
LYCOPODIACEAE																	
Lycopodium clavatum L.	x	x	x	x	x	x	x	x	x		x	x	x	x		EF 402, 472	Øllgaard 1988
L. thyoides Willd.	x	x	x	x	x	x	x									EF 530	Øllgaard 1988

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
MALVACEAE																
Tarasa hornschuchiana (Walp.) Krapov.	x	x	x												EF 238	Braco & Zarucchi 1993
MELASTOMATACEAE																
Brachyotum microdon (Naudin) Triana	x	x													EF 551	Nee 1999
MYRICACEAE																
Myrica pubescens Willd.	x	x	x	x	x	x			x						EF 451	Tropicos database
ONAGRACEAE																
Fuchsia apetala R. & P.	x	x	x												EF 170, 598	Munz 1943
F. nana P.E. Berry	x														EF 619	Berry 1985
Oenothera versicolor Lehm.	x	x	x	x											EF 180	Munz 1974
ORCHIDACEAE																
Habenaria pumiloides C. Schweinf.	x	x	x												EF 324	Dodson & Vásquez 1989
Myrosmodes paludosa (Rchb.f.) Garay	x	x	x												EF 278	Braco & Zarucchi 1993
OXALIDACEAE																
Hypseocharis pimpinellifolius J. Rémy	x	x	x												EF 268	Braco & Zarucchi 1993
Oxalis corniculata L.	x	x	x	x	x	x	x		x	x		x	x	x	EF 420	Tropicos database
O. lotoides Kunth	x	x	x	x											EF 264	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
PASSIFLORACEAE																
Passiflora exoperculata Mast.	x	x	x	x											EF 520	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
P. pinnatistipula Cav.	x	x	x	x	x		x								EF 229, 443	Holm-Nielsen *et al.* 1988
PIPERACEAE																
Peperomia cyclaminoides A.W. Hill	x	x													EF 206	Hill 1907, Yuncker 1953
P. fiebrigii C. DC.	x	x													EF 547	Yuncker 1953
PLANTAGINACEAE																
Plantago orbignyana Decne.	x	x	x	x			x								EF 288, 343	Rahn 1975

POACEAE																
Aristida adscensionis L.	x	x	x	x	x	x	x		x	x	x	x	x	x	EF 317, 339	Laegaard 1997
Briza subaristata Lam.	x	x	x		x		x		x	x	x				EF 334	Renvoize 1998
Bromus lanatus Kunth	x	x	x	x	x										EF 163, 419	Renvoize 1998
Calamagrostis antoniana (Griseb.) Hitchc.	x	x	x	x			x								EF 353, 418	Renvoize 1998
C. tarmensis Pilg.	x	x	x												EF 161, 162	Renvoize 1998
Cortaderia rudiuscula Stapf	x	x	x				x				x				EF 419	Laegaard 1997, Renvoize 1998
Deyeuxia curvula Wedd.	x	x	x				x								EF 585	Renvoize 1998
D. heterophylla Wedd.	x	x	x	x		x	x								EF 335	Renvoize 1998
D. vicunarum Wedd.	x	x	x	x	x	x	x								EF 574	Renvoize 1998
Elyonurus tripsacoides Willd.	x	x		x			x			x	x		x	x	EF 467	Renvoize 1998
Festuca dolichophylla J. Presl	x	x	x	x			x		x						EF 200, 355	Renvoize 1998
F. sublimis Pilg.	x	x	x	x	x										EF 171, 259	Renvoize 1998
Muhlenbergia peruviana (P. Beauv.) Steud.	x	x	x	x			x		x				x		EF 575	Renvoize 1998
Nassella inconspicua (J. Presl) Barkworth	x	x	x	x			x								EF 266, 492	Renvoize 1998
N. mucronata (Kunth) R.W. Pohl	x	x	x	x					x						EF 266B	Tropicos database
Piptochaetium montevidense (Spreng.) Parodi		x	x	x	x			x			x	x			EF 318	Renvoize 1998
Poa buchtienii Hack.	x	x													EF 194	Renvoize 1998
Sorghastrum stipoides (Kunth) Nash	x	x	x	x	x		x			x				x	EF 461	Renvoize 1998
Stipa ichu (R. & P.) Kunth	x	x	x	x	x	x	x		x		x				EF 267, 456	Renvoize 1998
S. brachyphylla Hitchc.	x	x	x	x			x								EF 319	Renvoize 1998
Trisetum spicatum (L.) K. Richt.	x	x	x	x				x	x	x		x			EF 280	Tropicos database
PODOCARPACEAE																
Prumnopitys exigua de Laubenf.	x	x													EF 650	LBP
POLYGALACEAE																
Monnina salicifolia R. & P.	x	x	x	x	x	x									EF 516, 578	Braco & Zarucchi 1993
POLYGONACEAE																
Muehlenbeckia tamnifolia (Kunth) Meisner	x	x	x	x	x	x	x		x	x					EF 514	Brandbyge 1992
M. volcanica (Benth.) Endl.	x	x	x	x	x	x			x						EF 283	Brandbyge 1992
Rumex acetosella L.	x	x	x	x	x	x	x		x		x		x	x	EF 388, 627	Brandbyge 1989
RANUNCULACEAE																
Anemone decapetala Ard.	x	x	x				x			x	x				EF 208, 287	Lourteig 1956

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
RHAMNACEAE																
Colletia spinosissima J.F. Gmel.	x	x	x	x			x			x	x		x		EF 361, 599	Torrico *et al.* 1997
ROSACEAE																
Acaena cylindristachya R. & P.	x	x	x		x	x			x						EF 430	Tropicos database
Hesperomeles cuneata Lindl.	x	x	x												EF 403	Braco & Zarucchi 1993
H. ferruginea (Pers.) Benth.	x	x	x	x	x	x									EF 532	Romoleroux 1996
H. obtusifolia (Pers.) Lindl.	x	x	x	x	x	x									EF 540, 587	Romoleroux 1996
Kageneckia lanceolata R. & P.	x	x	x												EF 433, 446	Nee 1999
Lachemilla pinnata (R. & P.) Rothm.	x	x	x	x	x	x	x		x						EF 265	Romoleroux 1996
Polylepis besseri Hieron. ssp. *subtusalbida* (Bitter) M. Kessler	x	x													EF 236, 254	Kessler 1995c
P. racemosa R. & P. ssp. *lanata* (O. Kuntze) M. Kessler	x														EF 409, 501	Kessler 1995c
P. tomentella Wedd. ssp. *incanoides* M. Kessler	x														EF 609	Kessler 1995c
P. tomentella Wedd. ssp. *nana* M. Kessler	x														EF 353	Kessler 1995c
Prunus tucumanensis Lillo	x	x					x				x				CN 528	Nee 1999
Rubus nubigenus Kunth in H.B.K.	x	x	x	x	x	x									EF 562	Romoleroux 1996
Tetraglochin cristatum (Britton) Rothm.	x	x	x				x								EF 358	Braco & Zarucchi 1993
RUBIACEAE																
Galium corymbosum R. & P.	x	x	x	x	x		x								EF 169, 225	Andersson 1992
G. hypocarpium (L.) Griseb.	x	x	x	x	x	x	x		x	x	x	x	x		EF 175, 421	Andersson 1992
Richardia coldenioides Rusby	x	x	x												EF 348	Andersson 1992
R. humistrata (Cham. & Schlecht.) Steud.	x	x					x			x	x				EF 313	Andersson 1992
SAPINDACEAE																
Dodonaea viscosa Jacq.	x	x	x	x	x	x	x		x	x		x	x	x	CA 411	Torrico *et al.* 1997
SCROPHULARIACEAE																
Agalinis bangii (Kuntze) Barringer	x	x													EF 250, 295	Canne-Hilliker 1988

Alonsoa acutifolia R. & P.	x	x	x												EF 481	Braco & Zarucchi 1993
Bartsia crenata Molau	x														EF 190, 368	Molau 1991
Calceolaria parvifolia Wedd.	x	x													EF 385	Molau 1988
C. aquatica Braun & Bouché	x														EF 386	Molau 1988
C. bartsiifolia Wedd.	x	x													EF 490	Molau 1988
C. engleriana Kränzl.	x	x	x												EF 191, 237	Molau 1988
C. parvifolia Wedd.	x	x	x												EF 187, 491	Molau 1988
Digitalis purpurea L.	x	x	x	x	x	x	x		x				x	x	EF 411	Tropicos database
SOLANACEAE																
Dunalia brachyacantha Miers	x	x					x								EF 664	Nee 1999
Salpichroa glandulosa (Hook.) Miers	x	x	x												EF 167	Braco & Zarucchi 1993
S. tristis Miers	x	x	x	x	x										EF 228	Jørgensen & León-Yánez 1999, Braco & Zarucchi 1993
Saracha punctata R. & P.	x	x	x	x	x										EF 539, 653	Nee 1999
SYMPLOCACEAE																
Symplocos subcuneata (Herzog) Ståhl	x	x													EF 552	Ståhl 1994
TROPAEOLACEAE																
Tropaeolum cochabambae Buch.	x	x	x												EF 435	Sparre & Andersson 1991
URTICACEAE																
Urtica chamaedryoides Pursh.	x	x					x		x		x	x	x		EF 176	LPB
VALERIANACEAE																
Valeriana decussata R. & P.	x	x	x	x											EF 203, 519	Eriksen 1989
VERBENACEAE																
Citharexylum punctatum Greenm.	x	x	x												EF 239, 502	Braco & Zarucchi 1993
Verbena berterii (Meisn.) Schauer	x	x	x												EF 357	Braco & Zarucchi 1993
FERNS																
Adiantum lorentzii Hieron.	x	x	x							x	x				EF 438	de la Sota 1977
A. poiretii Wikstr.	x	x	x	x	x	x	x		x	x	x	x		x	EF 595	Tryon & Stolze 1989
A. thalictroides Schltdl.	x	x	x	x	x	x	x		x	x	x	x		x	EF 459	de la Sota 1977
Asplenium castaneum Schltdl. & Cham.	x	x	x	x	x	x			x						EF 258, 630	Tryon & Stolze 1993

Taxon	Geographical area														Voucher	Reference
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
A. cuspidatum Lam.	x	x	x	x	x	x		x	x	x	x	x			EF 549	Tryon & Stolze 1993, Smith 1995
A. gilliesii Hook.	x	x	x				x								EF 291, 589	Tryon & Stolze 1993
A. lorentzii Hieron.	x	x	x				x								EF 546, 592	Tryon & Stolze 1993
A. monanthes L.	x	x	x	x	x	x	x		x	x	x			x	EF 436, 591	Tryon & Stolze 1993
Blechnum loxense (H.B.K.) Hieron.	x	x	x	x	x	x			x						EF 533	Tropicos database
B. penna-marina (Poir.) Kuhn	x	x	x				x			x	x			x	EF 415, 507	Tryon & Stolze 1993
B. sprucei C. Chr.	x	x	x	x			x		x	x					EF 544	Tryon & Stolze 1993
Campyloneurum angustipaleatum (Alst.) Lell.	x	x	x	x						x					EF 511	Tryon & Stolze 1993
C. densifolium (Hieron.) Lell.	x	x	x	x	x	x			x			x			EF 484, 576	Tryon & Stolze 1993
Cheilanthes myriophylla Desv.	x	x	x	x	x	x			x	x	x	x	x		EF 226	Yatskievych & Moran 1995
Ch. pruinata Kaulf.	x	x	x				x								EF 202, 340	Tryon & Stolze 1989
Dryopteris paleacea (Sw.) Hand. -Mazz.	x	x	x	x	x	x	x		x	x	x	x			EF 543	Tryon & Stolze 1991
Melpomene moniliformis (Sw.) A.R. Sm. & R.C. Moran	x	x	x	x	x	x		x	x	x	x	x			EF 557	Smith & Moran 1992
Pecluma choquetangensis (Lag.) A.R. Sm. & R.C. Moran	x	x													EF 481	Tryon & Stolze 1993
Pellaea ternifolia (Cav.) Link.	x	x	x	x	x	x	x		x	x					EF 612	Yatskievych 1995
Polypodium lasiopus Klotzsch	x	x	x	x	x	x									EF 483, 534	Tryon & Stolze 1993
P. megalolepis Maxon & C.V. Morton	x	x	x												EF 509, 637	Tryon & Stolze 1993
P. pynocarpum C. Chr.	x	x	x												EF 183, 479	Tryon & Stolze 1993
Saccoloma inaequale (Kunze) Mett.	x	x	x	x	x	x		x	x	x		x			EF 397	Smith 1995
Terpsichore athyroides (Hook.) A.R. Sm.	x	x													EF 632	Tryon & Stolze 1993
Thelypteris glandulosolanosa (C. Chr.) R.M. Tryon	x	x	x				x								EF 433	Smith 1991
Woodsia montevidensis (Spreng.) Hieron.	x	x	x	x	x	x	x			x	x	x		x	EF 204, 308	Stolze et al. 1994

Area designations: 1 Cordillera de Cochabamba, 2 Andes of Bolivia, 3 Andes of Peru, 4 Andes of Ecuador, 5 Andes of Colombia, 6 Andes of Venezuela, 7 Andes of northern Argentina-Chile, 8 Guayana Highlands, 9 Mesoamerica (Mexico-Panama), 10 Tropical lowland South America (below 1500 m alt.), 11 Extra-tropical South America, 12 West Indies, 13 North America, 14 Cosmopolitan or Pantropical. Voucher abbreviations: CA = C. Antezana, EF = E. Fernández, ES = E. Saravia, GN = G. Navarro, MA = M. Atahuachi, MM = M. Mercado. LPB = La Paz Herbarium. S = Stockholm Herbarium.