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Article

Endemic Hemicryptophyte Grasslands of the High Mountains of the Caribbean

Ana Cano-Ortiz [1], Ricardo Quinto Canas [2,3], José Carlos Piñar Fuentes [1], Sara del Río [4], Carlos José Pinto Gomes [5] and Eusebio Cano [1,*]

[1] Department of Animal and Plant Biology and Ecology, Section of Botany, University of Jaén, Jaén, Spain
[2] Faculty of Sciences and Technology, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal
[3] Centre of Marine Sciences (CCMAR), University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal
[4] Department of Biodiversity and Environmental Management (Botany), Mountain Livestock Institute (CSIC-ULE), Faculty of Biological and Environmental Sciences, University of León, Campus de Vegazana s/n, 24071 León, Spain; sriog@unileon.es (S.D.R.)
[5] Department of Landscape, Environment and Planning, School of Science and Technology, MED - Mediterranean Institute for Agriculture, Environment and Development, University of Évora, 7000-671 Évora, Portugal

*Correspondence: ecano@ujaen.es

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Abstract: Although there are numerous studies on the floristic composition of the Andean and Caribbean grasslands, there are limited information from a phytosociological point of view. This work therefore aims to highlight the differences in this important vegetation type in these two biodiversity hotspots to gain a better understanding of their floristic and vegetational richness. The floristic composition of Andean-grasslands (Ecuador) and the island of Hispaniola is also studied. The reason for this comparative analysis of Andean and Caribbean territories is their tropical character and their bioclimatic similarities. The comparative analysis of Peruvian Andean and Colombian grasslands is based on floristic knowledge from the literature, our inventories on the island of Hispaniola, and the works of Peguero. We applied the phytosociological methodology of Braun-Blanquet and the code of phytosociological nomenclature. We performed a statistical analysis to verify the differences between both community types using the statistical packages PAST© and CAP3. The comparative analysis of Andean and Caribbean grasslands shows a clear floristic and biogeographical differentiation and reveals that the only ecological character they share is their high-mountain attribute. In the Caribbean these communities are found only on the island of Hispaniola (Dominican Republic) in the Central biogeographic sector, Central subprovince, Hispaniola province. These grasslands are exclusive to Hispaniola and have a high rate of endemics. We propose the following new syntaxa: the association *Hyperico constanzae-Danthonietum domingensis*, the alliance *Hieracio domingensis-Deschampsion domingensis*, the order *Danthonietalia domingensis*, and the class *Deschampsio-Danthonietea domingensis.* We found high biodiversity values for Andean and Caribbean areas. This is due to the intense anthropic activity on the island of Hispaniola, which has led to a high percentage of naturalized plants.

Keywords: America; association; conservation diversity; endemics; grasslands; phytosociology; vegetation.

1. Introduction

The high mountains host an endemic flora and a characteristic vegetation around the world [1-5], are really hotspots of biodiversity [6-8], and are present not only in continental lands, but in several islands too and many of them are studied from a botanical point of view [9,10].

The Antillean archipelago is formed by the islands in the Greater and Lesser Antilles, and is located between the Caribbean Sea and the Atlantic Ocean on an arc between Florida and Venezuela. The islands have a territorial extension of 299,000 km^2, and their geological origins date from more or less 100 million years ago with the separation between Africa and America. According to some authors [11], throughout the geological eras the current islands have been shaped by three tectonic movements in the form of uplifts, subsidence and separation along faults, all of which are due to interactions between the Caribbean and the surrounding plates: Cocos, Nazca, North America and South America. The subduction of the Caribbean tectonic plate, which configured the mountains of Central America, began 25 million years ago in the Miocene era. Cuba was formed from the Mesozoic onward, specifically in the Jurassic and Cretaceous periods. The definitive separation of the Antilles from Central America occurred in the Pliocene era, leading to the establishment of essentially two migratory routes: North American route through Florida-Cuba, and the route of the Lesser Antilles from Venezuela; a third route from the Yucatán peninsula through the Caiman Islands was less important due to the distance from Central America to the Antillean arc [11].

The high mountains in Cuba that developed over millions of years were the Sierra Maestra, Sierra Escambray (Guamuhaya), Sierra Turquino at 1974 m asl, and Pico Cuba at 1972 m asl. The highest altitudes in Hispaniola are the Cordillera Central with Pico Duarte (3175 m asl), Pico del Yaque (3125 m asl) and la Rosilla (2860 m asl); the Cordillera Septentrional with Pico Diego de Ocampo (1229 m asl); other mountain ranges such as Bahoruco, Hotte and La Selle and Cordillera Oriental; and finally, in Puerto Rico the Cordillera Central with altitudes of less than 1500 m asl [12].

The Cordillera Central has a siliceous character and dates from the Cretaceous period; it represents the highest point in the whole Caribbean. The climate in all the Antilles is tropical with frequent and abundant rains on the oceanic face – sometimes exceeding 3,000 mm – and low rainfall on the Caribbean face, with up to 200 mm. The mean temperature is 24° C, and all the islands are subjected to hurricane winds with speeds of over 200 km/h [12].

The Antilles have undergone subsidence and uplifts throughout their geological history, although Cuba and Hispaniola have remained emerged while the rest of the islands sank into the sea; for this reason, these two islands became a reservoir for flora and subsequently served as dispersion centres [13].

The diversity of substrates, with a high frequency of siliceous, carbonated, ultramafic and serpentine rocks, its climate, and particularly its high-altitude orogeny, have given rise to a distinctive flora; these islands act as centres of speciation (hotspots) and have a very high rate of endemic plants: Cuba 45%; Hispaniola 36%; Jamaica 25-30%; Puerto Rico 24% and Lesser Antilles 10% [14].

Grasslands are hemicryptophyte communities located in the supratropical thermotype of Central America [15]. From the bioclimatic point of view, the thermotype in the Antilles ranges between the infra- and supratropical (the latter only in Hispaniola [16], where the temperature of the supratropical thermotype drops to 0 °C in winter. The dominant thermotypes are the infra-, thermo- and mesotropical, and the ombrotype ranges between the semiarid and the hyperhumid. The supratropical belt extends to altitudes above the sea of clouds, which causes winter temperatures to drop to 0 °C. These zones are characterised by their pluviseasonality, while the infra-, thermo- and mesotropical ombrotypes have a pluvial character. The inclusion of grassland communities in different phytosociological classes in the Andean region is due to the divergent floristic composition of the plant communities, their ecology and the biogeographic unit in which they are located [17].

Several authors have included Andean grasslands in various phytosociological classes. Izco [16] mentioned grasslands in a study on the San Francisco Reserve (Ecuador).

Grassland communities may be constituted solely by hemicryptophytes or by hemicryptophytes and small shrubs. Cabrera et al. [17] ascribed the High-Andean grasslands of Peru, Bolivia, northern Argentina and Chile to *Calamagrostietea vicunarum* Rivas-Martínez & Tovar 1982, and mesophilous scrublands and grasslands in temperate environments to other phytosociological classes. Galán & Orellana [18] assigned: a) the central Peruvian grasslands on limestone materials to the class *Stipetea mucronatae* Gutte 1986; b) the grasslands with small shrubs and cushion heaths in dry areas and on volcanic substrates in the Andean range in Bolivia, Chile and Argentina to the class *Fabiano bryoidis-Stipetea frigidae* Rivas-Martínez & Navarro in Navarro & Maldonado 2002; and c) the grasslands on the puna and intermediate valleys in Peru and Bolivia to the class *Calamagrostietea vicunarum*. Grassland communities belong to different phytosociological classes because of the diversity of the *Poaceae* family [19-27].

None of the classes cited can be extrapolated to the Caribbean as there are significant floristic, ecological and biogeographical differences; these grassland communities in Hispaniola are located on siliceous substrates in the Cordillera Central.

Grassland communities in the Andes have been studied from a floristic standpoint by several authors [18,19,23-27]. Grasslands in the Antillean archipelago are located only on the island of Hispaniola, specifically in the Cordillera Central, which has been the subject of various floristic and vegetation studies as indicated above.

On the northern or windward face there is a predominance of broadleaved or rainforest of *Magnolia* L., *Prestoea* Hook, *Ocotea* Aubl., *Podocarpus* Labill., *Cyathea* J.E. Smith (*Ocoteo-Cyrilletea racemiflorae* Borhidi 1996) [28], while on the Caribbean or leeward face there are pine forests growing on serpentines at low altitudes above the sea of clouds [4, 17,29-30]. Several authors have studied the flora and vegetation of the island of Hispaniola [31-47], essentially from a floristic approach, and addressed aspects of vegetation from the physiognomic point of view. We are the only authors until now to have conducted phytosociological studies [48-51].

The island of Hispaniola is a hotspot due to the high rate of endemisms, account for 2050 out of a total of 6000 species, even compared to other well-known hot spots in the worldwide as [52-55]. This is due to its orography and diversity of climate and substrates; its ombrotype ranges from semi-arid to hyper-humid, its thermotype from infratropical to supratropical, and its substrates are siliceous, carbonate rocks and serpentines

In this work we studied the flora and vegetation of the high mountains of the Caribbean, and compare them with similar Andean plant communities to highlight the differences between these two important biodiversity hotspots in order to gain a better understanding of their floristic richness. The floristic composition of the Andean scrub (Ecuador) and the scrub on the island of Hispaniola are also studied.

2. Materials and Methods

2.1 Comparative analysis

A comparative analysis is made between the Peruvian Andean and Colombian grasslands based on the floristic presence studies of Izco et al. [20], our own relevés collected on the island of Hispaniola, and other works of Peguero [13] in Valle Nuevo (Dominican Republic).

For the samplings carried out by us in the Central mountain range we have followed the phytosociological criteria. The plot size was chosen by previously calculating the minimum area, namely 300 m^2 [56]. In all cases the samplings were carried out in supratropical environments (Figures 1 and 2). For the abundance-dominance of the species, the work of Braun-Blanquet has been used [57].

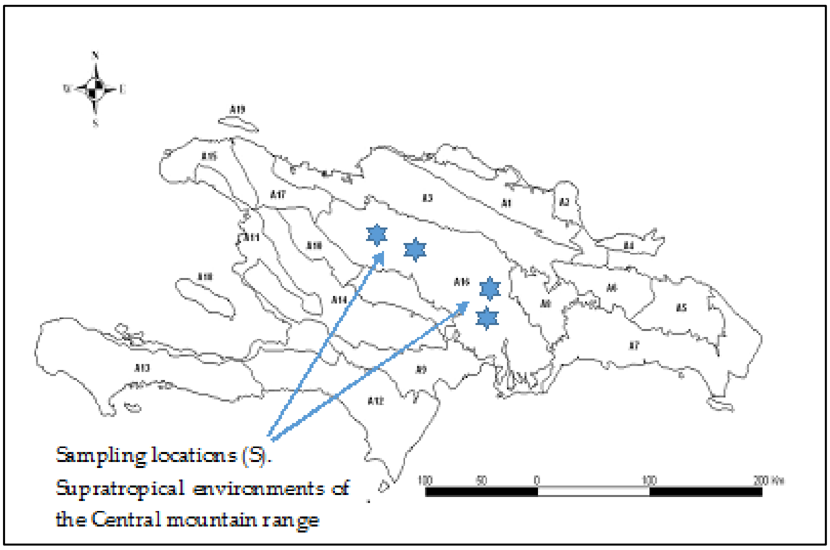

Figure 1. Localities studied. A16 Cordillera Central. Hispaniola Island.

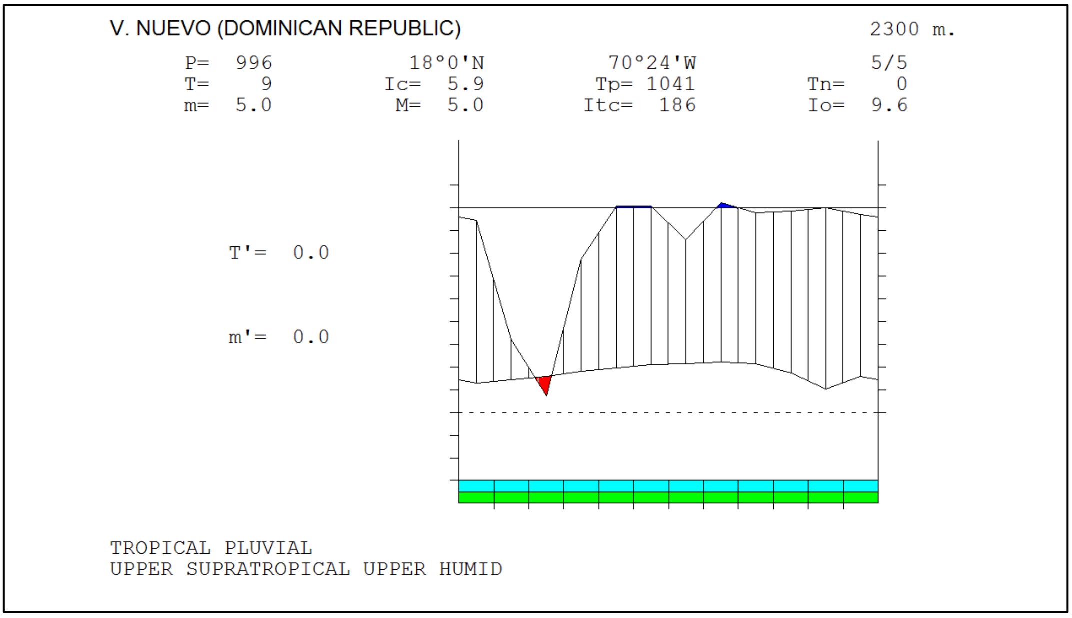

Figure 2. Bioclimatic diagram of Valle Nuevo. Upper supratropical thermotype and upper humid ombrotype. P = Precipitation. T = Average annual temperature. m = Average temperature of the minimum. M = Average temperature of the maximums. Tp = Positive temperature. m = Average temperature of the absolute minimums. Tn = Annual negative temperature. Ic = Annual continentality index. Io = Annual ombrothermic index. Itc = Compensated thermicity index.

2.2 Vegetation analysis

A study was carried out of the endemic scrub and grasslands of the Caribbean, until now exclusively located in Hispaniola.

We applied the phytosociological methodology of Braun-Blanquet [57] and the code of phytosociological nomenclature to name and describe the syntaxa [58]. A similarity analysis is carried out between areas of the Caribbean and Andean areas, through analysis of presence-absence of species and cluster. The environmental conditions have been sufficiently studied in references [14,48,51].

The statistical packages PAST (Paleontological Statistics)© [59] and CAP3 (Community Analysis Package, PISCES Conservation Ltd. IRC House, The Square, Pennington, Lymington Hants., SO41 8GN United Kingdom)© were used for this study. We applied the Jaccard distance to differentiate the Andean from the Caribbean communities. For the biogeographical and bioclimatic study, we followed [60-64]. The nomenclature of the taxa reported is according to Global Biodiversity Information Facility (GBIF) [65] and the Flora of Hispaniola [66].

The Shannon-Wiener, Margalef and Simpson indices were used to determine the diversity of the plots studied, since they offer the best fit with the measurement of diversity when using the table of presence and absence of species. However, it was impossible to use the Pielou Evennes index as it does not fit well when only the presence and absence of species is used.

The hemicryptophytic communities inventoried by us and by Peguero in the Valle Nuevo National Park (Dominican Republic) present a high endemic richness with 138 endemic plants. These communities are located only in supratropical environments above altitudes of 2000 metres on siliceous substrates. As these are environments exclusive to the Central Cordillera in the Dominican Republic, they represent endemic habitats with a high ecological value [67].

3. Results and Discussion

These endemic communities of Hispaniola cannot be located in the phytosociological classes described before for the Andean and Caribbean. The similarity, cluster and PCA analyses show clear differences between Andean and Caribbean grasslands (Figures 3 and 4) – plots P1 to P10 in the Caribbean group and plots P11 to P15 in the Andean group – with a significant floristic difference between the two groups (Tables S1 and S2, Supplementary materials). Although the analysis represented in Figure 3 is not exhaustive, it shows the significant differences between both territories. According to the Simpson, Shannon and Margalef diversity indices, this diversity is greater in the Andean plots (Table 1), where the mean diversity Pm (Simpson, Shannon and Margalef) of the plots is 0.94, 2.89 and 6.37 respectively. Some Andean plots have a maximum diversity of 0.97, 3.49 and 9.15, while the maximum diversity in Hispaniola is 0.94, 2.89 and 5.88 respectively, and their mean diversity Pm is 0.91, 2.45 and 4.46. This is possibly due to intense anthropic activity in the plots on the island, which have 31.25% of endemic species, 37.5% of native species and 31.25% of naturalized plants (10 species) (Figure 5).

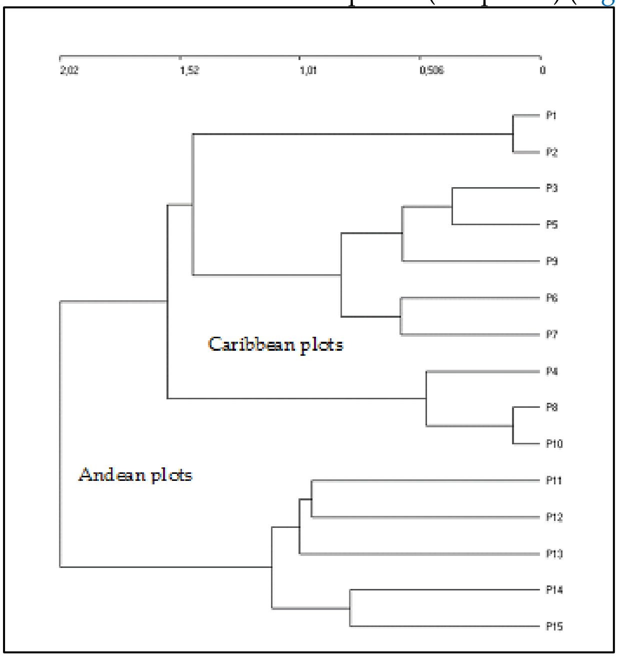

Figure 3. Comparative analysis of the Caribbean (P1-P10) and Andean (P11-P15) plots.

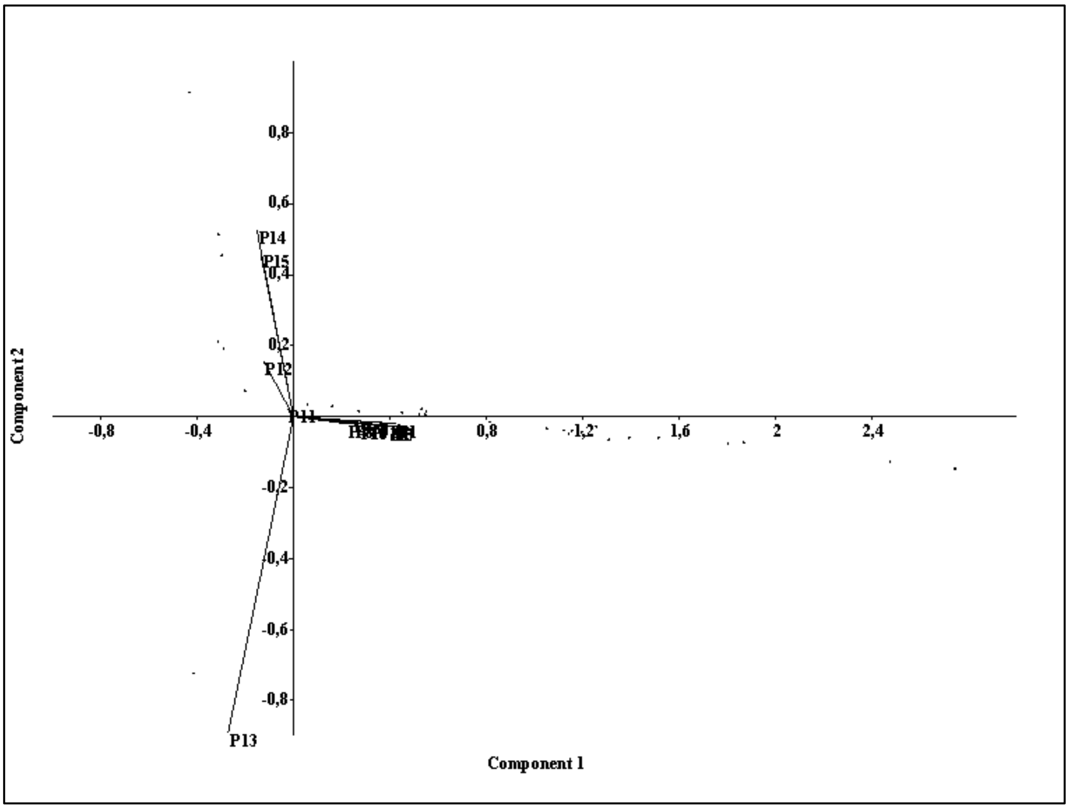

Figure 4. PCA analysis with separation of Andean and Caribbean plots. Caribbean (P1-P10) and Andean (P11-P15).

Figure 5. Hemicryptophytic communities of *Danthonia domingensis* Hack. & Pilg. in the supratropical sector of Hispaniola (protected natural area of Valle Nuevo) located in the clearings of the *Pinus occidentalis* Sw. pine forests. La Pirámide, between Ocoa and Constanza. Dominican Republic (ph. E. Cano).

Table 1. Diversity indices for the Caribbean (P1-P10) and Andean (P11-P15) plots. Pm: mean diversity (Simpson, Shannon and Margalef). In black the maximum values of diversity (P1 and P13), Pm = mean value of diversity.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Pm	P11	P12	P13	P14	P15	Pm
Species richness	18	16	15	6	16	14	10	8	11	9	12.3	6	22	33	22	20	20.6
Simpson_1-D	0.94	0.94	0.93	0.83	0.94	0.93	0.9	0.88	0.91	0.89	0,91	0.83	0.95	0.97	0.95	0.95	0.93
Shannon_H	2.89	2.77	2.71	1.79	2.77	2.64	2.3	2.08	2.4	2.2	2.46	1.79	3.09	3.5	3.09	3	2.89
Margalef	5.88	5.41	5.17	2.79	5.41	4.93	3.9	3.37	4.17	3.64	4.47	2.79	6.79	9.15	6.79	6.34	6.37

In our study we observe a clear difference between the Peruvian and Colombian grasslands and those of the Caribbean. Unfortunately, for the plots from Peru and Colombia we only have the reference by [24,26] on the species of the genus *Danthonia* in the Colombian Andes, and the floristic composition of the Andean grasslands (Ecuador) is different from on the island of Hispaniola. Izco et al. [20] report that the southern scrublands of Ecuador comprise over 33 species, among which it is worth highlighting *Agrostis tolucensis* Kunth, *Calamagrostis bogotensis* Pilg., *Calamagrostis intermedia* Sted., *Halenia wedeliana* Gilg, *Baccharis tricuneata* Pers., *Bejaria resinosa* L.f. None of these species is found on the Caribbean islands. In their work on the vegetation of the central Andes in Peru, Rivas-Martínez & Tovar [26] mention *Calamagrostis vicunarum* Pilg., which is not present in the Caribbean. Previously, the Caribbean scrublands have been located exclusively in the supratropical belt in Hispaniola, where they are dominated by *Danthonia domingensis* Hack & Pilg. and *Deschampsia domingensis* Hichc. & Ekman, accompanied by other hemicryptophytes and some woody shrubs. These are silicicolous communities that are interspersed with forests of *Pinus occidentalis* Sw. (*Dendropemon phycnophylli-Pinetum occidentalis* Cano, Velóz, & Cano-Ortiz 2011) [51].

These hemicryptophyte communities located in the clearings of the pine forest are very rich in endemic plants, as they are located in the high mountains [67]. Although climate change affects the forest of *P. occidentalis*, it does not seem to affect these communities. With the death of the pine, open spaces appear that allow the expansion of the "pajón" or *Danthonia domingensis*, as occurs in the protected natural area of Valle Nuevo (Hispaniola), although globalization is leading to an increase in human pressure and jeopardising the conservation of these communities [39]. It is evident that if climate change and human pressure continue, these fragile communities that are unique to the Caribbean will come under a certain degree of threat, since a set of naturalised (Na) species has already appeared as a result of anthropic action.

Cano et al. [50] recently published a syntaxonomical proposal for the grasslands of Hispaniola. This study reveals the existence of an endemic grassland community that is widespread throughout the supratropical thermotype in the central biogeographic sector, Central subprovince, Hispaniola province. This is an endemic community of grassland characterised by *Alchemilla domingensis* Urb., *Hypericum constanzae* Urb., *Danthonia domingensis, Deschansia domingensis*, *Gautheria domingensis* and *Rubus eggersii* which allows us to propose the association *Hyperico constanzae-Danthonietum domingensis* Cano, Cano-Ortiz, Quinto Canas, Piñar Fuentes & Pinto Gomes *hoc loco* (Table 2 relevé *typus* P1). The lack of phytosociological studies in which to include these communities leads us to propose higher ranking syntaxa, as follow:

DESCHAMPSIO-DANTHONIETEA DOMINGENSIS Cano, Cano-Ortiz, Quinto Canas, Piñar Fuentes & Pinto Gomes *class. nova*

Caribbean supratropical grasslands [*Danthonia domingensis*, *Deschampsia domingensis*, *Carex polystachya* Se. ex Wahlenb, *Baccharis myrsinites* (Lam.) Pers., *Panicum acuminatum* Sw., *Hieracium gronovii* L., *Gautheria domingensis* Urb.].

DESCHAMPSIO-DANTHONIETALIA DOMINGENSIS Cano, Cano-Ortiz, Quinto Canas, Piñar Fuentes & Pinto Gomes *ord. novo*

Caribbean supratropical grasslands [*Danthonia domingensis*, *Deschampsia domingensis*, *Carex polystachya*, *Baccharis myrsinites*, *Panicum acuminatum*, *Hieraciun gronovii*, *Gautheria domingensis*].

Hieracio domingensis-Deschampsion domingensis Cano, Cano-Ortiz, Quinto Canas, Piñar Fuentes & Pinto Gomes *all. nova*

Endemic supratropical grasslands of Hispaniola [*Rubus eggersii* (Focker) Rydb., *Deschampsia domingensis, Artemisia domingensis* Urb., *Chaptalia eggersii* Urb.].

Although *Chaptalia eggersii*, does not appear in the sites sampled due to its dispersed presence in the *pajonal* community and its distribution, we also consider it to be characteristic of the alliance for which we propose as the holotype *Hyperico constanzae-Danthonietum domingensis* Cano, Cano-Ortiz, Quinto Canas, Piñar & Pinto Gomes.

Hyperico constanzae-Danthonietum domingensis Cano, Cano-Ortiz, Quinto Canas, Piñar Fuentes & Pinto Gomes *ass. nova*

Endemic grassland association, supratropical, located in the eastern zone of the central sector, Central subprovince, Hispaniola province, characterised by the endemisms: *Alchemilla domingensis, Hypericum constanzae, Danthonia domingensis, Deschampsia domingensis* (Table 2).

Table 2. *Hyperico constanzae-Danthonietum domingensis ass. nova* (*Deschampsio-Danthonietea domingensis*; *Danthonietalia domingensis*; *Hieracio domingensis-Deschampsion domingensis*). Localities: La Pirámide. Between Ocoa and Constanza. Dominican Republic. UTM: 19331098E/2069723N. Origin: E= Endemic, N = Native, Na = Naturalised. Biotype: H = Hemicryptophyte, Ar = Shrub.

Relevé no.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	O	*B*	F
Area (m^2)	300	300	300	300	300	300	300	300	300	300	R	*I*	A
Cover (%)	90	80	80	80	80	90	90	80	80	80	I	*O*	M
Altitude m a.s.l. 1=10	238	235	228	230	210	220	226	230	235	218	G	*T*	I
Average vegetation height in metres	0.45	0.45	0.50	0.50	0.40	0.55	0.50	0.55	0.60	0.55	I	*Y*	L
Slope	-	-	-	-	-	-	-	-	-	-	N	*P*	Y
Exposition	-	-	-	-	-	-	-	-	-	-		*E*	
Characteristic species of association and higher syntaxa													
Danthonia domingensis	4	3	3	3	3	4	4	3	3	3	E	H	*Poaceae*
Hieracium domingensis	1	2	2	1	1	2	1	1	.	1	E	H	*Asteraceae*
Deschampsia domingensis	1	1	1	.	1	2	.	.	1	.	E	H	*Poaceae*
Rubus eggersii	1	1	1	.	2	1	.	.	1	.	E	Ar	*Rosaceae*
Hypericum diosmoides	+	1	1	.	1	.	.	.	.	.	N	H	*Hypericaceae*
Lyonia heptamera	+	+	.	.	.	.	.	+	.	+	E	Ar	*Ericaceae*
Baccharis myrsinites	+	1	1	.	.	1	.	.	.	.	N	Ar	*Asteraceae*
Satureja alpestris	+	+	.	.	+	+	.	.	.	.	E	Ar	*Lamiaceae*
Alchemilla domingensis	+	+	.	.	+	.	.	.	.	.	E	H	*Rosaceae*
Rhynchospora domingensis	.	+	.	.	.	+	.	.	.	.	N	H	*Cyperaceae*
Hypericum constanzae	2	1	.	.	.	.	.	.	.	.	E	H	*Hypericaceae*
Hieracium gronovii	1	1	.	.	.	.	.	.	.	.	N	H	*Asteraceae*
Gautheria domingensis	1	1	.	.	.	.	.	.	.	.	E	Ar	*Ericaceae*

Malaxis unifolia	+	+	.	.	.	.	.	.	.	.	N	H	*Orchidaceae*
Companion species													
Carex polystachya	2	1	.	+	1	.	.	+	1	+	Na	H	*Cyperaceae*
Lycopodium fawcetii	1	1	.	1	.	1	.	1	.	+	N	H	*Lycopodiaceae*
Lycopodium cernua	+	.	+	.	.	+	+	+	.	+	N	H	*Lycopodiaceae*
Symphyotricum dumosum	1	+	+	.	1	.	.	.	+	.	Na	H	*Asteraceae*
Panicum acuminatum	.	+	+	.	+	+	.	.	+	.	N	H	*Poaceae*
Lycopodium clavatum	2	1	.	.	.	.	.	.	.	.	Na	H	*Lycopodiaceae*
Centella asiatica	1	1	1	.	+	.	.	.	.	.	Na	H	*Apiacee*
Pinus occidentalis	+	.	.	+	.	+	+	.	.	+	E	Ar	*Pinaceae*
Sonchus oleraceus	.	+	+ .	.	.	.	+	+	+	+	Na	H	*Asteraceae*
Taraxacum officinale	.	+	+	.	+	+	+	.	.	.	Na	H	*Asteraceae*
Trifolium repens	.	+	+	.	+	.	.	.	.	.	Na	H	*Fabaceae*
Sisyrinchium angustifolium	.	+	.	.	.	.	.	.	.	.	N	H	*Iridaceae*
Juncus effusus	.	+	.	.	+	.	.	.	+	.	N	H	*Juncaceae*
Rumex cripus	.	+	+	.	+	+	+	.	+	.	Na	H	*Polygonaceae*
Verbascum thapsus	+	.	+	.	+	.	+	.	+	.	Na	H	*Scrophulariaceae*
Pteridium aquilinum	+	.	.	+		+	+	+	+	+	N	H	*Hypolepidaceae*
Verbena domingensis	.	.	.	.	.	.	+	.	.	.	N	H	*Verbenaceae*
Panicum acicularis	1	+	.	.	.	.	.	.	.	.	Na	H	*Poaceae*

5. Conclusions

The comparative analysis of Andean and Caribbean grasslands allows us to propose new syntaxa for the island of Hispaniola, as there are no phytosociological studies for these types of communities in the Caribbean. As these communities cannot be ascribed to any of the classes previously published for South America due to the major floristic and biogeographical differences between them, we propose a new class, order, alliance and association. These are endemic syntaxa that are currently restricted to the island of Hispaniola. Endemicity is due to the "insular effect": something similar occurs in other islands and peninsulas, including mountain areas, such as the Etna volcano on the island of Sicily (Italy), in which due to the above mentioned effect insular effect there are endemic taxa of interest [68]. The floristic diversity of the plots in the study reveals high values for Andean areas, with maximum Simpson, Shannon and Margalef values of 0.94, 2.89 and 5.88 (Hispaniola, Caribbean) and 0.97, 3.50 and 6.79 respectively (Andean areas). Altough this is also due to the intense anthropic activity on the island of Hispaniola, which has led to a high rate of naturalised plants – over 30% –, endangering these habitats and consequently their endemisms, the high floristic diversity is determined above all by the high percentage of endemisms and native flora as a whole.

We highlight the importance of these plant communities in the Caribbean area, since they are unique phytocoenoses in this territory; so although there is little phytosociological information available, their very significant floristic divergences, the origin of the floras and the epiontological differences are sufficient reasons for the diagnosis of new syntaxa.

Consequently, the diagnosis of new syntaxa for science will allow the protection of these habitats.

Supplementary Materials: The following are available online at www.scipublications.com/journal/index.php/rjees/article/view/184/tabs1, Table S1: Species occurring in the sampling plots of the Caribbean and Ecuador. Localities of the plots. P1 and P2: La Pirámide (between

Ocoa and Constanza), UTM:19331098E/2069723N. P3 to P10: Valle Nuevo, UTM: 19331998E/206923N [40]. P11 to P15 [14, 17]. X= Presence, - = Absence. Table S2: Comparative analysis of the flora in the plots PE = Island of Hispaniola. PA = Peruvian Andes..

Author Contributions:

Conceptualization, Eusebio Cano; Data curation, Ana Cano-Ortiz, Ricardo Quinto Canas, José Carlos Piñar Fuentes, Sara del Río, Carlos José Pinto Gomes and Eusebio Cano; Formal analysis, José Carlos Piñar Fuentes, Carlos José Pinto Gomes and Eusebio Cano; Funding acquisition, Ana Cano-Ortiz; Investigation, Ana Cano-Ortiz and Eusebio Cano; Methodology, Eusebio Cano; Resources, Eusebio Cano; Supervision, Eusebio Cano; Validation, Ana Cano-Ortiz, Ricardo Quinto Canas, José Carlos Piñar Fuentes and Eusebio Cano; Visualization, Ana Cano-Ortiz, and Eusebio Cano; Writing – original draft, Ana Cano-Ortiz and Eusebio Cano; Writing – review & editing, Ana Cano-Ortiz, Ricardo Quinto Canas, José Carlos Piñar Fuentes, Sara del Río, Carlos José Pinto Gomes and Eusebio Cano.

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Endemic Hemicryptophyte Grasslands of the High Mountains of the Caribbean

Ana Cano-Ortiz [1], Ricardo Quinto Canas [2,3], José Carlos Piñar Fuentes [1], Sara del Río [4], Carlos José Pinto Gomes [5] and Eusebio Cano [1,*]

SUPPLEMENTARY MATERIAL

Table S1. Species occurring in the sampling plots of the Caribbean and Ecuador. Localities of the plots. P1 and P2: La Pirámide (between Ocoa and Constanza), UTM:19331098E/2069723N. P3 to P10: Valle Nuevo, UTM: 19331998E/206923N [40]. P11 to P15 [14, 17]. X= Presence, - = Absence.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Danthonia domingensis	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-
Carex polystachya	X	X	-	X	X	-	-	X	X	X	-	-	-	-	-
Hieracium domingensis	X	X	X	X	X	X	X	X	-	X	-	-	-	-	-
Lycopodium fawcetii	X	X	-	X	-	X	-	X	-	X	-	-	-	-	-
Deschansia domingensis	X	X	X	-	X	X	-	-	X	-	-	-	-	-	-
Rubus eggersii	X	X	X	-	X	X	-	-	X	-	-	-	-	-	-
Sonchus oleraceus	-	-	X	-	-	-	X	X	X	X	-	-	-	-	-
Lycopodium cernua	-	-	X	-	-	X	X	X	-	X	-	-	-	-	-
Pteridium aquilinum	-	-	-	X	-	X	X	X	X	X	-	-	-	-	-
Pinus occidentalis	X	-	-	X	-	X	X	-	-	X	-	-	-	-	-
Panicum acuminatum	-	-	X	-	X	X	-	-	X	-	-	-	-	-	-
Rumex cripus	-	-	X	-	X	X	X	-	X	-	-	-	-	-	-
Verbascum thapsus	-	-	X	-	X	-	X	-	X	-	-	-	-	-	-
Baccharis myrsinites	X	X	X	-	-	X	-	-	-	-	-	-	-	-	-
Hypericum diosmoides	X	X	X	-	X	-	-	-	-	-	-	-	-	-	-
Centella asiatica	X	X	X	-	X	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	X	-	X	X	X	-	-	-	-	-	-	-	-
Siryrinchium angustifolium	-	-	X	-	X	-	-	-	X	-	-	-	-	-	-
Lyonia heptamera	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-
Juncus effusus	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-
Alchemilla domingensis	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Hypericum constanzae	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphyotricum dumosum	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum acicularis	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Hieracium gronovii	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium clavatum	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaultheria domingensis	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Malaxis unifolia	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifolium repens	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-

Satureja alperstris	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-
Rhynchospora domingensis	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Verbena domingensis	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Baccharis tricuneata	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Elleanthus amethystinoides	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Nertera granadensis	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Oreobolus venezuelensis	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Panicum stigmosum	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Setaria parviflora	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Bejaria resinosa	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Cicendia quadrangularis	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Danthonia secundiflora	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Diplostephium hartwegii	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Eriosorus cheilanthoides	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Gaultheria erecta	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Halenia taruga-gassso	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Hieracium soridoanum	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Histiopteris incisa	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Huperzia afinis	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Huperzia austroecuadorica	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Ilex rupicola	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Lachemilla holosericea	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Miconia aspergillaris	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Miconia bullata	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Myrcianthes myrsinoides	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Thelypteris pusilla	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Themistoclesia epiphytica	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Triniochloa stipoides	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Vaccinium crenatum	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Viola arguta	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Agrostis tolucensis	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Bidens andicola	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Briza monandra	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Calamagrostis bootensis	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Calamagrostis intermedia	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Castilleja fissifolia	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Diplostephium glandulosum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Eryngium humile	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Geranium diffusum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Gomphichis caucana	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Halenia weddeliana	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Hieracium frigidum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Huperzia sellifolia	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Hypochaeris sessiliflora	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Isidrogalvia falcata	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-

Lupinus tauris	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Lycopodiella alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Oreobolus goeppingeri	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Oritrophium mucidum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Oriotrophium peruvianum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Pascpalum bomplandianum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Pedicularis incurva	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Pinguicula calyptrata	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Poa pauciflora	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Puya glomerifera	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Rhynchospora tenuis	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Rhynchospora vulcani	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Scirpus rigidus	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Sisyrinchium chilense	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Sisyrinchim tinctorium	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Sticherus revolutus	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Vaccinium floribundum	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Valeriana microphylla	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Brachyotum benthamianum	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Gerarinum loxense	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Gynoxys cuicochensis	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Jamesonia gaudotii	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Oritrophium crocifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Pentacalia andicola	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Werneria nubigena	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Baccharis teindalensis	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Blechnum loxense	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Blechnum schomburgkii	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Eriocaulon microcephalum	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Festuca glumosa	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Festuca sabulifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Gaultheria reticulata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Hydrocotyle umbellata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Hypericum harlingii	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Huperzia attenuata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Miconia asperrima	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Monnina crassifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Niphlogeton dissecta	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Ranunculus peruvianus	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Calamagrostis ligulata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Calamagrostis ecuadorensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Cortaderia hapalotricha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Cortaderia sericantha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Diplostephium oblanceolatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Disterigma empetrifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X

Gentianella fascicaulis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Huperzia crassa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Hydrocotyle ranunculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Hypericum lancioides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Lysipomia cuspidata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Lysipomia cylindrocarpa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Neurolepis aristata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Neurolepis nana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X

Table S2 - Comparative analysis of the flora in the plots PE = Island of Hispaniola. PA = Peruvian Andes.

	PE	PA
Danthonia domingensis	V	-
Hieracium domingensis	V	-
Carex polystachya	IV	-
Deschansia domingensis	III	-
Rubus eggersii	III	-
Sonchus oleraceus	III	-
Lycopodium fawcetii	III	-
Pteridium aquilinum	III	-
Hypericum diosmoides	II	-
Baccharis myrsinites	II	-
Centella asiatica	II	-
Pinus occidentalis	II	-
Panicum acuminatum	II	-
Rumex cripus	II	-
Verbascum thapsus	II	-
Taraxacum officinale	II	-
Lycopodium cernua	II	-
Hypericum constanzae	I	-
Symphyotricum dumosum	I	-
Panicum acicularis	I	-
Hieracium gronovii	I	-
Lycopodium clavatum	I	-
Gaultheria domingensis	I	-
Malaxis unifolia	I	-
Rhynchospora domingensis	I	-
Lyonia heptamera	I	-
Trifolium repens	I	-
Siryrinchium angustifolium	I	-
Juncus effusus	I	-
Satureja alperstris	I	-

Alchemilla domingensis	I	-
Verbena domingensis	I	-
Oritrophium crocifolium	-	II
Pentacalia andicola	-	II
Setaria parviflora	-	II
Brachyotum benthamianum	-	II
Gerarinum loxense	-	II
Gynoxys cuicochensis	-	II
Jamesonia gaudotii	-	II
Werneria nubigena	-	II
Baccharis tricuneata	-	I
Bejaria resinosa	-	I
Cicendia quadrangularis	-	I
Danthonia secundiflora	-	I
Diplostephium hartwegii	-	I
Elleanthus amethystinoides	-	I
Eriosorus cheilanthoides	-	I
Gaultheria erecta	-	I
Halenia taruga-gassso	-	I
Hieracium soridoanum	-	I
Histiopteris incisa	-	I
Huperzia afinis	-	I
Huperzia austroecuadorica	-	I
Ilex rupicola	-	I
Lachemilla holosericea	-	I
Miconia aspergillaris	-	I
Miconia bullata	-	I
Myrcianthes myrsinoides	-	I
Nertera granadensis	-	I
Oreobolus venezuelensis	-	I
Panicum stigmosum	-	I
Thelypteris pusilla	-	I
Themistoclesia epiphytica	-	I
Triniochloa stipoides	-	I
Vaccinium crenatum	-	I
Viola arguta	-	I
Agrostis tolucensis	-	I
Bidens andicola	-	I
Briza monandra	-	I
Calamagrostis bootensis	-	I
Calamagrostis intermedia	-	I

Castilleja fissifolia	-	I
Diplostephium glandulosum	-	I
Eryngium humile	-	I
Geranium diffusum	-	I
Gomphichis caucana	-	I
Halenia weddeliana	-	I
Hieracium frigidum	-	I
Huperzia sellifolia	-	I
Hypochaeris sessiliflora	-	I
Isidrogalvia falcata	-	I
Lupinus tauris	-	I
Lycopodiella alopecuroides	-	I
Oreobolus goeppingeri	-	I
Oritrophium mucidum	-	I
Oriotrophium peruvianum	-	I
Pascpalum bomplandianum	-	I
Pedicularis incurva	-	I
Pinguicula calyptrata	-	I
Poa pauciflora	-	I
Puya glomerifera	-	I
Rhynchospora tenuis	-	I
Rhynchospora vulcani	-	I
Scirpus rigidus	-	I
Sisyrinchium chilense	-	I
Sisyrinchim tinctorium	-	I
Sticherus revolutus	-	I
Vaccinium floribundum	-	I
Valeriana microphylla	-	I
Baccharis teindalensis	-	I
Blechnum loxense	-	I
Blechnum schomburgkii	-	I
Calamagrostis ecuadorensis	-	I
Calamagrostis ligulata	-	I
Cortaderia hapalotricha	-	I
Cortaderia sericantha	-	I
Diplostephium oblanceolatum	-	I
Disterigma empetrifolium	-	I
Eriocaulon microcephalum	-	I
Festuca glumosa	-	I
Festuca sabulifolia	-	I
Gaultheria reticulata	-	I

Gentianella fascicaulis	-	I
Huperzia attenuata	-	I
Huperzia crassa	-	I
Hydrocotyle ranunculoides	-	I
Hydrocotyle umbellata	-	I
Hypericum harlingii	-	I
Hypericum lancioides	-	I
Lysipomia cuspidata	-	I
Lysipomia cylindrocarpa	-	I
Miconia asperrima	-	I
Monnina crassifolia	-	I
Neurolepis aristata	-	I
Neurolepis nana	-	I
Niphlogeton dissecta	-	I
Ranunculus peruvianus	-	I